Determinants of Disability and Disablement in Ontario Long-Term Care Residents

by

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Abstract

Purpose: Disability is difficulty with or dependence on others to conduct activities of daily living, such as bathing, eating and dressing; disablement is worsening disability measured over time. Among long-term care residents, disability and disablement lower quality of life and increase health care costs. Understanding the determinants of disability and disablement in this population is critical to guide clinical practice and accountability policies in long-term care homes.

Methods: This thesis is theoretically grounded in the Disablement Process Model. It consists of a literature review and two retrospective studies done using Ontario health administrative data. Study 1 features a critical literature review and analytic framework of the determinants of disability and disablement in older adults. Study 2 examines the relative effect of long-term care home versus resident characteristics in explaining residents' disability. Study 3 focuses on the association between disability and geriatric syndromes present at admission and disablement experienced by long-term care residents over time. Hierarchical linear regression models were used in both Studies 2 and 3.

Implications: The conceptually-grounded, evidence-based analytic framework from Study 1 can be used to advance future research on disability and disablement in older adults, whether or not they live in the community or long-term care. Study 2 demonstrates that the majority of variation in disability among Ontario long-term care home residents is explained by residents' geriatric syndromes, not characteristics of the homes in which they live. Study 3 shows that residents with lower disability at admission become disabled more rapidly over the course of their stay; our exploration of possible mechanisms for this finding is relevant to frontline providers and researchers alike.

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Dedication

This thesis is dedicated to the memory of William “Harry” Cornett, whose love and optimism permeated the lives of everyone he met.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1
Introduction

1 Overview

Self-care disability is difficulty with or dependence on others to conduct activities of daily living (ADLs), such as bathing, eating and dressing (Gill, 2010). This dissertation distinguishes between self-care disability (henceforth "disability") measured at one point in time and disablement, which is intensifying disability measured over two or more time points (Verbrugge & Jette, 1994). As the global population of older adults with multiple chronic conditions grows, the population burden of disability is also expected to increase (Atun, 2015). Older adults with disability experience more hospitalizations (Kruse, Petroski, Mehr, Banaszak-Holl, & Intrator, 2013), have higher health care costs (Lindholm, Gustavsson, Jonsson, & Wimo, 2013; Perrin et al., 2011) and report lower quality of life (Andersen, Wittrup-Jensen, Lolk, Andersen, & Kragh-Sorensen, 2004; Covinsky et al., 1999). Preventing or slowing the progression of disability and disablement could thus improve older adults' quality of life while reducing health system costs. This imperative is particularly strong in long-term care home (LTCH) residents, in whom disability and disablement are highly prevalent.

Evidence is needed to inform policy and practice related to disability and disablement in LTCH residents. A conceptual framework of the factors that lead to disability and disablement could help guide empirical research and evidence syntheses on disability. Empirical research is also needed to identify correlates and causes of disability and disablement, as well as interventions to prevent disablement; literature reviews could then synthesize these findings into policy- and practice-relevant packages and identify avenues for future research. Despite a clear and growing need for these kinds of research, evidence on the determinants of disability and disablement in LTCH residents is sparse and inconclusive.

This dissertation aims to enhance understanding of disability and disablement in LTCH residents by operationalizing a conceptual framework of disablement in older adults and using it to guide two empirical studies of disability and disablement in Ontario LTCH residents. These three related studies are presented in self-contained chapters (Table 1.1). Chapter 2 describes a critical literature review of correlates of disability and disablement in older adults in the context of the Disablement Process Model (DPM) (Verbrugge & Jette, 1994). These findings are then operationalized in an analytic framework and recommendations to address common limitations of existing evidence are made. Chapter 3 focuses on older adults in LTCHs and empirically examines how resident geriatric syndromes and chronic conditions, as well as features of LTCHs are associated with disability. Chapter 4 expands on the findings of Chapter 3 by examining the longitudinal relationship between disability at admission to LTCH, specific geriatric syndromes and disablement in LTCH residents. Chapter 5 summarizes the main findings of these three studies and identifies their potential applications to theory and practice, as well as limitations and directions for future research.

Table 1.1: Summary of Research Aims and Methods for Dissertation Studies

Study	Chapter	Aims	Methods
1	2	• Summarize research on disability and disablement in the context of the DPM. • Identify methodological limitations of existing evidence on disability in older adults. • Create DPM-based analytic framework to inform future research on disability among older adults.	Critical literature review and conceptual synthesis into analytic framework.
2	3	• Identify which resident geriatric syndromes and chronic conditions are most strongly associated with disability in LTCH residents. • Examine whether these relationships are moderated by residents' sex, age or cognitive status. • Determine the proportion of variance in resident disability explained by resident characteristics versus LTCH characteristics.	Hierarchical multivariable linear regression using population-based health administrative data from Ontario.
3	4	• Test whether having high versus low disability at admission to LTCH is associated with an increased rate of resident disablement over two years.	

	• Examine whether balance impairment, cognitive impairment, or or severe pain at admission to LTCH are associated with an increased rate of resisdent disablement over two years.

This introductory chapter provides context for these studies by reviewing the ties between resident disability and LTCH eligibility, funding, delivery and accountability structures in in Ontario and Canada. Although Ontario's LTCH residents are the focus of this dissertation, discussion of these structures in the American LTCH context is included due to the many similarities between these two systems. An overview of the conceptual framework and the terminology used throughout the dissertation is also provided. The final section of this chapter summarizes the rationale for this work and potential relevance of findings to research, policy and practice. Abbreviations and definitions used throughout are summarized in Appendices 1.1 and 1.2.

2 Long-Term Care in Ontario, Canada

More than 200,000 older Canadians currently live in LTCHs, with approximately 76,535 of these residents located in the province of Ontario (Statistics Canada, 2011; OLTCA, 2014). These publicly-funded facilities are home to older adults whose care needs are greater than the level provided by home care or retirement homes, but less than that provided in hospital (CIHI, 2013). Most residents are admitted to LTCHs from hospital or their own homes and spend the remainder of their lives there. The majority of residents have some degree of disability and tend to experience ongoing disablement throughout the duration of their stay (CIHI, 2013).

2.1 Eligibility for Long-Term Care in Ontario

A major reason LTCH demand is expected to increase in the coming years is that eligibility for entry into LTCHs in Ontario is strongly linked to disability. When older Ontarian adults or their caregivers apply for entry to LTCHs, they are assessed by a Home Placement Coordinator, who is employed by one of 14 Community Care Access Centres in 14 distinct regions (Local Health Integration Networks – LHINs) of Ontario (OACCAC, 2011). To be eligible for entry to a LTCH

an individual must be at least 18 years old, insured under the Ontario Health Insurance Plan (OHIP), and require either (a) 24-hour access to nursing care, (b) assistance with ADLs at frequent intervals throughout the day or (c) constant supervision to ensure safety and well-being (OACCAC, 2011).

Whether individuals meet criteria (a) through (c) is determined by their Resident Assessment Instrument (RAI) Score. A RAI Score is the sum of individuals' scores on validated scales that measure independence in ADLs and instrumental ADLs, cognitive performance, mortality risk and health resource needs (OACCAC, 2011). Once deemed eligible, individuals are ranked on a waiting list for up to five LTCHs in Ontario selected by applicants and their families. These LTCHs prioritize entry for older adults with high levels of need (as defined above) and inadequate community resources to help them (OACCAC, 2011). This process is detailed elsewhere (OACCAC, 2011).

2.1.1 Disability and complexity are the norm in Ontarian and Canadian LTCH residents

The emphasis on disability and high need in LTCH eligibility criteria is reflected in the characteristics of Ontario LTCH residents, of whom 93% have multimorbidity, 62% have Alzheimer's disease or other dementias, 33% have a psychiatric diagnoses and 90% have disability (OLTCA, 2014). The Ontario LTCH population is fairly representative of Canadian LTCH residents, who are 85 years old on average, mostly female, multimorbid with high prevalence of dementia and disability (Hirdes, Mitchell, Maxwell, & White, 2011; CIHI, 2013; McGregor & Ronald, 2011). Concomitant with Ontario's recent investment in resources to facilitate aging at home and delay LTCH entry, older adults being admitted to LTCHs today are significantly more disabled and medically complex than those admitted as recently as five years ago (OLTCA, 2014). A similar trend has been observed across Canada, where the level of disability and multimorbidity among LTCH residents has increased significantly over the past decade (McGregor & Ronald, 2011).

2.1.2 Comparability of Ontarian versus American LTCH residents

Ontario LTCH residents are fairly similar to American long-stay nursing home residents (Gillen, Spore, Mor, & Freiberger, 1996; McGregor & Ronald, 2011). Long-stay nursing home residents tend to be multimorbid women, older than 80 years of age, with mobility limitations and moderate disability; similar to Ontario LTCH residents, they are unlikely to be discharged home once they are admitted (Kaye, Harrington, & LaPlante, 2010; Quagliarello et al., 2005). This is an important distinction from older American adults who require short-stay skilled nursing care (e.g. 30 to 90 days following a hospitalization) and are cared for in US skilled nursing facilities alongside long-stay residents. In Ontario, older adults with comparable short-stay care needs are housed in Complex Continuing Care hospitals (OMHLTC, 2014), while extensive home care services are used meet similar short stay complex needs in other Canadian provinces. Thus, findings from studies of LTCH residents in Ontario are generalizable to long-stay nursing home residents in the US, but not short-stay residents.

2.2 Funding of Long-Term Care in Ontario

Providing constant care for older adults with disability is expensive. In contrast with hospital and physician care, which falls under the universality clause of the Canada Health Act, the amount of public coverage for LTCHs is determined by individual provinces and territories (Canada Health Act, 1984). In Ontario, the Ministry of Health and Long-Term Care (MOHLTC) heavily subsidizes costs for 628 LTCHs; in 2014, $3.9 billion Ontario tax dollars (7.8% of the provincial health budget) was used to fund LTCHs (Berta, Laporte, & Wodchis, 2014; OLTCA, 2014). Each of the 14 Ontario LHINs is responsible for distributing provincial (MOHLTC) money to all publicly-funded health care organizations (including LTCHs) in each region. In Ontario, LTCHs receive standardized public funding per resident, per diem (~$137) in four separate “envelopes”: (**1**) Nursing and Personal Care (~$91), (**2**) Program and Support Services ($11), (**3**) Raw food ($8) and (**4**) Other accommodations ($27) (OMHLTC, 2011). All residents are covered by the same base funding per diem in each envelope, except for Nursing and Personal Care, which is case-mix adjusted for each resident (OMHLTC, 2011).

Case-mix is determined from each resident's Resource Utilization Group (RUG), calculated quarterly in Ontario using the Resident Assessment Instrument Minimum Data Set (RAI-MDS). The RAI-MDS is a standardized, multidimensional assessment tool used to classify LTCH residents into one of 34 RUG groups based on their clinical condition, physical and cognitive function and past-14 day treatment (CIHI, 2014a, 2014b). Residents with higher disability scores (based on degree of dependence in seven ADLs) are classified into more heavily reimbursed RUG groups (OMHLTC, 2011).

Thus, LTCHs receive more funding per capita from the MOHLTC to care for older adults with more disability; they also lose MOHLTC funding if they report improvements in their residents' disability scores. At the end of each fiscal year, any unspent funds in any of the previously described envelopes must be returned to the MOHLTC. LTCHs are only able to keep profits from residents' "other accommodation" funding envelope, including amounts paid by the MOHLTC and additional amounts paid privately by residents at a provincially standardized rates ($56.93 per diem for basic accommodation) (OLTCA, 2014). In most Canadian provinces other than Ontario the amount of co-pay is income-adjusted, whereas Ontario's rate is uniform except among low-income individuals for whom it is waived (McGregor & Ronald, 2011). Residents who wish to live in semi-private or private rooms in publicly funded LTCHs must pay a higher per diem rate (~$64-81), the profits of which can also be kept by LTCHs (OLTCA, 2014).

2.2.1 Comparison to LTCH Funding in the US

The minimum proportion (~30%) of LTCH costs paid for out-of-pocket by Ontario LTCH residents is comparable with the average across other Canadian provinces (CIHI, 2005), and slightly more than the 22% of expenses paid out-of-pocket by Medicaid LTCH residents (Kaye et al., 2010; Miller & Nadash, 2014). This may be somewhat balanced out by the higher per diem public funding ($172 per diem) American nursing homes receive per resident (Kaye et al., 2010). In the US, state-funded Medicaid pays for most (>60%) long-term nursing home services for older adults, whereas federally-funded Medicare covers the majority of hospital services and short nursing home stays (30-90 days) for this group (Grabowski, Stewart, Broderick, & Coots, 2008). Similar to Canada, disability measured using the RAI-MDS is a key determinant of

Medicaid and Medicare LTCH reimbursements in the US (Arling, Kane, Lewis, & Mueller, 2005; OMHLTC, 2011).

2.2.2 Summary

From a public payer (MOHLTC) perspective, slowing disablement among Ontario LTCH residents is desirable. Beyond the direct resident benefits of minimizing disability, the cost of LTCHs for the MOHLTC would be reduced if residents' disablement could be delayed or prevented. These monetary stakes are high. For example, a report by Wodchis et al found that if LTCH costs alone were reduced by 10% in the most costly 1% of Ontarians, $177 million could be saved per annum (Wodchis, Austin, Newman , Corallo, & Henry, 2012). These fiscal concerns related to long-term care are global: a recent Organisation for Economic Co-operation and Development survey of 28 countries found that more than half of these countries identified "ensuring fiscal and financial sustainability" among their chief goals for the long-term care sectors in their countries (OECD, 2011). The financial incentive for reducing disability among LTCH residents is clear.

2.3 Delivery of Long-Term Care in Ontario

Province-wide comparisons show that although residents in Ontario LTCHs experience disablement at a rate of 36% per year, residents in some Ontario homes had rates as low as 22% (Hirdes et al., 2011). This variation across LTCHs suggests that there may be LTCH-level factors that affect disablement. Estimates from studies in American LTCHs indicate that between 8% and 25% of the variation in LTCH residents' disablement is attributable to characteristics of LTCHs (Phillips, Chen, & Sherman, 2008; Phillips, Shen, Chen, & Sherman, 2007), however these studies have not been replicated in the Ontario context. The proceeding sections summarize and compare Ontario's LTCH delivery mechanisms to those in other settings.

One of the most discussed features of long-term care delivery associated with resident outcomes is ownership status, which can be broadly separated into for-profit versus not-for-profit. Not-for-profit LTCHs in Ontario are municipally owned, attached to acute care hospitals, or owned and operated by religious or community groups; in these facilities excess revenues are retained by

LTCHs and can be spent on home resources (i.e. staff hours, food), resident care, or other LTCH costs (McGregor & Ronald, 2011). In for-profit LTCHs (small privately-owned facilities and large corporate chains), excess revenues are distributed among owners or shareholders (McGregor & Ronald, 2011). In Canada the proportion of for-profit LTCHs is increasing and 57% of Ontario LTCHs are operated on a for-profit basis (Berta et al., 2014; Defending Public Healthcare, 2014). Per diem provincial funding to LTCH residents is the same in Ontario, regardless of whether an LTCH is for-profit or not-for-profit (McGrail, McGregor, Cohen, Tate, & Ronald, 2007). The relatively high level of for-profit long-term care delivery in Ontario renders this province the most comparable to regions in the US, in which approximately 70% of Medicaid-funded long-stay (>90 day) nursing home beds are operated on a for-profit basis (Hirth, Grabowski, Feng, Rahman, & Mor, 2014; Kaye et al., 2010).

Many studies have sought to determine whether for-profit versus not-for-profit LTCH ownership affects resident outcomes. In their systematic review of 38 North American studies published between 1990 and 2002, Hillmer et al found that quality was lower in for-profit LTCHs, but that the relationship between profit status and quality of care was strongest in the lowest quality studies and tenuous in more rigorous studies (Hillmer, Wodchis, Gill, Anderson, & Rochon, 2005). In their meta-analysis of 82 studies published from 1962 to 2003, Comondore et al concluded that not-for-profit homes deliver higher quality care but that selection bias cast some doubt on these associations (Comondore et al., 2009). Findings from other studies suggest that overall quality in LTCHs may be affected by ownership type via mechanisms (e.g. staffing hours per resident) that vary across contexts (Berta, Laporte, & Valdmanis, 2005; Hillmer et al., 2005; M. J. McGregor et al., 2005). Evidence is needed to understand whether ownership type affects disability and disablement, particularly in a Canadian context.

2.4 Accountability Structures in Ontario Long-Term Care

Despite the differences in disability and other health outcomes seen across LTCHs, individual homes are not held financially accountable for many of these outcomes in Ontario. All LTCHs in Ontario are governed under the Long-Term Care Homes Act (LTCHA), which came into force in July 2010 (OMHLTC, 2010). The LTCHA contains over 600 regulations for LTCHs in Ontario,

some of which relate to residents' disability outcomes. According to the LTCHA, all residents must be assessed using the RAI-MDS within 14 days of admission and a personalized plan of care must be developed within 21 days of admission (OMHLTC, 2010). Disability assessment at admission and strategies for minimizing disablement should be a key part of this care plan, according to the LTCHA (OMHLTC, 2010).

Each LTCH is to be held accountable for their adherence to the LTCHA by one of the 14 LHINs that distribute MOHLTC funding to LTCHs in their regions. MOHLTC staff may perform unannounced quality audits in each LTCH; those that do not meet safety minimums identified in the LTCHA will be sanctioned by their LHIN with a hold on new admissions. LHINs are also able to set performance targets for LTCH quality indicators as part of Long-Term Care Home Service Accountability Agreements (L-SAAs) (Berta et al., 2014), however none of the province's 633 L-SAAs currently measure disablement among residents as a performance metric (L-SAA Steering Commitee, 2013). Thus, although the LTCHA calls for a focus on reducing disability among residents, LTCHs are not held fiscally accountable for residents' disablement.

In contrast with this lack of fiscal accountability, each of Ontario's LTCHs are publicly accountable for quality of care (generally) and (specifically) for their residents' disablement over time. The MOHLTH regularly updates a publicly accessible website with information on ownership type, results of quality inspections, complaints and unmet process of care standards for each publicly funded LTCH in Ontario (OMHLTC, 2008). In addition to these structure and process reports, in 2013 Health Quality Ontario began publicly reporting "percent of residents with increasing difficulty carrying out Activities of Daily Living (over 90 days)" for all LTC residents in the province (HQO, 2014). In June 2015, the Canadian Institute for Health Information added national LTCH data to the *Your Health System* website, which reports the proportion of residents with improved or worsened disability scores over a 90 day period for each LTCH in Ontario (CIHI, 2015). LTCH-level disability outcomes on the *Your Health System* website are also compared to those outcomes achieved in other LTCHs owned by the same provider, as well as those in the same LHIN and across the province (CIHI, 2015).

2.4.1 Comparison to Accountability Structures in the US

Comparison of Ontario and Canadian LTCH accountability structures to American ones is informative because American systems have experimented with more stringent approaches than those used in Canada. In the US, the Omnibus Budget Reconciliation Act (OBRA) of 1987 mandated that nursing home residents attain and maintain their highest level of function (Hawes et al., 1997). In response, some state Medicaid programs have introduced financial incentives to reduce LTCH residents' disablement (White et al., 2006). The effect of these financial accountability programs has been lackluster (Bellows & Halpin, 2008; Werner, Konetzka, & Polsky, 2013). In terms of public accountability, the Centers for Medicare and Medicaid Services has a national LTCH reporting system (Nursing Home Compare Website), on which staffing levels, complaints history and quality indicators are available for all publicly funded LTCHs. Disablement among an LTCH's residents is one of the quality indicators reported on the site (Phillips et al., 2008).

2.5 Summary

Implicit in public reporting and LTCH financial penalties for residents' disability outcomes is the assumption that disablement in LTCH residents is significantly related to LTCH-driven interventions. Whether or not LTCHs should be individually held responsible for residents' disablement is heavily dependent on the extent to which LTCH characteristics (versus individual resident characteristics) explain variation in disability. To date, no Canadian studies have examined this and existing studies from abroad may not apply given differences in regulatory oversight and the single payer environment in Ontario. Given that some provinces (e.g. Ontario, British Columbia) now publicly report disability outcomes for individual homes and compare them to others (CIHI, 2015), the role of home-level characteristics (versus resident characteristics) in affecting resident disability requires clarification.

3 Conceptual Framework

3.1 Framework Considerations

Three conceptual frameworks were considered to guide this dissertation: The Disablement Process Model (DPM) (Verbrugge & Jette, 1994), the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001) and the Conceptual Model of Independence and Dependence for Adults with Chronic Physical Illness and Disability (Gignac & Cott, 1998). A major consideration when selecting a framework was its uptake and usage among disability and disablement researchers. The DPM and ICF outperformed Gignac and Cott's framework on this measure, with more than 1,500 and 6,900 Scopus citations respectively, compared with 89 for the Model of Independence and Dependence. A strength of Gignac and Cott's framework is its inclusion of subjective perceptions and other relevant psychosocial determinants of disability; however it is more visually complex than the ICF and DPM and does not include constructs for biological causes of disability (e.g. chronic conditions, geriatric syndromes), which were key constructs in this dissertation. Based on these considerations and its relatively low citation count, the Model of Independence and Dependence for Adults with Chronic Physical Illness and Disability was not used as a conceptual framework in this study.

The ICF is more heavily cited than the DPM, however the DPM was selected to guide this study for several reasons. First, the visual depiction of the DPM is "disablement skewed," with arrows and constructs moving in the direction of increasing disability. In contrast, the ICF is "reablement skewed" with constructs such as "activity" and "participation" as outcomes in the visual depiction of the framework. Although this positive skewing is makes sense in populations for whom "reablement" is the most likely outcome, it confuses analyses in older adults, or whom the rate of onset of disability typically exceeds the rate of complete recovery (Wolinsky, Armbrecht, & Wyrwich, 2000). Second, other researchers have noted that there are ambiguous distinctions between ICF constructs for activity and participation (Jette, 2006; Masala & Petretto, 2008) and these ICF outcome terms have not been incorporated into indexing terms or thesauri of major search engines (Schaefer, 2015), making synthesis of evidence guided by this framework more difficult. Third, while the DPM offers these conceptual and practical advantages over the ICF, many of the constructs identified in the ICF are the inverse of DPM

constructs (Jette, 2006; Thyberg, Arvidsson, Thyberg, & Nordenfelt, 2015). Thus although the DPM was selected to guide this dissertation, findings of this work could readily be understood and applied in the context of the ICF.

3.2 The Disablement Process Model

This dissertation will use Verbrugge and Jette's Disablement Process Model (DPM) (1994) to examine the determinants of disability and disablement among older adults (Chapter 2) and LTCH residents (Chapters 3 and 4). Published in 1994, the DPM builds on concepts proposed by Nagi (1965) and the International Classification of Impairments, Disabilities and Handicaps (WHO, 1980). It identifies a pathway through which pathologies lead to impairments, then limitations in functional capacity and ultimately disability in the context of people's social and physical world (Verbrugge & Jette, 1994). The terms used to describe constructs in the DPM are defined alongside examples for the purpose of this dissertation in Table 1.2. Definitions and examples provided for pathology, impairment, functional limitation, extra-individual factors and intra-individual factors are congruent with those in the original DPM paper (Verbrugge & Jette, 1994). There was an additional "risk factors" construct in the original DPM, however because all of the risk factors were also intra-individual factors these categories were collapsed in this study, with the understanding that they may affect the disablement process at any stage, including its initiation.

Table 1.2: Disablement Process Model definitions used this Dissertation

Term	Definition	Examples
Pathology	Biochemical and physiological abnormalities that are detected and medically labeled as disease or injury.	
	Sub-clinical pathology: detectable biochemical and physiological abnormalities not associated with impairment.	- hypocholesteremia - reduced cardiac ejection fraction
	Acute pathology: Short-term diseases and injuries, usually lasting three months or less.	- fall - delirium - lower respiratory tract infection
	Chronic pathology: Progressive diseases, injuries with chronic	- arthritis

Term	Definition	Examples
	sequelae, and enduring structural/sensory abnormalities	- chronic obstructive pulmonary disease - heart failure
Impairment	Dysfunction and significant structural abnormalities in specific body systems that have consequences for physical, mental or social function.	- cognitive impairment - chronic pain - visual impairment
Functional limitation	Restrictions in performing physical and mental actions used in daily life by one's age-sex group. Refers to individual capability without reference to situational requirements.	Difficulty performing any of following actions: - walking specified distances - lifting objects of specified weight - climbing stairs
Disability	Difficulty with or dependence on others to conduct activities of daily living (ADLs), measured at a single point in time.	Difficulty with or dependence on others to conduct ADLs such as: - bathing - dressing - transferring from bed to chair - toileting - grooming - feeding
Disablement	Intensifying disability over at least two time points.	Requiring additional assistance to conduct – or becoming newly dependent in – one of the self-care ADLs above.
Extra-Individual factors	Factors that operate outside or external to a person and affect the Disablement Process. Can be grouped into one of the following categories:	
	Medical care and rehabilitation	- surgery - physical therapy
	Medications and other therapeutic regimens	- drugs taken - recreational therapy
	External supports	- receipt of personal assistance e.g. meals on wheels - use of special equipment and devices
	Built physical and social environment	- structural modification at home - health insurance and access to medical care - laws and regulations
Intra-Individual Factors	Factors that operate within a person and affect the Disablement Process. Can be grouped into one of the following categories:	
	- Demographic characteristics - Biological attributes - Lifestyle and behavioral factors	- age, sex, race - genetics - smoking, physical activity

Term	Definition	Examples
	- Psychosocial attributes	- beliefs, religiosity, socioeconomic status

This conceptual framework will be operationalized with a literature review in Chapter 2, and then used to guide empirical studies in Chapters 3 and 4. A strength of this framework is that it is readily understood and heavily used in research on disability and disablement.

3.3 Other Conceptual Frameworks Considered for this Dissertation

4 Rationale for Three Studies and Relevance to Research, Policy and Practice

In 2012, 34.3% of LTCH residents in Ontario experienced disablement over a 90-day period (HQO, 2014). When older adults experience disablement, their quality of life decreases and their costly health service use increases. There has never been a more critical time to examine the determinants of disability and disablement in LTCH residents. Old age and multimorbidity are strongly associated with disablement (Li, 2005a, 2005b), which in turn is one of the strongest independent predictors of admission to a LTCH (Branch & Jette, 1982; Challiner, Carpenter, Potter, & Maxwell, 2003; Cohen, Tell, & Wallack, 1986). As the population ages and the prevalence of multimorbidity increases over time (Barnett et al., 2012; Fortin, Hudon, Haggerty, Akker, & Almirall, 2010; Starfield, 2011), Canada and countries with similar demographic profiles can expect a surge in the number of individuals who are disabled and require constant care (Hirdes et al., 2011; Hung, Ross, Boockvar, & Siu, 2011; Koller et al., 2014; Nihtilä et al., 2008; OECD, 2011). Paired with shrinking family size and growing participation of females in the labour market, the demand for long-term care is anticipated to rise dramatically in coming decades (OECD, 2011). In Canada, an additional 120,000 LTCH beds will be required by 2041 (McGregor & Ronald, 2011). Forecasts done in the US and Europe suggest a doubling of need for LTCH beds in these regions over the next 40 years (European Commission, 2008; U.S.

Department of Health and Human Services, 2003). In this context, the findings from this dissertation are relevant to research, policy and practice as described below.

Findings from these studies are relevant to older adults and the clinicians who care for them, researchers, and policy-makers. Study 1 fills an important gap in the cycle of theory-driven knowledge generation. By operationalizing a heavily used conceptual framework with up-to-date evidence, it provides disability researchers with a framework for structuring variable measurement and analyses. It also identifies gaps in what we know about disability in older adults, in terms of how we measure exposures and disability outcomes, and the populations that they have been studied in. These outputs can be used to identify fruitful avenues of future disability research and inform rigorous study design. The downstream effects of research informed by Study 1 would be experienced by older adults, clinicians and policy-makers.

Study 2 has important implications for health policy-makers who regulate long-term care and organizations who publicly report LTCH outcomes. By estimating the proportion of variation in resident disability attributable to resident versus LTCH characteristics it provides much needed insight on the appropriate locus of accountability for this resident outcome. Study 2's examination of age, sex and cognition effects on geriatric syndromes' and chronic conditions' association with disability is also important to inform future longitudinal studies.

Study 3 is the most clinically relevant of the three studies and its findings will benefit frontline care providers in LTCH as well as residents themselves. It examines the course of disablement in LTCH residents from the time they are admitted to two years later. It also tests whether rate of disablement is different for residents admitted to LTCH with high versus low disability, and whether balance impairment, severe cognitive impairment and severe pain are predictors of faster disablement over two years after adjusting for confounders. Study 3 will examine important differences between cross-sectional correlates of disability versus markers for disablement over time. These findings can be used to inform targeting of interventions to slow disablement in those LTCH residents most likely to benefit.

Chapter 2
Operationalizing the Disablement Process Model for Empirical Research

5 Abstract

Purpose of the study: Self-care disability is difficulty with or dependence on others to conduct activities of daily living, such as bathing, eating and dressing. Disablement is worsening self-care disability measured over two or more time points. The Disablement Process Model (DPM) is often used to conceptualize research on disability and disablement, however its application to study design and analysis has been inconsistent. This study presents an evidence-based analytic framework that operationalizes relationships between disability and disablement with variables in the DPM.

Design and methods: The DPM was used as a framework to summarize findings from a critical literature review of factors associated with disability or disablement. Searches and study appraisals were done iteratively and stopped when they ceased to yield studies that suggested new variables or levels or measurement in a DPM-based analytic framework. An analytic framework for DPM-guided research on disability in older adults was developed concomitantly. Methodological limitations of existing studies were identified and guidance for future research was proposed.

Results: Of 94 reviewed studies, 56 of them studied community-dwelling older adults, 26 studied residents of long-term care or nursing homes and 12 studied a mix of older adults from both settings. We present an analytic framework for the relationships between intra- and extra-individual characteristics, pathologies, impairments, functional limitations and disability. This framework is organized by three levels of measurement, alongside example variables identified from empirical studies to measure DPM constructs.

Implications: Researchers studying disability or disablement in older adults can use this research summary and analytic framework to sharpen the focus of research questions asked in systematic reviews, or to operationalize the DPM for further empirical research.

6 Introduction

Older adults with disability experience more hospitalizations (Kruse et al., 2013), have higher health care costs (Lindholm et al., 2013; Perrin et al., 2011) and report lower quality of life (Andersen, Wittrup-Jensen, Lolk, Andersen, & Kragh-Sorensen, 2004; Covinsky et al., 1999; Lam & Wodchis, 2010). Delaying the onset and progression of disability could thus improve older adults' quality of life while reducing health system costs. A conceptual framework of the factors that lead to disability can help achieve these patient and system outcomes by guiding intervention design and informing important analytic choices in research (Johnston & Dixon, 2014). Verbrugge and Jette's Disablement Process Model (DPM) (1994) is an example of one such conceptual framework that has received more than 1,500 citations since its publication in 1994 (Appendix 2.1).

6.1 Role of the DPM in the Cycle of Theory-Driven Knowledge Generation

The DPM is necessary but not sufficient to guide the next generation of disability research. Scientific journal editors increasingly require that authors place empirical studies in the context of existing evidence summarized in a systematic review or meta-analysis (Clark & Horton, 2010); however the application of a conceptual framework to a systematic review is rarely direct when questions go beyond the effectiveness of a specific intervention (Mays, Pope, & Popay, 2005). Using examples from DPM-motivated disability research (Gitlin, 2003; Marquardt et al., 2011; Verbrugge & Jette, 1994; Wahl, Fange, Oswald, Gitlin, & Iwarsson, 2009; Wahl, Iwarsson, & Oswald, 2012), we identify a five-stage research cycle (*Figure 2.1*) through which theory-driven knowledge generation is conducted in fields with extensive existing literature. As illustrated in *Figure 2.1*, a conceptual framework such as the DPM needs to be operationalized with a preliminary critical review (Grant & Booth, 2009) prior to its application to either a systematic review of a narrow research question or – pending the adequacy of evidence identified – further empirical research. Existing critical reviews have examined components of the DPM related to the effects of physical activity (Keysor, 2003) and home environments

(Gitlin, 2003), however these reviews have fallen short of operationalizing the person-level DPM constructs (e.g. demographic factors, pathologies) that could inform targeting of future interventions to slow or prevent disablement.

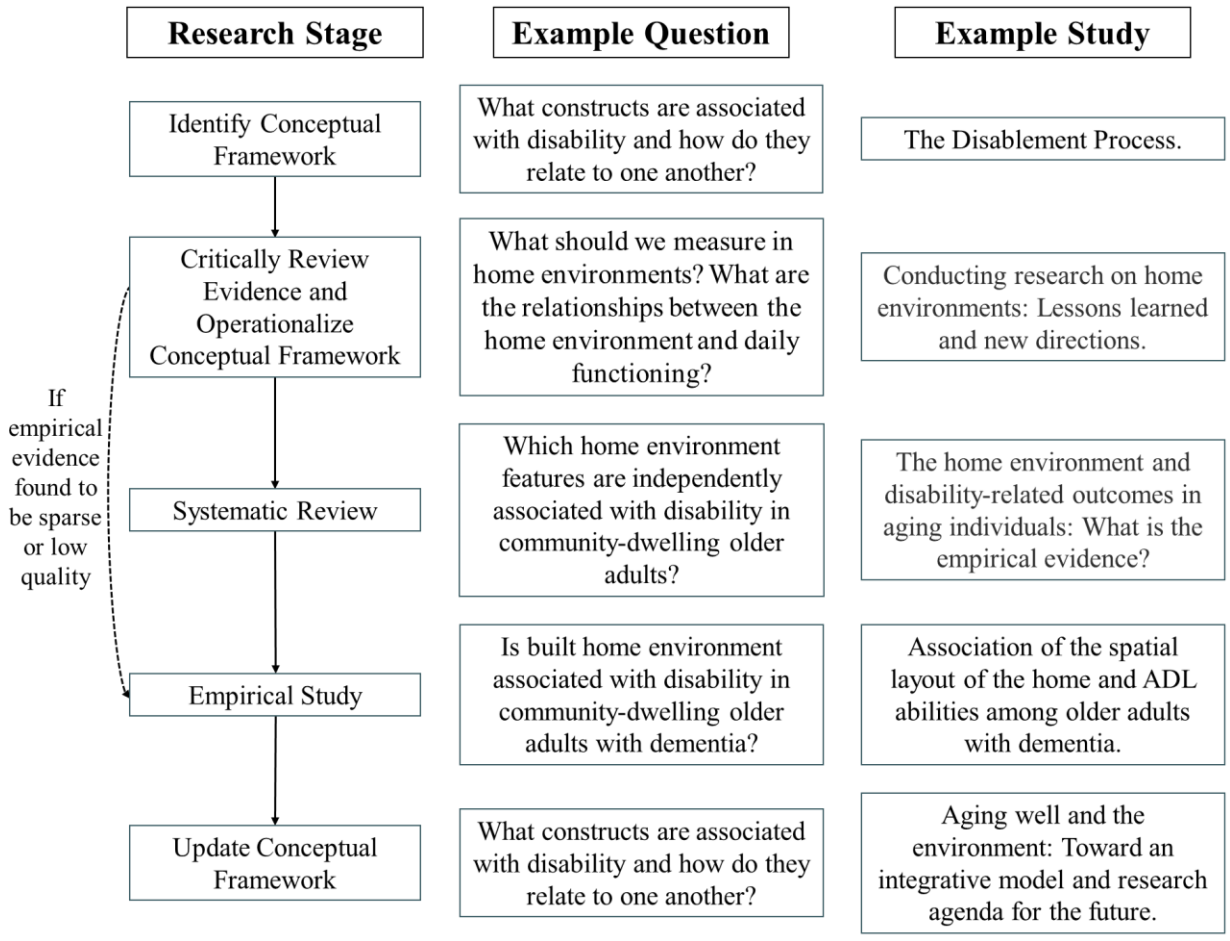

Figure 2.1 Five-Stage Cycle of Theory-Driven Knowledge Generation

Some current uses of the DPM in research are also theoretically and empirically inconsistent. The DPM was originally developed to conceptualize "the trajectory of functional consequences over time and the factors that affect their direction, pace and patterns of change" (Verbrugge & Jette, 1994), but it is used extensively in cross-sectional studies of disability. A synthesis of empirical evidence for this extended conceptualization of the DPM has yet to be undertaken. Another conceptual issue arises from the DPM's grouping of factors external to individuals that affect disablement into one construct, without consideration for the different levels (e.g. person,

provider) at which these constructs should be measured. The DPM is also commonly used to rationalize the measurement of select constructs in research while other constructs in the model are unmeasured without mention.

6.2 What this Study Adds

To facilitate the application of the DPM in theory-driven knowledge generation (*Figure 2.1*), we undertook a critical review (Stage 2 of *Figure 2.1*) with two aims:

- Our first aim was to summarize a comprehensive body of research on disability in the context of the DPM, from which methodological limitations and pragmatic guidance for future research were identified. This summary includes information on DPM constructs and disability measured at one time point, to examine the evidence for extension of the DPM to cross-sectional studies.
- Our second aim was to use this research summary to develop an analytic framework for application of the DPM to disability research in older adults. Recommendations on variable measurement and modelling of relationships between constructs in the DPM and disability are made alongside this analytic framework to aid in the consistent application of the DPM.

Gerontology researchers studying disability and disablement in older adults can use this research summary and analytic framework to sharpen the focus of research questions asked in systematic reviews on disability, or to operationalize the DPM for further empirical research.

6.3 Overview of Key Disablement Process Model Concepts

Prior to populating it with empirical evidence, the key concepts and definitions from the DPM were reviewed (See Chapter 1, Section 3) and summarized in Table 1.2. According to the DPM, disability is the interaction between functional limitations and a persons' context; it encompasses dependence on others for ADLs, instrumental ADLs (e.g. household chores, grocery shopping), mobility, social and occupational roles (Verbrugge & Jette, 1994). ADL disability is the most frequently assessed form of disability in older adults (Yang, Ding, & Dong, 2014) and also our

primary outcome of interest based on its prevalence and impacts. In a preliminary review of the literature, we determined that the pathologies, impairments, intra- and extra-individual factors associated with one type of disability (e.g. instrumental ADLs) were not interchangeably associated with other types of disability (e.g. self-care disability) (Jackson et al., 2015). To create an analytic framework that linked specific constructs with a specific outcome, our definition of disability was therefore limited to self-care disability, in contrast with the broad definition used in the DPM. The "chronic pathologies" construct included "chronic conditions" defined as "illnesses lasting six months or more, including past illnesses requiring continuous care, diseases with risk of recurrence or previous health problems that continue to affect health management (Kernick, 2012)." The "impairments" construct included "geriatric syndromes," defined as "a collection of signs and symptoms common in older residents but not necessarily fitting into discrete disease categories (Chen, Yen, Dai, Wang, & Huang, 2011). Several other definitions of geriatric syndromes were considered (Appendix 3.3), all of which use the term "syndrome" to represent specific phenomenologies arising from multiple morbid processes (Flacker, 2003). This use of the term "syndrome" differs from the traditional medical meaning of multiple phenomenologies arising from a specific morbid process (Flacker, 2003). We also distinguish between "disability" – a measure of self-care disability one point in time – and "disablement" which indicates intensifying disability measured over at least two points in time. The "disablement process" refers to the process through which pathologies, impairments, functional limitations and intra- or extra-individual factors lead to disability or disablement.

7 Methods

7.1 Study Search and Appraisal

The aim of the search phase of a critical literature review is to identify the most significant items in a given field (Grant & Booth, 2009). To achieve this goal, we searched Medline and Google Scholar using combinations of MeSH terms, keywords and commonly used synonyms for disability, determinants and populations (Table 2.1).

Table 2.1: Summary of Search Terms Used in Study 1

	Disability	Determinants	Population
MeSH Terms	- Activities of daily living	- Risk Factors	- Long term care - Independent living - Homes for the Aged
Keywords	- disability - functional limitation - disablement - functional capacity - Activities of daily living - ADL	- determin* - risk - predict* - associat*	- community - nursing home

Reference lists of original studies were searched and Scopus was used to identify studies that had cited key manuscripts, such as Verbrugge and Jette's Disablement Process paper. Searches were not limited to specific Medline-defined age group categories but only those studies focused on older adults (aged 50 and up) were eligible for inclusion. Studies were excluded if they met any of the following exclusion criteria:

(1) Not an original quantitative study of variables independently associated (Brotman, Walker, Lauer, & O'Brien, 2005) with either disability or disablement, as defined in Table 1.2.

(2) Did not have a comparator group.

(3) Did not define the activities assessed in measures of disability, or cited inaccessible articles for descriptions of activities.

(4) Published after June 30, 2015, or in a language other than English.

Studies published between inception and June 30th, 2015 that combined eligible and ineligible measures of disability (i.e. outcome scales of combined ADL and IADL dependence) were included.

In keeping with the appraisal criteria of a critical literature review (Grant & Booth, 2009), our study search and appraisal was guided by a theoretical sampling approach (Mays et al., 2005): studies that met the inclusion criteria were included in the full review based on the insight they provided into a variable or level of measurement for a DPM construct; there was no formal study quality assessment. Because our goal was to identify common measures of given constructs (rather than draw conclusions about the presence or absence of specific variable relationships),

searches and appraisals were done iteratively and stopped when they began to yield studies that suggested no new variables or level or measurement in a DPM-based analytic framework. Studies of clinical interventions that could be (or already were) synthesized in a systematic review were not included (e.g. (Crocker, Young, et al., 2013)), as this evidence is at a more advanced stage (*Figure 2.1*) than targeted by this critical review.

7.2 Synthesis and Analysis of Study Findings

Our synthesis goal was to create an analytic framework and provide examples of measures of each construct to sharpen future research questions about disability and disablement in older adults. We summarized the following information for each included study (where applicable) in Appendix 2.2: lead author name, country, year of publication, sample size, sample's location of dwelling (community, nursing home, mix of both), measure of disability (or disablement), and which variables were independent predictors of disability outcomes in the study. Variables within studies were further identified by superscript letters to indicate whether they were: (a) exposure variables identified *a priori* by study authors, (b) adjustment variables or (c) part of a predictive model or of an unspecified role. We then synthesized these findings within the constructs identified in the DPM (Appendices 2.3 through 2.8), noting the number of studies that measured each variable (e.g. "respiratory infection"), the proportion of studies done in different settings (e.g. "nursing home") and whether or not studies supported an independent association between the variable and disability, disablement (measured in pre-post study) or disablement (measured over two or more time points). Appendix 2.9 summarizes the frequency of different measures of disability in reviewed studies.

In keeping with our goal of learning about variables used to measure various DPM constructs, a final synthesis step saw the combination of variables and the DPM constructs they measured into Tables 2.2 and 2.3. These tables only contain variables that at least one included study found was associated with disability or disablement. To facilitate extension of the DPM to cross-sectional studies, these tables also highlight the proportion of studies that measure each broad type of DPM construct in association with disability (measured at one time point) or disablement (measured longitudinally), as well as the proportion of studies examining that type of DPM

construct as an exposure, adjustment, or unspecified variable. To examine the distribution of included evidence across settings, the proportion of evidence for each association from studies done in community or nursing home settings was also recorded. We defined a nursing home as a home for elderly people in which most residents require daily nursing care (Comondore et al., 2009). This definition of nursing homes included "skilled nursing facilities," but excluded rehabilitation hospitals in which patients were admitted briefly due to their need for daily rehabilitation services. Study populations that included individuals from a combination of community, nursing home or hospital dwellings were classified as "mix."

We developed the *Analytic Framework for Application of the Disablement Process Model in Older Adults (Figure 2.2*) concomitantly with the synthesis steps described above. We identified levels of measurement for the analytic framework based on studies that found relationships between variables measured at those levels and disability or disablement in older adults. Tables 2.2 and 2.3 contain examples of variables that included studies used to measure DPM constructs at the levels indicated in *Figure 21*.

8 Results

8.1 Characteristics of Critically Reviewed Studies

Of 94 critically reviewed studies, 56 of them studied community-dwelling older adults, 26 studied residents of nursing homes and 12 studied a mix of older adults from the community or nursing homes, some of whom were hospitalized. The majority of studies (65/94) examined variable relationships with disablement over two or more points of time, while 22 studies examined independent associations with disability measured at one point in time. Only seven studies reported variable associations with both disability and disablement. Of the 72 studies that included longitudinal assessments of disablement, 49 considered only two measures (i.e. pre- and post) of disability, while 23 measured disablement over at least three time points. Appendix 2.2 contains detailed information extracted from each of the 94 included studies, including those variables *not* associated with disability or disablement in adjusted analyses. Details from our critical review on the association of DPM variables with disability and disablement can be found

in Appendices 2.3 through 2.8. Our findings suggest that variables associated with disablement (measured longitudinally) also tend to be associated with disability (measured at one time point), however contradictory findings for the independent association of variables with disability and disablement were extremely common: for example, Appendix 2.3 shows that 10 studies found cardiovascular disease was positively associated with disability and disablement, while six studies found no such association. These inconsistent findings across individual studies support the need for systematic reviews to inform empirical research, as indicated in *Figure 2.1*.

8.2 Analytic Framework for Application of the Disablement Process Model in Older Adults

Based on our critical literature review, we developed an analytic framework (*Figure 2.2*) to operationalize the DPM variables contained in Table 1.2 for application to research in older adults. This framework bears a resemblance to Verbrugge and Jette's original model (Verbrugge & Jette, 1994) with several important distinctions. First, this framework is organized by three levels of measurement for different DPM constructs, with suggested construct measures from empirical studies identified in Tables 2.2 and 2.3. This nested structure makes important distinctions between extra-individual factors that are measured in individuals, institutions, and geographic areas like cities or states. It also has important analytic implications; observations of individuals' disability within institutions (e.g. nursing homes) should not be considered independent, nor should observations of institutions across geographic areas (e.g. cities, states) with varying built and social environment variables.

Empirical evidence from our critical review also showed that baseline level of disability is independently associated with subsequent rate of disablement (Abizanda et al., 2014; Kruse et al., 2013; Wolinsky et al., 2011). Thus, a second change to the original DPM is the addition of a feedback loop arrow, wherein existing disability and disablement affect likelihood of further disablement. Although our focus was on self-care disability, evidence from included studies suggested that other forms of baseline disability – in instrumental ADLs (Barnes et al., 2013; Clark, Stump, Tu, & Miller, 2012) and mobility (Boyd, Xue, Guralnik, & Fried, 2005) – are independently associated with subsequent disablement. We believe that these associations provide further support for the analytic separation of different types of disability in older adults,

as reflected in the proposed analytic framework. Based on this framework, we recommend that future studies of disablement consider adjustment for baseline levels of disability.

A third property of the analytic framework in *Figure 2.2* is that – similar to the original DPM – it arranges pathology, impairment, functional limitation and disability in sequence. The text of the original DPM manuscript highlights that "existing impairments and disability can also give rise to incident pathologies and impairments which contribute to disablement themselves" (Verbrugge & Jette, 1994). We suggest that this understanding be extended to recognize that constructs within the DPM (as depicted in *Figure 2.2*) likely mediate the relationships between constructs distal to them and disability. For example, the effect of a chronic pathology such as arthritis on disability is likely at least partly mediated by an impairment such as chronic pain. So analyses that adjust for every available data element represented in the DPM are at risk for over-adjustment by controlling for mediating variables. We thus recommend that the analytic

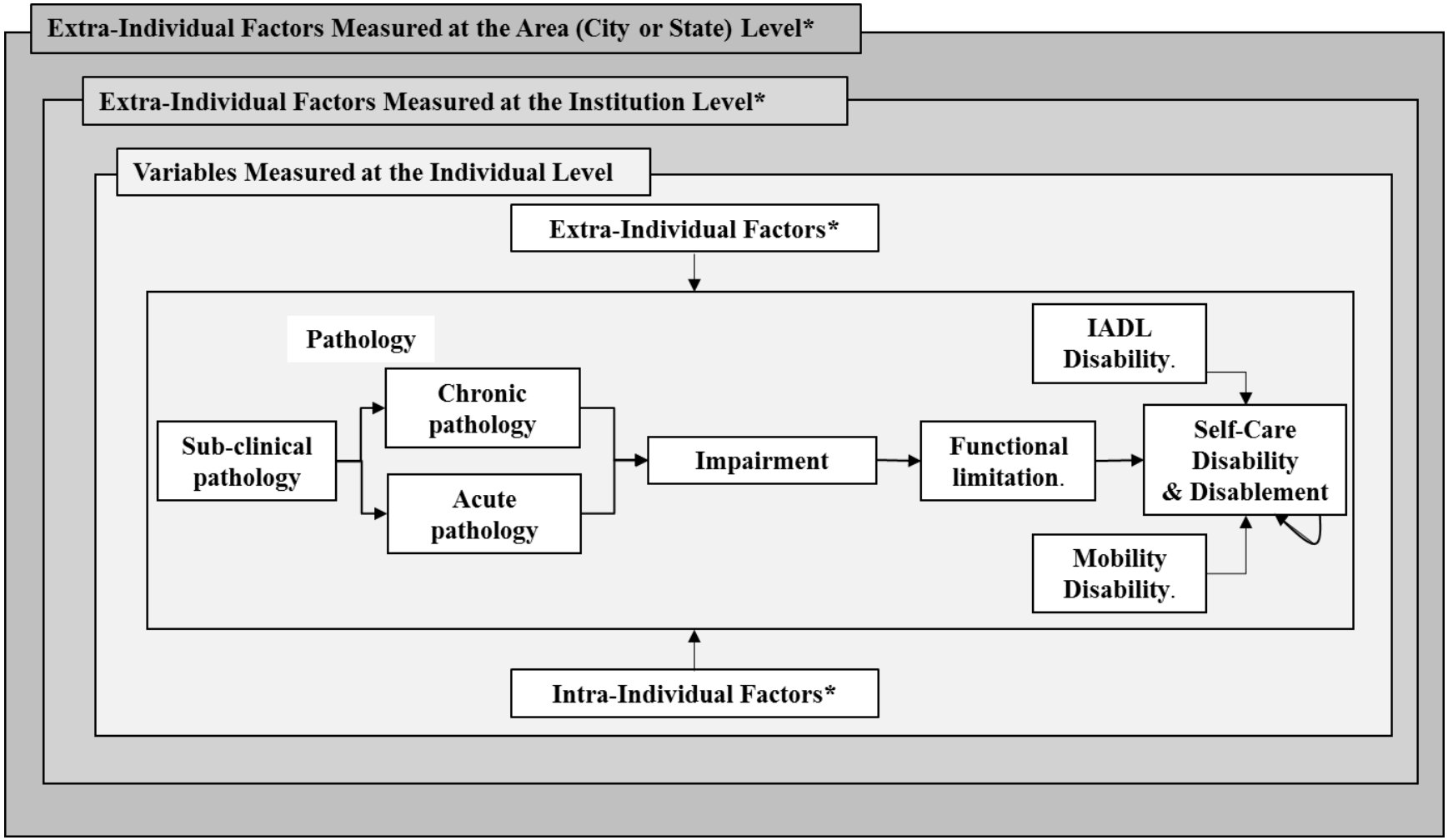

Figure 2.2: Analytic Framework for Application of the Disablement Process Model in Older Adults

* Indicates constructs for which variables specific to nursing home residents have been measured.

framework provided be used as a starting point for causal diagrams of relationships between exposures and disability prior to study conduct.

A fourth noteworthy difference between the original DPM and *Figure 2.2* are the asterisks indicating constructs for which variables specific to nursing home residents should be considered. We found examples of intra-individual factors and extra individual factors measured in individuals (Table 2.2), as well as extra-individual factors measured in institutions and geographic areas (Table 2.3) that are specific to older adults residing in nursing homes. The burden of disability is high in nursing home residents (CIHI, 2013), many of whom continue to experience disablement throughout the course of their stay (Dutcher et al., 2014). By identifying nursing home-specific variables and their level of measurement within the DPM, the analytic framework in *Figure 2.2* provides an important starting point for research in this population.

Finally, our critical literature review identified pathologies, impairments, intra-individual factors and extra-individual factors measured in individuals that may act as effect modifiers, defined as variables that have significant statistical interaction with other exposures in predicting disability outcomes (Kraemer, Kiernan, Essex, & Kupfer, 2008). Verbrugge and Jette (1994) similarly described “exacerbators” in the DPM as interventions gone awry, maladaptive behavioural responses to disability and societal barriers for people with disability that might prompt or maintain dysfunctions (Verbrugge & Jette, 1994), however they did not elaborate on the analytic implications of exaberbators, or how to distinguish between mediators and moderators within this category. Effect modifiers create alternate versions of the disablement process for older adults in whom they are present, thus distinct versions of *Figure 2.2* should exist for each level of effect modifying variables. In contrast, mediators are responsible for some or all of the effects of one construct on another, therefore distinct versions of *Figure 2.2* would not be necessary for different levels of a mediator. By identifying examples of effect modifiers in the DPM, we flag situations in which multiple versions of *Figure 2.2* may be required to conceptualize the disablement process in a study sample.

Table 2.2 Measurement and Analysis of Variables Measured in Individuals

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	**Total # of studies**	**Reported association with disability (cross-sectional)**	**Reported association with disablement (over 2+ time points)**	**Reported association with disability & disablement**	**Variable classification in Studies**	**Populations of Studies**
Pathology						
Sub-Clinical Pathologies Anemia (1), low glomerular filtration rate (1), low serum albumin (2), high pro-inflammatory molecules (e.g. IL-6) (1)	5	2	5	0	3: exposure 1: adjustment 1: unspecified	3: community 1: nursing home 1: hospital or mix
Acute pathologies Incident acute health episode or chronic pathology exacerbation (4), delirium (4), fall (8), fractures (hip and other) (5), infection (e.g. urinary tract, respiratory tract (3)	19	3	16	0	11: exposure 3: adjustment 5: unspecified	12: community 5: nursing home 2: hospital or mix
Chronic pathologies # chronic conditions (25), Alzheimer's disease (1), angina (2), anxiety (3), arthritis or joint impairment (13), asthma (5), bone disease (1), cancer (general or specific types) (15), cardiovascular disease (15), cough (1), congestive heart failure (7), kidney disease (3), chronic obstructive pulmonary disease (7), coronary artery disease (5), dementia (8), depression (25), diabetes (22), endocrinopathy (1),	65	21	40	4	27: exposure 16: adjustment 22: unspecified	40: community 15: nursing home 10: hospital or mix

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	**Total # of studies**	**Reported association with disability (cross-sectional)**	**Reported association with disablement (over 2+ time points)**	**Reported association with disability & disablement**	**Variable classification in Studies**	**Populations of Studies**
hypertension (9), limb paralysis/amputation (1), lung disease (9), musculoskeletal disease (2), myocardial infarction (4), neuropathy (2), osteoporosis (5), Parkinson's disease (10), peripheral vascular disease (3), psychiatric conditions (6), seizure disorders (1), skin disorders (1), stroke (24)						
Impairment						
#geriatric syndromes (6), body mass index (high or low) (13), decreased alertness (1), dizziness (1), balance impairment (3), bladder incontinence (9), bowel incontinence (3), cognitive impairment (27), fainting/blackouts (1), frailty (5), gastrointestinal impairment of unspecified type (3), hearing impairment (13), pain (general or site specific) (7), pressure ulcer(s) (3), shortness of breath (1), visual impairment (14), weight loss or malnutrition (6)	52	15	31	6	24: exposure 8: adjustment 20: unspecified	33: community 13: nursing home 6: hospital or mix

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	**Total # of studies**	**Reported association with disability (cross-sectional)**	**Reported association with disablement (over 2+ time points)**	**Reported association with disability & disablement**	**Variable classification in Studies**	**Populations of Studies**
Functional Limitation						
Lower combined physical functioning score (timed walk, chair stand, tandem stand) (4), difficulty lifting 10 pounds (1), difficultly walking several blocks (1), slowed gait speed (2)	7	1	6	0	1: exposure 2: adjustment 4: unspecified	6: community 1: nursing home
Intra-Individual Factors						
Demographic characteristics Age (46), years of education (23), ethnicity (21), marital status (7), sex (36)	50	8	37	5	9: exposure 21: adjustment 20: unspecified	29: community 14: nursing home 7: hospital or mix
Lifestyle and Behavioural Factors Alcohol consumption (5), period of restricted activity (bedrest) (2), low physical activity (6), low level of recreation and social activities (2), current or former smoker (8)	12	2	9	1	3: exposure 4: adjustment 5: unspecified	9: community 1: nursing home 2: hospital or mix
Psychosocial Attributes apathy (1), fear of falling (1), home ownership (1), income (8), religiosity (1), lack of optimism or low mood (2), low self-efficacy about functional improvement (1) low self-rated health (2), low	17	3	10	4	5: exposure 5: adjustment 7: unspecified	12: community 5: nursing home

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	**Total # of studies**	**Reported association with disability (cross-sectional)**	**Reported association with disablement (over 2+ time points)**	**Reported association with disability & disablement**	**Variable classification in Studies**	**Populations of Studies**
subjective social status (1), "do not resuscitate" order on file (1)						
Nursing Home Resident characteristics Higher case-mix score at admission (1), longer period of time since entry into nursing home (5), lived with others prior to nursing home admission (2), resident pays privately for nursing home services (1),	8	0	7	1	4: adjustment 4: unspecified	8: nursing home
Extra-Individual Factors						
Medical Care Hospitalizations (any, or frequency) (12), features of hospitalizations (e.g. length of stay) (3), high patient-clinician communication (1), specific clinical interventions (e.g. colon cancer surgery, coronary bypass) (4), polypharmacy (4), specific medications (e.g. anti-psychotics, anti-depressives) (3), use of assistive devices (1)	22	4	17	1	9: exposure 3: adjustment 10: unspecified	14: community 8: nursing home
External Support Lives with other people (4), receipt of help from others (4), low level of social engagement or contact with	17	2	12	3	1: exposure 7: adjustment 9: unspecified	10: community 5: nursing home 2: hospital or mix

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	**Total # of studies**	**Reported association with disability (cross-sectional)**	**Reported association with disablement (over 2+ time points)**	**Reported association with disability & disablement**	**Variable classification in Studies**	**Populations of Studies**
proxies (4), Medicare insured (2), lives in a nursing home (versus the community) (1)						
Nursing Home Resident characteristics Where (home, hospital) resident admitted from (4), staff belief in resident potential for ADL improvement (1)	5	1	4	0	1: exposure 1: adjustment 3: unspecified	4: nursing home 1: hospital or mix

Table 2.3: Measurement and Analysis of Variables Measured at the Institution or Area Level

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	Total # of studies	Reported association with disability (cross-sectional)	Reported association with disablement (over 2+ time points)	Reported association with disability & disablement	Variable classification in Studies	Populations of Studies
Extra-Individual Factors						
Nursing Home *Level-Aggregate Measures of Resident Characteristics* % of residents who receive skin care (1), mean organized activity days per resident per month (1), proportion of Medicaid-funded residents (1), nursing home-level ADL acuity index (3), proportion of black residents in nursing home population (1), proportion of residents with catheters (1), smaller proportion of private-pay resident days (1)	5	0	5	0	2: exposure 3: adjustment	5: nursing home
Nursing Home: *Built Physical and Social Environment* residence in specific nursing home (3), case-mix reimbursement used in nursing home (1), ownership (for profit vs. not) of nursing home (1), higher number of admissions per bed in nursing home (1), high bed occupancy in nursing home (1), small nursing home size (2),	9	2	7	0	4: exposure 3: adjustment 2: unspecified	9: nursing home

DPM Construct and Examples of Representative Variables (number of studies in which variable included)	Total # of studies	Reported association with disability (cross-sectional)	Reported association with disablement (over 2+ time points)	Reported association with disability & disablement	Variable classification in Studies	Populations of Studies
certification of nursing home medical director (1), total licensed staff per day in nursing home (3), urban or rural location of nursing home (3), Receipt of fewer federal citations for serious deficiencies (1)						
City or State/Province: *Built Physical and Social Environment* urban or rural location of community residence (3), city-wide influenza rate (1), lower area wage index for nursing homes (1), State Medicaid rate (1), State in which nursing home located uses MDS-based Medicaid reimbursement system (1), state-level influenza severity (1)	6	1	3	2	4: exposure 1: adjustment 1: unspecified	2: community 3: nursing home 1: hospital or mix

8.3 Measurement and Analysis of DPM Variables Measured in Individuals

Table 2.2 presents a summary of variables measured in older adults and independently associated with either disability or disablement according to our critical literature review. Variables are classified by DPM constructs that align with those presented in *Figure 2.2*. A majority of reviewed studies that examined pathologies were interested in the effects of chronic (versus sub-clinical or acute) pathologies, such as depression or arthritis; 41% of these studies were focused on chronic pathologies as an exposure variable. Of the 52 studies that examined the independent effects of impairments – which encompass most geriatric syndromes – more than half included these variables in analyses as adjustment variables or variables with unspecified roles. Almost two thirds of included studies of chronic condition or geriatric syndrome effects on disability were done in community-dwelling older adults.

The most frequently measured intra-individual variables in included studies were demographic characteristics such as age and sex, however these variables were considered exposure variables in only a quarter of the 50 studies that included them. The most commonly measured extra-individual variables measured at the individual level were hospitalizations or medications received; of the 22 included studies of these variables, almost half (n = 10) did not specify their role in statistical models. Eight reviewed studies examined intra-individual nursing home resident characteristics measured at the individual level and five looked at extra-individual nursing home resident characteristics measured at the individual level.

We identified several potential effect modifying variables measured at the individual level. Older adults with arthritis may be at higher risk of disability due to stroke (Fried, Bandeen-Roche, Kasper, & Guralnik, 1999), while those with diabetes have greater risk of disablement over time if they have coexisting cognitive impairment (Fultz, Ofstedal, Herzog, & Wallace, 2003). The effect of pathologies and impairments on disability outcomes was also found to be modified by sex (Carrière et al., 2011) and advanced age (Piernik-Yoder & Ketchum, 2013). Finally, older adults who are hospitalized tend to experience some degree of disablement following

hospitalization (Covinsky et al., 2003) even if they experience a full recovery from the medical diagnoses for which they were hospitalized (Covinsky, Pierluissi, & Johnston, 2011).

8.4 Measurement and Analysis of DPM Variables Measured at the Institution or Area Level

Table 2.3 presents a summary of extra-individual variables measured at the institution or area level and independently associated with either disability or disablement in older adults. These variables have been separated from the extra-individual variables in Table 2.2 to reflect their different level of measurement (*Figure 2.2*). Compared to studies of effects of variables measured in individuals, our search yielded relatively few studies of institutional and area-level effects on disability outcomes in older adults (Appendix 2.8). Of the included studies, five examined the independent effect of nursing home-level aggregate variables of individual resident characteristics, such as the proportion of residents with catheters (Spector & Takada, 1991). Consideration of these resident composition effects is important in the realm of disability, both for case-mix adjustment of quality metrics and identification of nursing home practices (e.g. restraint use) associated with disablement.

8.5 Common Methodological Limitations of Existing Studies

Within the 94 studies reviewed, several methodological limitations recurred; we identify them here and present strategies to improve the internal and external validity of future research. Less than a third of included studies of disablement included more than two time points at which disability was measured. This is not ideal because large fluctuations in disability levels between two time points may misrepresent the extent of disablement that would be apparent with multiple follow-up points (Wolinsky et al., 2011).

One of the stated goals of the original DPM was to simplify and standardize the “bedlam vocabulary” use in disability research (Verbrugge & Jette, 1994). Our review and others (Gill, 2010; Jette, 2006) found that this goal has not been achieved. Authors commonly substituted the term “functional decline” for disablement (Marengoni, Von Strauss, Rizzuto, Winblad, &

Fratiglioni, 2009; McLaren, Lamantia, & Callahan, 2013), even when citing the DPM as their guiding framework. Others incorporated new constructs into the DPM, but considered operationalizing specific variables to measure those constructs out of scope (Meade, Mahmoudi, & Lee, 2015). We hypothesize that the former occurs due to variation in how researchers from different disciplines interpret the terms "functional limitation" and "disability." By applying Verbrugge and Jette's definitions to examples from 94 empirical studies, we hope to have exemplified the use of these terms for more consistent use in future research on disability, as well as provide a framework in which to insert new constructs and examples of variables to measure them.

Even among those researchers whose conceptualization of disability and disablement aligned, the tools used to measure these outcomes varied significantly across studies. Of the 94 studies reviewed, 45% classified disability based on a count of ADLs older adults had difficulty or needed assistance with, many of which were dichotomized to "disability present" versus "not" based on the presence of dependence in or difficulty with any ADLs (Appendix 2.9). These count-based classifications varied in their composition, scoring and overlap with validated disability assessment tools such as the Katz or Barthel indices, which were used in only 17 reviewed studies.

9 Implications

As the prevalence of disability increases in older adults (Atun, 2015), a growing body of researchers are using the DPM to study how to prevent or slow its progression (Appendix 2.1). Given the broad nature of the DPM and the expansive body of evidence in this field, the gap between conceptual framework to empirical research is too wide (*Figure 2.1*). The application of the DPM to research is also conceptually and empirically inconsistent because it represents variables that should be measured at different levels as part of the same construct and is frequently applied to cross-sectional disability studies beyond the scope of the original model. To facilitate the application of the DPM in theory-driven knowledge generation, we undertook a critical review (Grant & Booth, 2009) of 94 studies, summarized research on disability in the context of the DPM (Tables 2.2 and 2.3) and identified methodological limitations and pragmatic

guidance for future research. We also examined evidence on the relationship between DPM constructs and disability measured at one time point to facilitate an evidence-based extension of the DPM to cross-sectional studies. We used this research summary to develop an analytic framework for application of the DPM to disability research in older adults (*Figure 2.2*) and to inform recommendations on measurement and modelling of DPM constructs.

9.1 Definition and Measurement of DPM Variables in Research

We found that the relationships between constructs in the DPM are much more complex than they are often treated in empirical research. Intra-individual variables such as age and sex that are typically adjusted for as confounders may also act as effect modifiers of the relationships between DPM constructs (Carrière et al., 2011; Piernik-Yoder & Ketchum, 2013). This conceptual relationship has important implications for research design; if the level of an effect modifier is imbalanced among older adults in a study sample, it may skew results. At the analysis stage, results should be examined and reported by level of intra-individual effect modifiers to produce results specific to populations who experience disablement differently (Carriere et al., 2009).

We also identified pathologies and impairments that may modify the effects of other pathologies (Fried et al., 1999; Fultz et al., 2003); we recommend that future research build on this evidence base by examining differences in disablement among individuals with and without common chronic conditions or geriatric syndromes.

The results of our critical review led us to hypothesize that constructs in the DPM may partly mediate one another's effects on disability and disablement. In support of this, a paper published following our inclusion cut-off date found that self-control partly mediated the effects of depression on disability among community-dwelling stroke survivors (Kim & Park, 2015). Statistical adjustment for mediating variables can bias regression findings (Richiardi, Bellocco, & Zugna, 2013), therefore we advise future researchers adapt our analytic framework to map out causal relationships between all variables under consideration for their analysis, prior to computation of results.

In their original DPM manuscript, Verbrugge and Jette attest that "Presumptions that some [disability] domains matter more than others should be abandoned," (1994) and we agree. However based on our critical review, we also advise that different disability domains (e.g. self-care, IADLs, occupational etc.) be considered as separate outcomes in research, given the incomplete overlap between variables associated with each of them (Jackson et al., 2015). Close to half of the studies we reviewed classified disability based on a count of ADLs people had difficult with, or a dichotomous variable to indicate the presence or absence of disability. We recommend that future research use validated and commonly employed measures of disability (Yang et al., 2014), such as Katz or Barthel in community-dwelling older persons or the RAI ADL long-form score in nursing home residents. We further advise against use of counts or arbitrary scoring of select ADLs or dichotomization of disability as "present versus not," as this renders incomparable findings across studies and risks classifying extremely heterogeneous groups of older adults as simply "disabled" (Nusselder, Looman, & Mackenbach, 2006).

Many of the relationships between variables and disability that we report are based on variables added to analyses for adjustment, or to predictive models aimed at maximizing the amount of variance in disability outcomes explained. We acknowledge these as important goals, but believe that more hypothesis-driven analyses of specific exposure-outcome relationships (especially with demographic characteristics) would offer important insights into our understanding of disablement.

9.2 Analytic Considerations for Future Disability Research in Older Adults

We present an analytic framework that operationalizes constructs in the DPM (*Figure 2.2*) and provide examples of variables that others have used to measure these constructs (Tables 2.2 and 2.3). We propose that future DPM-guided research use these outputs to sharpen the focus of research questions asked in systematic reviews on disability, or to operationalize the DPM for further empirical research. For example, if a researcher was interested in the effect of

malnutrition on disablement, Table 2.2 shows that only six of the studies we reviewed examined the independent effects of malnutrition or weight loss on disability or disablement, and Appendix 2.4 indicates that half of those studies were done in community-dwelling older adults. The specific references for each study could be found in Appendix 2.2, and looked up to identify common MeSH terms to use in a systematic review. Depending on whether the systematic review revealed a paucity or abundance of literature on malnutrition and disablement, the researcher could either stop there, or use the analytic framework in *Figure 2.2* to guide their analysis in an empirical study. Ideally, cases in which relevant constructs from the analytic framework are *not* measured should also be identified and explained by researchers, with likely implications for their findings examined.

Extra-individual structures (e.g. nursing homes, neighborhoods, states) in which multiple individuals are clustered should be analytically treated as "nesting" variables to recognize the inter-dependence of individuals in clusters. We identify some examples of such clustering variables in Table 2.3, but refer readers to recent reviews of environmental predictors of disability (Clarke & Nieuwenhuijsen, 2009; Philibert, Pampalon, & Daniel, 2015) for more examples. Area-level correlates of health (including disability) in community-dwelling older adults have been particularly well-studied and summarized in recent literature reviews (Garin et al., 2014; Yen, Michael, & Perdue, 2009).

From the 38 reviewed studies that included nursing home residents, we identified numerous variables measured at the institutional (nursing home) level that were independently associated with disability or disablement. Although this seems a critical body of evidence to inform nursing home legislation and practice, we did not find a literature review of nursing home features associated with disability. We hypothesize that this is due to a dearth of evidence in this field; for example, Zimmerman et al's systematic review of effective characteristics of nursing homes and other residential long-term care settings for people with dementia found only two studies of nursing home organizational features or processes associated with resident disablement (Zimmerman et al., 2013). High quality empirical research on this topic is needed in future gerontology research.

Less than a third of studies that examined disablement over time had more than one follow-up point. Acknowledging that a single baseline and follow-up measure may be all that was logistically feasible in considered studies, we note that such measures are more sensitive to impermanent fluctuations in disability than measures based on multiple follow-up points (Wolinsky, Armbrecht, & Wyrwich, 2000b). Given the availability of robust analytic methods (Murphy et al., 2015) and user-friendly statistical packages to assess multiple follow-up points over time (Rabe-Hesketh & Skronda, 2012; Raudenbush & Bryk., 2002), we and others (Gill, 2014; Tappen & Ouslander, 2010) recommend an increase in collection of these longitudinal data wherever possible.

9.3 Applicability of Findings to the ICF

The preceding literature review and analytic framework aimed to operationalize the DPM, but is also relevant to researchers using the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001) to guide their disability research in older adults. In contrast with the DPM, the ICF is "reablement" skewed with constructs such as "activity" and "participation" as outcomes in the framework. Many of the constructs identified in the ICF are the inverse of DPM constructs (Thyberg, Arvidsson, Thyberg, & Nordenfelt, 2015), therefore our analytic framework and conceptual framework could potentially be modified and extended to operationalize the ICF as well.

9.4 Study Limitations and Strengths

We aimed to critically review the empirical evidence linking DPM constructs and operationalize this commonly used framework for future systematic reviews or empirical studies. Because the existing evidence in this area is so vast, a systematic review of evidence for relationships between variables within each DPM construct was not appropriate or feasible. Our non-systematic search and appraisal techniques are aligned with the knowledge support aim of a critical review (Grant & Booth, 2009; Mays et al., 2005), but may not be exactly replicable or capable of producing conclusive findings regarding variable relationships with disability. We did

not include grey literature or qualitative studies of older adults' experience with disability and may have omitted landmark research. We also may have over-sampled studies from North America, due to our inability to review work that was not in English and our familiarity with prevalent search terms. These limitations render our findings regarding specific variable relationships with disability inconclusive. To reflect this, we have placed these variable-specific findings in Appendices 2.2 through 2.8 and recommend that each of these relationships be explored systematically before firm conclusions are drawn about them.

Although our methods do not allow for conclusions about causal relationships between constructs in the DPM, the breadth of our critical review yielded an analytic framework and measurement recommendations that will strengthen future systematic reviews and empirical studies of such relationships. This study used comprehensively described and justified methods to achieve clearly stated knowledge support aims that will aid researchers doing theory-driven research on disability in older adults. In contrast with existing narrative reviews on disability (Clarke & Nieuwenhuijsen, 2009; Gitlin, 2003; Keysor, 2003; Philibert et al., 2015; Wahl et al., 2009), we summarized our findings in a readily applied analytic framework and summary table based on the constructs in the DPM. We also provide rich supplementary data on all 94 reviewed studies, which can be used as a launching point for specific research questions. For those readers who intend to conduct a systematic review of relationships in the DPM, we recommend Schaefer's guide (2015) to databases, search terms and websites related to disability content.

10 Conclusion

Identification of a conceptual framework such as the DPM is the first step in conducting theory-driven knowledge generation. Critically reviewing the evidence and operationalizing the conceptual framework as we have done here is the next required step. Gerontology researchers studying disability in older adults can use this research summary and analytic framework to sharpen the focus of research questions asked in systematic reviews on disability, or to operationalize the DPM for further empirical research. Recommendations on measurement and analysis of constructs in the DPM can also inform a more structured and consistent approach to knowledge generation in this important field.

Chapter 3
Association of Resident and Long-Term Care Home Characteristics with Resident Disability

11 Abstract

Objectives: To determine which resident geriatric syndromes and chronic conditions are associated with residents' disability and whether these relationships vary across strata of age, sex and cognitive impairment. Also to examine the proportion of variance in residents' disability that is explained by resident versus long-term care home characteristics.

Methods: We conducted a cross-sectional study using a health administrative cohort of 77,165 long-term care home residents residing in 614 Ontario long-term care homes. Eligible residents had their self-care disability assessed using the RAI-MDS 2.0 activities of daily living long-form score (range: 0 – 28) within three months of April 1st, 2011. Hierarchical multivariable regression models with random effects for long-term care homes were used to estimate the association between disability and resident geriatric syndromes, chronic conditions and long-term care home characteristics. Differences in findings across strata of sex, age and cognitive functioning were examined.

Results: Geriatric syndromes were much more strongly associated with disability than chronic conditions in multivariable models. The direction and size of some of these effects were different for cognitively impaired versus intact residents. Residents' geriatric syndromes explained 50% of the variation in their disability scores, while characteristics of long-term care homes explained an additional 2% of variation.

Conclusion: Differences in long-term care residents' disability are largely explained by prevalent geriatric syndromes. After adjusting for resident characteristics, there is little variation in disability associated with long-term care home characteristics. This suggests that residents' geriatric syndromes – not the homes in which they live – may be the appropriate target of interventions to reduce disability, and that such interventions may need to differ for cognitively impaired versus unimpaired residents.

12 Introduction

Long-term care homes (LTCHs) are publicly-funded facilities for older adults whose care needs are greater than the level provided by home care or retirement homes, but less than that provided in hospital (CIHI, 2013). Demand for institutional long-term care is increasing globally, as are the acuity and complexity of LTCH (or "nursing home") residents (Katz, 2011). Most LTCH residents have some disability, defined as difficulty with or dependence on others to conduct activities of daily living (ADLs), such as bathing, eating and dressing (CIHI, 2013). Disability tends to increase over time among LTCH residents (Dutcher et al., 2014) and is associated with lower self-rated quality of life (Andersen et al., 2004), repeat hospitalizations (Kruse et al., 2013), higher health care utilization (de Meijer, Koopmanschap, Koolman, & van Doorslaer, 2009) and all-cause mortality (Thomas, Cooney, & Fried, 2013; Yeh et al., 2014). Based on its association with these important resident outcomes, resident disability measures are included in pay-for-performance schemes and publicly reported LTCH quality metrics in jurisdictions across North America (Bellows & Halpin, 2008; CIHI, 2015; Werner et al., 2013).

Study 1 found that there is limited evidence regarding the association of specific resident and LTCH characteristics with resident disability, or the extent that these associations differ by age, sex and cognitive status. Identifying the resident or LTCH characteristics that explain differences in resident disability could guide targeting of clinical interventions to prevent or slow its onset. Determining whether the effects of geriatric syndromes and chronic conditions on disability differ by age, sex and cognitive status is important because imbalanced effect modifiers in research samples skew findings. Existing studies of these relationships are limited by small or single-sex samples, inadequate control for confounders, lack of adjustment for clustering of residents within LTCHs, and selection bias due to voluntary LTCH participation (Chen et al., 2013; Fedecostante et al., 2015; Frytak, Kane, Finch, Kane, & Maude-Griffin, 2001; Phillips et al., 2008).

We conducted a theoretically-grounded administrative data study to answer the following questions and fill this evidence gap:

1. Which geriatric syndromes and chronic conditions are most strongly associated with disability in LTCH residents?
2. Are these relationships moderated by residents' sex, age or cognitive status?
3. What is the proportion of variance in resident disability explained by resident characteristics versus LTCH characteristics?

13 Theory

Verbrugge and Jette's Disablement Process Model is a theoretical framework that outlines a pathway through which pathologies lead to impairments, which give way to limitations in functional capacity and ultimately disability, depending on an individuals' sociodemographic characteristics and context (Verbrugge & Jette, 1994). We incorporated this framework into this study in two ways. First, our variable selection and model specification were guided by the analytic framework based on the Disablement Process Model that was developed in Study 1. Second, we tested an extension of the original model built into the analytic framework that proposed effect modification of exposure-disability relationships by resident age, sex and cognitive status. Based on this study, we hypothesized that the effect of chronic diseases and geriatric syndromes on disability would be stronger among women, the oldest age groups and individuals who were cognitively impaired.

14 Methods

We conducted a population-based cross-sectional study to determine the association between resident and LTCH characteristics with resident disability. We enrolled all LTCH residents in Ontario, Canada, whose disability was assessed within 90 days (+/-) of the index date, April 1, 2011. We then applied several exclusions (Appendix 3.1) and used residents' de-identified and encrypted provincial health insurance numbers to link health administrative databases housed at the Institute for Clinical Evaluative Sciences (ICES). ICES is a prescribed entity for the purposes of section 45 of Ontario's Personal Health Information Privacy Act.

14.1 Data Sources

Resident records were linked using unique, anonymized, encrypted identifiers across multiple Ontario health administrative databases containing information on all publicly insured, medically necessary hospital and physician services. These included the Discharge Abstract Database (DAD) for chronic conditions coded during hospital admissions; the Ontario Health Insurance Plan (OHIP) for physician billings, including diagnosis codes and procedures; the Registered Persons Database (RPDB) for resident age and sex; and the Continuing Care Reporting System (CCRS) for LTCH characteristics and resident disability, demographic characteristics, and chronic condition and geriatric syndrome diagnoses obtained from Resident Assessment Instrument Minimum Dataset 2.0 (RAI-MDS) assessments (Hirdes et al., 2013). The RAI-MDS is a standardized, multidimensional assessment tool used in LTCHs across Canada, the US and Europe (Hirdes, Ljunggren, et al., 2008). Trained LTCH staff complete the assessments when residents are admitted to LTCH, quarterly, and when there is any significant resident health status change (Hirdes et al., 2011).

14.2 Outcome

The primary outcome was resident disability, measured using the ADL long-form score (ADL LFS) from the RAI-MDS assessment closest to the index date. The ADL LFS quantifies resident disability from 0 to 28 based on degree of dependence on others for bed mobility, transfer, locomotion, dressing, eating, toilet use and personal hygiene (Appendix 3.2). Higher values of ADL LFS indicate higher disability. The ADL LFS is less prone to ceiling effects than more abbreviated disability scales (Neuman et al., 2014), has been validated against standardized measures of disability (Frederiksen K., Tariot P., & E., 1996; Lawton M.P. et al., 1998), and is reliable and internally consistent (Morris, Fries, & Morris, 1999). Although it is an ordinal measure, it was treated as a continuous variable in this study, in keeping with statistical guidelines (Rhemtulla, Brosseau-Liard, & Savalei, 2012) and precedent in other research (Fedecostante et al., 2015; Wang, Chang, Eberly, Virnig, & Kane, 2010; Wang, Kane, Eberly, Virnig, & Chang, 2009; Wolinsky, Armbrecht, & Wyrwich, 2000a).

14.3 Exposures

Residents' prevalent chronic conditions and geriatric syndromes identified in Study 1 as potentially associated with disability in older adults were the primary exposures of interest. As indicated in Table 1.2, chronic conditions are classified as pathologies in this thesis and geriatric syndromes are classified as impairments. Details on these definitions and their justification from the evidence are provided in Appendix 3.3. The accrual period for chronic condition diagnoses was five years prior to the index date. Conditions were coded as prevalent if they were identified in hospital or physician billing data as primary or comorbid diagnoses in one inpatient or two outpatient visits within two years of each other (Koné Pefoyo et al., 2015) or if they were denoted as "active conditions" in RAI-MDS assessments at least once. Geriatric syndromes were coded as present as indicated in residents' RAI-MDS assessment closest to the index date. The full set of 16 chronic conditions and nine geriatric syndromes included, as well as the diagnostic codes used to define them, are listed in Appendices 3.4 and 3.5.

14.4 Covariates

Selection of resident and LTCH-level covariates for multivariable models was guided by Study 1's evidence-based analytic framework of variables in the Disablement Process Model as they relate to disability. LTCH-level variables based on aggregate resident characteristics (e.g. proportion of residents restrained) were calculated using all residents in each LTCH who were assessed within three months (+/-) of the index date and were still alive on the index date.

14.5 Statistical Analyses

Individual residents were the unit of analysis; the outcome was disability, measured on a continuous scale from zero to 28, and the exposures were prevalent geriatric syndromes and chronic conditions. The frequency and distribution of resident and LTCH characteristics in the sample were determined. Bivariate unadjusted relationships between resident and LTCH characteristics and disability were assessed in linear regression models. A null model containing only random LTCH intercepts and no explanatory resident or LTCH variables was then run and a

likelihood ratio test compared the maximized log likelihood from this model to one without random intercepts to test whether there was significant between-LTCH variance in resident disability. Hierarchical multivariable Model 1 contained only random LTCH effects and resident variables, whereas Model 2 contained random LTCH effects, resident and LTCH variables. This model sequence facilitated stepwise calculation of the total proportion of variance in disability explained by variables in each model (R^2), and the proportion of variance in disability that was between LTCHs in the sample (ρ) (Rabe-Hesketh & Skronda, 2012). The assumption of normally distributed residual errors was also verified. To test whether the effect of chronic diseases and geriatric syndromes on disability were stronger among women, the oldest residents and individuals who were cognitively impaired, we conducted a descriptive analysis of Model 1 stratified by sex, age and presence of cognitive impairment.

14.5.1 Sensitivity Analyses

We re-ran Model 1 with fixed effects instead of random effects for LTCHs to examine whether unmeasured LTCH effects were biasing our findings. Fixed effects account for individual LTCH's effect on variance in residents' disability, without specifying the LTCH variables responsible, whereas random effects adjust for the overall variation across all LTCHs. If coefficient estimates from the fixed effects version of Model 1 differed significantly from the random effects version, it would suggest that our estimation was biased by unmeasured LTCH-level confounders. A linear regression with no random or fixed effects for LTCHs was also run. We also re-ran Model 1, alternatively removing all geriatric syndromes, all chronic conditions, and all variables except for four geriatric syndromes to test how sensitive effects for each type of exposure was to adjustment for the other. To examine the sensitivity of our findings to coding of chronic conditions, we re-ran Model 1 using chronic condition codes from claims data only, and using chronic condition codes from RAI-MDS data only. Model 2 was re-run excluding residents whose data were from admission assessments to examine whether their inclusion weakened relationships between LTCH characteristics and resident disability. Descriptive analyses were done using SAS version 9.3 (SAS Institute, 2012) and regression modelling was done in STATA. This study received ethics approval from the University of Toronto Office of Research Ethics and the Sunnybrook Health Sciences Research Ethics Board (Appendix 3.6).

15 Results

15.1 Resident and long-term care home characteristics

A total of 77,165 residents from 614 LTCHs were included in the sample and are described in Table 3.1. The median disability score for all residents in the sample was 18 (IQR: 9, 23); 71.2% of them were female and their mean age was 84.9 years (SD: 7.5). LTCHs had an average of 126 (SD: 67.3) active beds and the majority of homes in the sample were classified as medium size, for-profit, and located in urban settings (Table 3.2). There was very little variation in LTCH-level mean disability associated with different levels of the measured LTCH characteristics (Table 3.2).

Table 3.1: Characteristics of Long-Term Care Residents in Sample

Characteristics	**N**	**%**	**Mean Disability (SD)**
Full Cohort	77,165	100	16.1 (8.4)
Age (years)			
65 – 74	7,859	10.2	15.1 (8.0)‡
75 – 84	25,703	33.3	15.9 (8.6)‡
85 – 94	36,676	47.5	16.2 (8.3)‡
95+	6,927	9.0	17.6 (7.7)‡
Sex			
Female	54,953	71.2	16.4 (8.4)‡
Male	22,212	28.8	15.4 (8.5)‡
Marital Status			
Married	18,632	17.0	17.0 (8.4)‡
Widowed	46,067	16.1	16.1(8.4)‡
Never married/Separated/Divorced	11,299	14.8	14.8 (8.6)‡
Missing data	1,167	15.7	15.7 (8.4)‡
Pre-LTCH Neighborhood Income Quintile			
1 (low)	17,671	22.9	15.4 (8.5)‡
2	13,510	17.5	16.0 (8.4)‡
3	13,473	17.5	15.9 (8.5)‡
4	11,790	15.3	16.4 (8.3)‡
5 (high)	10,909	14.1	16.4 (8.4)‡

Characteristics	N	%	Mean Disability (SD)
Missing data	9,812	12.7	17.0 (8.4)‡
Days in LTCH Prior to Index Date			
0 - 4 months	19,202	24.9	15.3 (8.1)‡
> 4 months - 12 months	14,045	18.2	15.0 (8.2)‡
> 1 year - 2 years	13,854	17.9	15.3 (8.4)‡
> 2 years - 3 years	8,515	11.0	16.1 (8.5)‡
> 3 years	21,549	27.9	18.0 (8.6)‡
Prevalent Geriatric Syndromes			
Balance impairment	59,502	77.1	18.5 (7.4)‡
Bowel incontinence	37,966	49.2	21.4 (5.7)‡
Cognition			
Intact or borderline intact	18,426	23.9	10.9 (8.0)‡
Mild/moderate impairment	37,204	48.2	14.8 (7.5)‡
Moderate-severe/severe impairment	21,535	27.9	22.7 (5.8)‡
Hearing impairment			
None	66,718	86.5	15.9 (8.5)‡
Hearing impaired	10,269	13.3	17.6 (8.0)‡
Missing data	178	0.2	15.3 (8.3)‡
Body mass index (BMI)			
BMI < 18.5	6683	8.7	18.7 (7.8)‡
18.5 ≤ BMI ≤ 25	32,614	42.3	16.7 (8.4)‡
25 < BMI <30	22,134	28.7	15.2 (8.6)‡
BMI ≥ 30	15,734	20.4	15.0 (8.3)‡
Pain			
None	46,595	60.4	16.3 (8.5)‡
Less than daily pain	17,895	23.2	15.6 (8.2)‡
Daily or severe daily pain	12,675	16.4	16.2 (8.4)‡
Pressure ulcer	4,834	6.3	22.2 (6.0)‡
Urinary incontinence	54,922	71.2	19.1 (6.8)‡
Visual impairment			
None	43,701	56.6	14.4 (8.4)‡
Moderate impairment	27,264	35.3	17.5 (7.9)‡
Severe impairment	6,022	7.8	22.0 (7.2)‡
Missing	178	0.2	15.3 (8.3)‡
Prevalent Chronic Conditions			
Arthritis	48,114	62.4	15.8 (8.3)‡
Asthma	5,740	7.4	15.4 (8.3)‡
Cancer	25,016	32.4	15.3 (8.4)‡

Characteristics	N	%	Mean Disability (SD)
Kidney disease	17,124	22.2	16.1 (8.2)
Coronary artery disease	29,999	38.9	15.6 (8.4)‡
Chronic obstructive pulmonary disease	16,823	21.8	15.0 (8.3)‡
Dementia	65,291	84.6	16.6 (8.3)‡
Diabetes	24,456	31.7	16.0 (8.3)
Epilepsy	5,262	6.8	18.1 (8.3)‡
Heart failure	19,430	25.2	15.9 (8.1)†
Limb paralysis or amputation	7,031	9.1	20.2 (6.5)‡
Mood disorders	32,389	42.0	16.4 (8.3)‡
Parkinson's disease	7,082	9.2	18.7 (7.6)‡
Peripheral vascular disease	7,132	9.2	16.0 (8.1)
Psychiatric conditions other than depression and dementia	21,288	27.6	15.1 (8.5)‡
Stroke	17,005	22.0	17.4 (7.9)‡

All p-values from ANOVAs to test differences in ADL LFS across different levels of each category.
*p-value <0.05
†p-value <0.01
‡p-value <0.0001

Table 3.2: Characteristics of Long-Term Care Homes (LTCHs) in Sample

Characteristic	**N**	**%**	**Grand Mean (SD) of homes' ADL LFS means**
Full Sample	614	100	15.7 (2.0)
LTCH Size (# beds)			
Small (≤64)	128	20.8	15.4 (2.3)
Medium (65 – 128)	248	40.4	15.5 (2.2)
Large (129 – 192)	154	25.1	15.7 (2.2)
Extra-large (≥193)	84	13.7	16.0 (2.0)
Ownership status			
Not-for-profit	228	37.1	15.5 (2.2)*
For-profit	378	61.6	15.8 (2.1)*
Missing data	8	1.3	12.1 (2.4)*
Location			
Rural	136	22.2	14.8 (2.1)*
Sub-urban (census agglomerations)	97	15.8	14.9 (1.92)*
Urban (census metropolitan areas)	381	62.1	16.0 (2.1)*
Receipt of Rehabilitation Services			
Lowest quartile (Received by ≤74.5% of residents in home)	153	24.9	15.3 (2.2)*
2nd quartile (Received by >74.5% and ≤86.4% of residents in home)	154	25.1	15.3 (2.3)*
3rd quartile (Received by >86.4, and ≤94.1% of residents in home)	154	25.1	15.9 (2.2)*
Highest quartile (Received by >94.7% of residents in home)	153	24.9	15.8 (2.0)*
Restraint use			
Lowest quartile (Homes in which ≤6.0% residents restrained)	153	24.9	15.3 (2.6)*
2nd quartile (Homes in which >6.0% and ≤13.4% residents restrained)	154	25.1	15.2 (2.0)*
3rd quartile (Homes in which >13.4% and ≤20.6% residents restrained)	153	24.9	15.5 (2.1)*
Highest quartile (Homes in which ≥20.6% residents restrained)	154	25.1	16.4 (1.8)*
Median ADL of residents in each home§			

Characteristic	N	%	Grand Mean (SD) of homes' ADL LFS means
Lowest quartile (Homes whose residents' median ADL LFS ≤15)	176	28.7	13.2 (1.3)*
2nd quartile (Homes whose residents median ADL LFS >15, ≤17)	180	29.3	15.3 (0.9)*
3rd quartile (Homes whose residents median ADL LFS >17, <19)	103	16.8	16.2 (0.9)*
Highest quartile (Homes whose residents ADL LFS ≥19)	155	25.2	18.2 (1.3)*

*Significant ($p < 0.05$) difference between levels of categorical variable according to ANOVA.
§The 614 LTCHs in the sample did not divide into quartiles of even size because of the small range of values for this variable and large number of homes with identical values.

15.2 Multivariable models of disability in long-term care residents

The coefficients in Table 3.3 represent the association of chronic conditions and geriatric syndromes with the 29-point ADL LFS measure of disability. Variables with significant positive coefficients (e.g. Parkinson's) are associated with greater disability, whereas variables with significant negative coefficients (e.g. coronary artery disease) are associated with less disability, adjusting for other variables in the table. A one-point increase in ADL LFS is considered clinically significant, as it indicates increased dependence in an ADL or dependence in a new ADL, both of which are associated with intensified care needs from LTCH staff (Carpenter, Hastie, Morris, Fries, & Ankri, 2006). Because LTCH characteristics had small and non-significant effects on disability (Model 2, Appendix 3.7), estimates from Model 1 – which includes random effects for LTCHs but no LTCH characteristics – are reported. Coefficient estimates for all covariates included in Models 1 and 2 can be found in Appendix 3.7.

Table 3.3: Geriatric Syndromes and Chronic Conditions Associated with Disability in Long-Term Care Residents

	Unadjusted Bivariate Regressions	**Model 1**[§]
	Estimate (95% CI)	Estimate (95% CI)
Prevalent Geriatric Syndromes		
Balance impairment	10.48 (10.34, 10.60)[‡]	5.69 (5.51, 5.87)[‡]
Bowel incontinence	10.46 (10.37, 10.55)[‡]	4.53 (4.38, 4.68)[‡]
Cognition		
Intact/borderline	Reference	Reference
Mild/moderate impairment	3.89 (3.76, 4.01)[‡]	1.67 (1.55, 1.79)[‡]
Moderate-severe/severe impairment	11.73 (11.58, 11.87)[‡]	5.27 (5.10, 5.44)[‡]
Hearing impairment		
None	Reference	Reference
Hearing impaired	1.73 (1.55, 1.90)[‡]	0.03 (-0.08, 0.14)
Missing data	-0.56 (-1.80, 0.67)	0.66 (-0.15, 1.46)
Body mass index (BMI)		
BMI < 18.5	Reference	Reference
18.5 ≤ BMI ≤ 25	-2.02 (-2.24, -1.80)[‡]	-0.54 (-0.68, -0.40)[‡]
25 < BMI <30	-3.49 (-3.72, -3.26)[‡]	-0.87 (-1.03, -0.72)[‡]
BMI ≥ 30	-3.74 (-3.98, -3.50)[‡]	-0.59 (-0.75, -0.43)[‡]
Pain		
None	Reference	Reference
Less than daily pain	-0.70 (-0.85, -0.56)[‡]	0.29 (0.19, 0.39)[‡]
Daily or severe daily pain	-0.12 (-0.29, 0.04)	0.82 (0.70, 0.94)[‡]
Pressure ulcer	6.47 (6.23, 6.72)[‡]	2.67 (2.52, 2.82)[‡]
Urinary incontinence	10.50 (10.40, 10.61)[‡]	4.19 (4.04, 4.35)[‡]
Visual impairment		

	Unadjusted Bivariate Regressions	**Model 1**[§]
	Estimate (95% CI)	Estimate (95% CI)
None	Reference	Reference
Moderate impairment	3.09 (2.97, 3.22)[‡]	0.68 (0.59, 0.77)[‡]
Severe impairment	7.62 (7.40, 7.84)[‡]	2.49 (2.33, 2.65)[‡]
Prevalent Chronic Conditions		
Arthritis	-0.66 (-0.78, -0.54)[‡]	0.08 (-.0003, 0.15)
Asthma	-0.71 (-0.94, -0.48)[‡]	0.10 (-0.04, 0.24)
Cancer	-1.23 (-1.36, -1.11)[‡]	-0.12 (-0.19, -0.04)[†]
Chronic kidney disease	0.06 (0.08, 0.20)[‡]	0 .31 (0.22, 0.40)[‡]
Coronary artery disease	-0.86 (-0.98, -0.74)[‡]	-0.13 (-0.21, -0.05)[†]
Chronic obstructive pulmonary disease	-1.39 (-1.54, -1.25)[‡]	-0.07 (-0.17, 0.02)
Dementia	3.39 (3.22, 3.55)[‡]	-0.22 (-0.35, -0.10)[†]
Diabetes	-0.09 (-0.21, 0.04)	-0.06 (-0.14, 0.02)
Epilepsy	2.17 (1.94, 2.41)[‡]	0.47 (0.32, 0.61)[‡]
Heart failure	-0.24 (-0.38, -0.11)[‡]	0.36 (0.27, 0.46)[‡]
Limb paralysis or amputation	4.49 (4.29, 4.70)[‡]	1.78 (1.63, 1.93)[‡]
Mood disorder	0.53 (0.41, 0.65)[‡]	0.30 (0.22, 0.38)[‡]
Parkinson's disease	2.87 (2.66, 3.07)[‡]	1.75 (1.63, 1.87)[‡]
Peripheral vascular disease	-0.14 (-0.34, 0.07)	0.03 (-0.10, 0.16)
Psychiatric conditions other than depression and dementia	-1.35 (-1.48, -1.22)[‡]	-0.42 (-0.50, -0.33)[‡]
Stroke	1.85 (1.73, 1.98)[‡]	0.46 (0.38, 0.55)[‡]
Random Effects		
$\sqrt{\psi}$	N/A	1.58 (1.50, 1.68)
$\sqrt{\theta}$	N/A	4.90 (4.84, 4.96)
Derived Estimates		
R^2	N/A	0.627
ρ	N/A	0.095

Reference: Variable category is the reference group for all other categories within that variable.

*p-value <0.05
†p-value <0.01
‡p-value <0.0001
§**Model 1:** Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes.
$\sqrt{\psi}$: Square root of between-long-term care home variance
$\sqrt{\theta}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
R^2: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$
N/A: Not applicable because each coefficient in this column from distinct unadjusted bivariate regression with its own $\sqrt{\psi}$, $\sqrt{\theta}$, R^2 and ρ.

15.2.1 Geriatric syndromes and chronic conditions associated with disability

Balance impairment, urinary and bowel incontinence, pressure ulcer, severe visual impairment and severe cognitive impairment each had statistically significant independent associations with a minimum 2.5 point increase in disability (Table 3.3). Mild to moderate cognitive impairment, moderate visual impairment and daily or severe daily pain were also positively associated with more disability, but their effects were smaller, ranging from 0.59 to 1.79 (Table 3.3). Having a healthy body mass, being overweight or obese were all associated with less disability than being underweight.

Compared to geriatric syndromes, chronic conditions had small associations with disability in multivariable models (Table 3.3). Exclusion of geriatric syndromes from the model resulted in increased effect size and statistical significance of chronic condition coefficients, but reduced the model R^2 from 62.7% to 11.2% (Appendix 3.8). Having Parkinson's, heart failure, stroke, limb paralysis or amputation, kidney disease, or mood disorder were significantly associated with higher resident disability, however the size of these independent associations were smaller than those of geriatric syndromes, ranging from 0.22 to 1.93. Asthma, peripheral vascular disease and diabetes were not significantly associated with disability in multivariable models.

Dementia was strongly associated with higher disability in a bivariate model (Table 3.3), and in a model without geriatric syndromes (Appendix 3.8); this association between dementia and

disability is reversed in in Model 1, which also adjusts for cognitive impairment. Although bivariate analyses indicated a negative association between pain and disability, pain was positively associated with disability in fully adjusted analyses (Table 3.3); exploratory analyses revealed that the change in sign for pain occurred due to adjustment for coexisting geriatric syndromes and number of days since admission (data not shown). A similar reversal of a negative bivariate relationship between heart failure and disability occurred in multivariate models (Table 3.3), due to adjustment for number of days since admission (data not shown).

15.2.2 Effect modification by residents' sex, age and cognitive status

As shown in Table 3.4, the estimated association between chronic conditions and geriatric syndromes with disability in the study sample did not differ in sub-samples of men, women, or individuals aged 74 to 94. The effect sizes of bowel incontinence, diabetes and cognitive impairment varied in the youngest (aged 65 – 74) and oldest (aged 95-plus) residents, however these differences were minor. Only 24% of residents in the sample did not suffer from moderate to severe cognitive impairment; in these people the association between pressure ulcer and limb paralysis or amputation and disability increased significantly. Conversely, co-existing dementia, visual impairment or bowel incontinence were associated more strongly with disability in those with cognitive impairment than in the whole sample. Model estimates for all covariates included in sex-, age- and cognitive status-stratified versions of Models 1 can be found in Appendix 3.9.

Table 3.4: Stratification by Sex, Age, Cognitive Impairment Effects Associations between Geriatric Syndromes, Chronic Conditions and Disability

		Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
	Model 1	Females (n=54,953)	Males (n=22,212)	Age 65-74 (n=7,859)	Age 75-84 (n=25,703)	Age 85-94 (n=36,676)	Age 95-105 (n=6,927)	No cognitive impairment (n=18,426)	Cognitive impairment present (n = 58,739)
Prevalent Geriatric Syndromes									
Balance impairment	5.69 (5.51, 5.87)‡	5.73 (5.52, 5.93)‡	5.51 (5.28, 5.74)‡	5.94 (5.57, 6.31)‡	5.71 (5.49, 5.93)‡	5.46 (5.25, 5.68)‡	5.42 (5.00, 5.85)‡	5.55 (5.31, 5.80)‡	5.95 (5.75, 6.16)‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.43 (4.26, 4.60)‡	4.77 (4.57, 4.97)‡	5.00 (4.66, 5.33)‡	4.61 (4.41, 4.82)‡	4.46 (4.28, 4.65)‡	3.98 (3.65, 4.32)‡	4.60 (4.35, 4.86)‡	5.43 (5.26, 5.60)‡
Cognition									
Intact/ borderline	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.69 (1.55, 1.83)‡	1.67 (1.46, 1.88)‡	1.14 (0.85, 1.43)‡	1.51 (1.31, 1.70)‡	1.88 (1.71, 2.04)‡	1.86 (1.50, 2.22)‡	N/A	N/A
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	5.40 (5.21, 5.59)‡	4.94 (4.67, 5.21)‡	4.21 (3.81, 4.61)‡	5.16 (4.91, 5.41)‡	5.57 (5.34, 5.79)‡	5.35 (4.88, 5.81)‡	N/A	N/A
Hearing impairment									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.14)	0.02 (-0.12 0.15)	0.07 (-0.12, 0.26)	-0.13 (-0.71, 0.45)	-0.04 (-0.26, 0.18)	-0.04 (-0.18, 0.11)	0.26 (0.002, 0.51)*	0.43 (0.14, 0.72)†	0.08 (-0.04, 0.20)
Missing data	0.66 (-0.15, 1.46)	0.33 (-0.67, 1.34)	1.21 (-0.09, 2.52)	1.85 (-0.79, 4.49)	0.005 (-1.21, 1.22)	1.18 (-0.21, 2.57)	0.007 (-3.06, 3.08)	0.32 (-1.27, 1.90)	0.74 (-0.16, 1.64)
Body mass index (BMI)									
BMI < 18.5	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.56 (-0.71, -0.41)‡	-0.52 (-0.84, -0.21)†	-0.03 (-0.57, 0.52)	-0.46 (-0.72, -0.19)†	-0.67 (-0.86, -0.49)‡	-0.55 (-0.89, -0.20)†	-0.80 (-1.16, -0.43)‡	-0.51 (-0.66, -0.36)‡
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.83 (-0.99, -0.66)‡	-1.04 (-1.36, -0.71)‡	-0.69 (-1.24, -0.14)*	-0.82 (-1.09, -0.54)‡	-0.96 (-1.17, -0.76)‡	-0.83 (-1.23, -0.44)‡	-1.04 (-1.42, -0.67)‡	-0.97 (-1.14, -0.80)‡
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.52	-0.89	-0.68	-0.55	-0.62	-0.31 (-0.80, 0.18)	-0.50	-0.98

		Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
	Model 1	Females (n=54,953)	Males (n=22,212)	Age 65-74 (n=7,859)	Age 75-84 (n=25,703)	Age 85-94 (n=36,676)	Age 95-105 (n=6,927)	No cognitive impairment (n=18,426)	Cognitive impairment present (n = 58,739)
		(-0.69, -0.34)‡	(-1.24, -0.53)‡	(-1.23, -0.12)*	(-0.84, -0.26)‡	(-0.84, -0.41)‡		(-0.89,-0.10)†	(-1.16, -0.81)‡
Pain									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)‡	0.25 (0.13, 0.36)‡	0.39 (0.22, 0.57)‡	0.26 (-0.03, 0.54)	0.18 (0.03, 0.34)*	0.34 (0.20, 0.48)‡	0.19 (-0.09, 0.48)	0.50 (0.30, 0.69)‡	-0.007 (-0.12, 0.11)
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.78 (0.64, 0.92)‡	0.90 (0.68, 1.13)‡	0.70 (0.35, 1.05)‡	0.76 (0.57, 0.95)‡	0.86 (0.69, 1.02)‡	0.67 (0.28, 1.05)†	0.81 (0.59, 1.04)‡	0.62 (0.47, 0.76)‡
Pressure ulcer	2.67 (2.52, 2.82)‡	2.70 (2.52, 2.87)‡	2.59 (2.32, 2.86)‡	3.03 (2.57, 3.48)‡	2.70 (2.45, 2.95)‡	2.63 (2.42, 2.84)‡	2.39 (1.98, 2.81)‡	3.34 (2.98, 3.71)‡	2.78 (2.62, 2.94)‡
Urinary incontinence	4.19 (4.04, 4.35)‡	4.30 (4.12, 4.49)‡	3.97 (3.76, 4.19)‡	4.00 (3.66, 4.34)‡	4.19 (3.98, 4.40)‡	4.28 (4.08, 4.49)‡	4.06 (3.66, 4.45)‡	4.48 (4.25, 4.71)‡	4.28 (4.10, 4.46)‡
Visual impairment									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Moderate impairment	0.68 (0.59, 0.77)‡	0.68 (0.57, 0.78)‡	0.70 (0.55, 0.85)‡	0.73 (0.48, 0.98)‡	0.64 (0.50, 0.79)‡	0.67 (0.55, 0.79)‡	0.80 (0.53, 1.07)‡	0.53 (0.33, 0.73)‡	0.99 (0.88, 1.09)‡
Severe impairment	2.49 (2.33, 2.65)‡	2.45 (2.27, 2.63)‡	2.58 (2.30, 2.86)‡	2.82 (2.38, 3.26)‡	2.72 (2.45, 3.00)‡	2.39 (2.18, 2.60)‡	2.21 (1.83, 2.59)‡	1.98 (1.49, 2.48)‡	3.50 (3.32, 3.67)‡
Prevalent Chronic Conditions									
Arthritis	0.08 (-.0003, 0.15)	0.09 (-0.007, 0.18)	0.04 (-0.09, 0.16)	-0.16 (-0.40, 0.08)	0.10 (-0.03, 0.23)	0.12 (0.006, 0.23)*	0.13 (-0.11, 0.38)	0.13 (-0.05, 0.32)	-0.10 (-0.18, -0.008)*
Asthma	0.10 (-0.04, 0.24)	0.09 (-0.06, 0.24)	0.17 (-0.11, 0.45)	0.03 (-0.42, 0.48)	0.10 (-0.14, 0.34)	0.20 (-0.001, 0.40)	-0.11 (-0.62, 0.39)	0.07 (-0.22, 0.35)	0.08 (-0.07, 0.24)
Cancer	-0.12 (-0.19, -0.04)†	-0.15 (-0.25, -0.06)†	-0.06 (-0.20, 0.06)	-0.09 (-0.36, 0.18)	-0.16 (-0.29, -0.03)*	-0.08 (-0.20, 0.02)	-0.17 (-0.43, 0.08)	-0.20 (-0.38, -0.03)*	-0.21 (-0.30, -0.12)‡
Chronic kidney disease	0.31 (0.22, 0.40)‡	0.26 (0.15, 0.37)‡	0.40 (0.24, 0.55)‡	0.39 (0.09, 0.68)*	0.32 (0.17, 0.48)‡	0.31 (0.18, 0.44)‡	0.32 (0.02, 0.62)*	0.22 (0.03, 0.41)*	0.26, (0.15, 0.36)‡
Coronary artery disease	-0.13 (-0.21, -0.05)†	-0.11 (-0.20, -0.02)*	-0.18 (-0.32, -0.04)*	-0.29 (-0.56, -0.02)*	-0.04 (-0.17, 0.10)	-0.15 (-0.26, -0.04)*	-0.19 (-0.44, 0.05)	-0.25 (-0.43, -0.08)†	-0.17 (-0.26, -0.07)‡
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	-0.09 (-0.21, 0.02)	-0.04 (-0.20, 0.12)	-0.09 (-0.38, 0.21)	-0.30 (-0.47, -0.14)‡	0.08 (-0.05, 0.21)	0.11 (-0.21, 0.44)	-0.16 (-0.35, 0.03)	-0.23 (-0.34, -0.12)‡

	Sex Stratified Models			Age Stratified Models				Cognitive Impairment-Stratified Models	
	Model 1	Females (n=54,953)	Males (n=22,212)	Age 65-74 (n=7,859)	Age 75-84 (n=25,703)	Age 85-94 (n=36,676)	Age 95-105 (n=6,927)	No cognitive impairment (n=18,426)	Cognitive impairment present (n = 58,739)
Dementia	-0.22 (-0.35, -0.10)†	-0.32 (-0.47, -0.17)‡	0.02 (-0.20, 0.23)	-0.41 (-0.72, -0.10)*	-0.39 (-0.61, -0.17)‡	-0.10 (-0.29, 0.08)	0.21 (-0.16, 0.59)	-0.25 (-0.43, -0.06)†	0.23 (0.06, 0.40)†
Diabetes	-0.06 (-0.14, 0.02)	-0.03 (-0.13, 0.07)	-0.12 (-0.25, 0.01)	-0.24 (-0.49, 0.009)	-0.10 (-0.23, 0.03)	-0.004 (-0.12, 0.12)	0.32 (0.04, 0.60)*	-0.34 (-0.52, -0.16)‡	-0.12 (-0.21, -0.03)*
Epilepsy	0.47 (0.32, 0.61)‡	0.61 (0.44, 0.78)‡	0.20 (-0.03, 0.44)	0.47 (0.16, 0.77)†	0.36 (0.14, 0.58)†	0.60 (0.37, 0.84)‡	-0.05 (-0.77, 0.67)	0.13 (-0.23, 0.49)	0.62 (0.46, 0.79)‡
Heart failure	0.36 (0.27, 0.46)‡	0.36 (0.25, 0.47)‡	0.37 (0.20, 0.53)‡	0.31 (-0.009, 0.63)	0.41 (0.24, 0.58)‡	0.35 (0.22, 0.48)‡	0.34 (0.06, 0.61)*	0.47 (0.29, 0.65)‡	0.20 (0.09, 0.31)‡
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	1.81 (1.63, 2.00)‡	1.79 (1.55, 2.02)‡	1.59 (1.27, 1.91)‡	1.93 (1.70, 2.17)‡	1.77 (1.55, 1.99)‡	1.57 (1.11, 2.04)‡	2.54 (2.24, 2.83)‡	1.44 (1.27, 1.60)‡
Mood disorder	0.30 (0.22, 0.38)‡	0.32 (0.23, 0.42)‡	0.26 (0.12, 0.41)‡	-0.10 (-0.33, 0.14)	0.20 (0.08, 0.33)†	0.44 (0.33, 0.55)‡	0.38 (0.12, 0.64)†	0.42 (0.23, 0.60)‡	0.15 (0.06, 0.24)†
Parkinson's disease	1.75 (1.63, 1.87)‡	1.79 (1.63, 1.95)‡	1.72 (1.53, 1.91)‡	1.61 (1.25, 1.97)‡	1.87 (1.69, 2.06)‡	1.66 (1.46, 1.86)‡	1.66 (1.09, 2.23)‡	2.18 (1.89, 2.47)‡	1.54 (1.41, 1.67)‡
Peripheral vascular disease	0.03 (-0.10, 0.16)	0.11 (-0.05, 0.27)	-0.10 (-0.31, 0.11)	-0.24 (-0.65, 0.17)	0.01 (-0.21, 0.23)	0.13 (-0.06, 0.31)	0.001 (-0.44, 0.45)	-0.18 (-0.43, 0.06)	-0.03 (-0.18, 0.13)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	-0.39 (-0.49, -0.29)‡	-0.46 (-0.62, -0.31)‡	-0.61 (-0.84, -0.39)‡	-0.38 (-0.52, -0.24)‡	-0.35 (-0.48, -0.23)‡	-0.20 (-0.49, 0.09)	-0.65 (-0.83, -0.46)‡	-0.39 (-0.48, -0.30)‡
Stroke	0.46 (0.38, 0.55)‡	0.48 (0.37, 0.58)‡	0.45 (0.29, 0.60)‡	0.39 (0.13, 0.66)†	0.48 (0.34, 0.63)‡	0.45 (0.32, 0.58)‡	0.56 (0.28, 0.83)‡	0.68 (0.49, 0.86)‡	0.35 (0.25, 0.44)‡

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes

Reference: Variable category is the reference group for all other categories within that variable.

*p-value <0.05

†p-value <0.01

‡p-value <0.0001

N/A – Not applicable; variable not included in indicated model.

15.2.3 Long-term care home characteristics associated with resident disability

Residents' demographic characteristics and morbidity explained 62.7% of the variance in disability score. Although a likelihood ratio test indicated that there were statistically significant between-LTCH differences in resident disability ($\chi^2 = 3389.1$, $p < 0.000$), LTCH variables such as intensity of rehabilitation services or ownership type, explained only an additional 2% of the variance.

15.3 Sensitivity Analyses

Sensitivity analyses that removed geriatric syndromes and chronic conditions from multivariable models (Appendix 3.8) show that geriatric syndromes explained a large amount of the variance in residents' disability, including some of the effects of chronic conditions. In fact, a sensitivity analysis in which only four geriatric syndromes (balance impairment, urinary and bowel incontinence and cognitive impairment) were modelled explained 59.9% of the variance in disability (Appendix 3.8). Use of fixed effects to adjust for clustering within LTCHs did not significantly change any model estimates (Appendix 3.10); proportion of variance in residents' disability attributable to between-home differences was 10.3% in a fixed effects Model 1 versus 9.5% in the random effects Model 1. A version of Model 1 without random or fixed effects for LTCHs explained just as much variance in disability as models that accounted for differences between LTCHS (Appendix 3.10). Use of only administrative claims data to code chronic conditions reduced the effects of limb paralysis or amputation and mood disorders, rendering them non-significant, while significantly increasing the effect of stroke (Appendix 3.11). Use of only RAI-MDS chronic condition codes did not significantly change the effects of any chronic conditions or geriatric syndromes (Appendix 3.11). Exclusion of the 9,302 residents (12% of sample) whose data were from admission assessments had no effect on findings from Model 2 (Appendix 3.12).

16 Discussion

16.1 Geriatric syndromes explain major differences in disability

Geriatric syndromes were much more strongly associated with disability in LTCH residents than were chronic conditions; their removal from Model 1 reduced the R^2 from 62.7% to 11.2% (Appendix 3.8), showing that they explain approximately 50% of unique variation in resident disability in this population-based sample. The geriatric syndromes that were most strongly associated with disability were balance impairment, cognitive impairment and urinary and bowel incontinence; these four syndromes alone explained 59% of variance in disability in sensitivity analyses (Appendix 3.8): both geriatric syndromes and chronic conditions had fairly consistent effects on disability across sex and age groups, however several correlates of disability differed significantly among cognitively impaired versus unimpaired LTCH residents. Characteristics of LTCHs accounted for less than 2% of the variance in resident disability once resident characteristics were considered. These findings suggest that residents and their geriatric syndromes – not the LTCHs in which they live – may be appropriate targets of interventions to reduce disability, and that such interventions may need to differ for cognitively impaired versus unimpaired residents.

16.2 Mechanisms for geriatric syndrome, chronic condition and LTCH effects

The Disablement Process Model that guided hypothesis generation and analysis for this study is also instructive in understanding its main findings. The strong association between geriatric syndromes and disability was insensitive to adjustment for coexisting chronic conditions, whereas effects of chronic conditions diminished or rendered non-significant after adjustment for coexisting geriatric syndromes. A probable mechanism for this finding is that geriatric syndromes mediate some of the effects of chronic conditions on disability, as outlined in the Disablement Process analytic framework in Study 1. For example, limb paralysis or amputation is strongly associated with disability, but some of this association may be mediated by daily pain. An alternative explanation is that geriatric syndromes are proxy measures for disease severity or

close proximity to end of life, both of which are associated with disability but not directly measured in our study.

Although there was significant variation in the distribution of LTCH characteristics, descriptive analyses showed that these variations were not associated with corresponding variations in resident disability. This is the likely cause of the lack of explanatory power LTCH characteristics had in models of resident disability.

16.3 Understanding effect modification by age, sex and cognitive impairment

The consistency of chronic condition and geriatric syndrome effects on disability across age and sex strata may represent a nullification of age- and sex- effect modification due to the advanced age and morbidity of LTCH residents. However, it is also possible that females and the oldest old residents in whom chronic conditions and geriatric syndromes were the most strongly associated with disability were under-represented in this cross-sectional sample due to early mortality. We found that some chronic conditions and geriatric syndromes effected residents who were cognitively impaired differently than those who were cognitively intact. Cognitive impairment may exacerbate the effect of prevalent conditions and syndromes due to its impact on older adults' ability to self-care (Feil, Zhu, & Sultzer, 2012), whereas activity-limiting conditions like limb paralysis and Parkinson's may have stronger effects among cognitively intact residents due to their lower overall disability.

16.4 Findings in the context of existing evidence

The dominance of geriatric syndromes over chronic conditions as determinants of health status has recently been demonstrated in community-dwelling older adults (Koroukian et al., 2016), but our exploration of this relationship in LTCH residents offers new insight. Other studies of geriatric syndromes' effect on disability in LTCH residents adjusted for number of chronic conditions, rather than examining the effects of specific chronic conditions alongside specific geriatric syndromes (Chen et al., 2013; Phillips et al., 2008; Phillips et al., 2007; Wang et al.,

2009). Our inclusion of specific chronic conditions in multivariable models revealed that effects of some chronic conditions (e.g. dementia) were particularly sensitive to adjustment for coexisting geriatric syndromes in models of disability.

While we found a stronger effect of pressure ulcer on disability in cognitively intact residents, the effect of bowel incontinence and visual impairment on disability was significantly stronger in cognitively impaired residents in our sample. These mixed results align with existing evidence, some of which supports exacerbated effects of chronic conditions among cognitively impaired older adults (Fultz et al., 2003) and some of which shows worse effects among cognitively intact older adults (Wang et al., 2010).

The proportion of variance in resident disability (<2%) explained by LTCH characteristics in this sample is smaller than the 8-25% variance in ADL LFS found by Phillips et al in their studies of 1,334 American LTCHs (2008; 2007). We hypothesize that this difference occurred because we adjusted for significantly more chronic conditions and geriatric syndromes than Phillips et al, and explained a larger proportion of total model variance (R^2 = 64.2%) than Phillips et al achieved (R^2 = 18%) (Phillips et al., 2007), thus reducing variance attributed LTCHs. The weak effects of specific LTCH variables in our study is consistent with another study of LTCH effects on disablement in LTCH residents (Wang et al., 2009), as well as equivocal evidence for the relationship between LTCH characteristics and other resident health outcomes (Comondore et al., 2009; Zimmerman et al., 2013).

16.5 Strengths

This study used health administrative data in a single-payer health care system to study the relationships between resident morbidity, LTCH characteristics and disability in a large, representative sample with adjustment for multiple confounders. Our large sample size also allowed for examination of effects among strata of putative effect modifiers that were larger than many studies' main samples. In contrast with most studies in LTCH residents that use either validated administrative claims algorithms or RAI-MDS active diagnoses to identify chronic conditions, we combined these measures and tested the sensitivity of our findings to this choice.

Although claims data tend to be more sensitive for the detection of some diagnoses (e.g. heart failure, arthritis), RAI assessments are more sensitive to other conditions (e.g. Alzheimer's, hip fracture) (Lix et al., 2014). Our findings suggest that using combined chronic condition measures from both data sources yields findings that are fairly comparable to those generated using only one. Existing studies that examine the relationship between morbidity and disability either do not include specific chronic conditions in models (Chen et al., 2013; Phillips et al., 2008; Phillips et al., 2007; Wang et al., 2009), or do not examine the sensitivity of model estimates to adjustment for geriatric syndromes (Fedecostante et al., 2015). By doing both, we produced robust empirical findings while also strengthening a theory-based analytic framework for use in future longitudinal studies in older adults.

16.6 Limitations

Due to the cross-sectional nature of our study, we cannot make causal inferences regarding the associations that we report. Our sample also captures residents at different stages of their LTCH journey; because the magnitude of association between specific chronic conditions and geriatric syndromes and disability may change over time since admission, we adjusted multivariable models for the duration of time residents had been in their LTCH. We did not have data on numerous LTCH characteristics potentially associated with residents' disability, therefore interpretation of the effects for the few LTCH variables we did measure (e.g. for-profit ownership) should be tempered by the knowledge that these variables may be absorbing variance from unmeasured variables. However, we did replicate our findings in fixed effect models and thus verified that they were not due our inability to measure relevant LTCH characteristics in our random effects models.

17 Conclusions

Our findings show that geriatric syndromes explain more variation in resident disability than chronic conditions and features of LTCHs combined. These findings suggest that residents and their geriatric syndromes – not the LTCHs in which they live – may be the appropriate target of interventions to reduce disability, and that such interventions may need to differ for cognitively

impaired versus unimpaired residents. These findings should be further explored in longitudinal studies.

Chapter 4
Low Disability at Admission Predicts Disablement in Long-Term Care Residents

18 Abstract

Objectives: To determine whether high versus low disability at admission to long-term care is associated with residents' subsequent disablement over two years and to test whether balance impairment, cognitive impairment and pain at admission to long-term care are predictive of subsequent rate of disablement.

Methods: We conducted a longitudinal study using health administrative data for a cohort of 12,334 residents admitted to 633 Ontario long-term care homes between April 1st 2011 and March 31st 2012. Eligible residents received an admission assessment of disability using the RAI-MDS 2.0 activities of daily living (ADL) long-form score (range: 0 – 28), as well as two subsequent disability measures in the home they were admitted to. Hierarchical multivariable regression models with random effects for residents, long-term care homes and the effect of time (months) were used to estimate the confounder-adjusted association between high versus low disability, pain, balance impairment and cognitive impairment at admission with residents' rate of disablement over two years.

Results: At admission, residents had a median disability score of 13 measured using the ADL long-form score. The 6,229 residents with disability scores below or equal to this median at admission experienced disablement at a rate of 0.43 (95% CI: 0.42, 0.45) points per month, whereas those with above-median disability at admission became disabled at a rate of 0.17 (95% CI: 0.15, 0.18) points per month. Pain, balance impairment and cognitive impairment present at admission had negligible effects on resident disablement over two years.

Conclusion: Residents who were more disabled at admission experienced disablement over two years at a slower rate than residents who were less disabled at admission. This rate difference was clinically significant and may reflect an untapped opportunity for slowing disablement among residents who are admitted to long-term care with low disability.

19 Introduction

Demand for institutional long-term care is increasing globally, as are the acuity and complexity of long-term care (LTCH or "nursing home") residents (Katz, 2011). Most LTCH residents have disability at admission (CIHI, 2013) and experience disablement over the course of their time in long-term care (Dutcher et al., 2014). Because disablement is associated with lower self-rated quality of life (Andersen et al., 2004), repeat hospitalizations (Kruse et al., 2013), higher health care utilization (de Meijer et al., 2009), and all-cause mortality (Thomas et al., 2013; Yeh et al., 2014), frontline staff in Canadian and American LTCHs are required to assess disability at admission and incorporate strategies for minimizing disablement into residents' care plans (Hawes et al., 1997; OMHLTC, 2010). Understanding the association of disablement with specific clinical indicators at admission can inform care planning and guide cost-effective allocation of rehabilitation and restorative care services.

Study 2 demonstrated that geriatric syndromes have particularly strong cross-sectional associations with disability in Ontario LTCH residents. Geriatric syndromes present at admission to long-term care could also increase the *rate* at which residents become disabled over the course of their stay. The geriatric syndromes most strongly associated with disability in Study 2 were balance impairment, severe cognitive impairment, pressure ulcer, and urinary or bowel incontinence; however the mechanism through which the latter three would cause disablement in multiple activities of daily living (Appendix 3.2) is unclear. This study focuses on geriatric syndromes strongly associated with disability in Study 2 for which global effects on disablement could be expected. Balance impairment or pain at admission could hasten disablement through activity restriction, either due to fear of falling or discomfort with movement (Allison, Painter, Emory, Whitehurst, & Raby, 2013; Krein, Heisler, Piette, Makki, & Kerr, 2005). Similarly, cognitive impairment could accelerate disablement through lack of comprehension or motivation to maintain activity (Fultz et al., 2003), or by delaying identification and treatment of disabling comorbidities (McConnell, Branch, Sloane, & Pieper, 2003).

Study 1 found that prevalent geriatric syndromes are associated with disability, which is itself a strong predictor of subsequent disablement. Many existing studies of geriatric syndromes as accelerators of resident disablement do not account for the direct effects of baseline disability on

disablement (Burge, von Gunten, & Berchtold, 2013; Fedecostante et al., 2015; Talley et al., 2015; Wang et al., 2009), which hampers their clinical interpretation. Studies that have examined the direct effect of disability on subsequent disablement in LTCH residents have not done so in an admission cohort (Kruse et al., 2013) or have restricted analyses to residents with a low level of disability at admission (Buttar, Blaum, & Fries, 2001) or residents without multiple chronic conditions (Carpenter et al., 2006). Small sample size (Buttar et al., 2001), short duration of follow-up (Buttar et al., 2001; Wang et al., 2009), and dichotomization of disablement outcomes as "declined" versus "did not decline" (Burge et al., 2013; Buttar et al., 2001) also weaken our understanding of the role geriatric syndromes and disability at admission have in hastening disablement of LTCH residents.

The objective of this study was to gain insight about the influence of disability and geriatric syndromes present at admission on LTCH residents' subsequent disablement. We sought to answer the following research questions in a population cohort of newly admitted LTCH residents followed for two years:

1. Is high versus low disability at admission to LTCH associated with an increased rate of disablement over two years?
2. Are balance impairment, moderate severe to severe cognitive impairment, and daily or severe daily pain at admission associated with an increased rate of disablement over two years?

We hypothesize that both high disability and presence of these three geriatric syndromes at admission will be independently associated with increased rate of disablement in LTCH residents due to their association with activity restriction and reduced management of comorbidities.

20 Methods

We conducted a population-based longitudinal cohort study to determine the association between high versus low disability, balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain at admission to long-term care with disablement over two years. We enrolled all LTCH residents in Ontario, Canada, who were newly admitted to an LTCH and received a Resident Assessment Instrument Minimum Dataset 2.0 (RAI-MDS) admission assessment between April 1st, 2011 and March 31st, 2012. We then applied several exclusions

(Appendix 4.1), such that residents included in the study sample had at least two subsequent RAI-MDS assessments in the LTCH that they were admitted to and had admission disability scores below the maximum score of 28.

We used residents' de-identified and encrypted provincial health insurance numbers to link health administrative databases housed at the Institute for Clinical Evaluative Sciences (ICES). ICES is a prescribed entity for the purposes of section 45 of Ontario's Personal Health Information Privacy Act.

20.1 Data Sources

Resident records were linked using unique, anonymized, encrypted identifiers across multiple Ontario health administrative databases containing information on all publicly insured, medically necessary hospital and physician services. These included the Discharge Abstract Database (DAD) for chronic conditions coded during hospital admissions; the Ontario Health Insurance Plan (OHIP) for physician billings, including diagnosis codes and procedures; the Registered Persons Database (RPDB) for resident age and sex; and the Continuing Care Reporting System (CCRS) for repeated resident disability measures, demographic characteristics and geriatric syndrome diagnoses obtained from RAI-MDS assessments (Hirdes et al., 2013). The RAI-MDS is a standardized, multidimensional assessment tool used in LTCHs across Canada, the US and Europe (Hirdes, Ljunggren, et al., 2008). Trained LTCH staff complete the assessments when residents are admitted to LTCH, quarterly, and when there is any significant resident health status change (Hirdes et al., 2011).

20.2 Outcome

The primary outcome was repeated measures of disability from RAI-MDS assessments done approximately every three months over two years. Disability was measured using the Activities of Daily Living Long-Form Score (ADL LFS), which quantifies resident disability from 0 to 28 based on degree of dependence on others for bed mobility, transfer, locomotion, dressing, eating, toilet use and personal hygiene (Appendix 3.2). Higher values of ADL LFS indicate higher disability. A one-point increase in ADL LFS is considered clinically significant, as it indicates increased dependence in an ADL or dependence in a new ADL, both of which are associated

with intensified care needs from LTCH staff (Carpenter et al., 2006). The ADL LFS has been validated against standardized measures of disability (Frederiksen K. et al., 1996; Lawton M.P. et al., 1998), is reliable and internally consistent (Hawes et al., 1995; Morris et al., 1999), and responsive to changes in disability over time (Carpenter et al., 2006). Time was measured in months since the date of residents' admission assessment.

Although it is an ordinal measure, ADL LFS was treated as a continuous variable in this study, in keeping with statistical guidelines (Rhemtulla et al., 2012) and precedent in other research (Fedecostante et al., 2015; Wang et al., 2010; Wang et al., 2009; Wolinsky et al., 2000a). Appendix 4.2 shows the broad distribution of disability scores in sample residents at admission. Among individuals who died during the two-year observation period, a final ADL LFS measure of 28 was imputed on the date of their death. This analytic treatment of missing data due to adverse events has precedent in other longitudinal studies of disablement (Kurella Tamura et al., 2009; Spiers et al., 2005) and aligns with extant knowledge on the rapid disablement individuals experience in the month prior to death (Gill, Gahbauer, Han, & Allore, 2010).

20.3 Exposures

To assess the effect of high versus low disability at admission, a dichotomous variable for resident disability at admission classified residents as having a disability score that was less than or equal to the sample median of 13 (ADL LFS of 0 to 13) or greater than the sample median (ADL LFS of 14 to 27). Categories of this variable will henceforth be described as "low disability" (ADL LFS 0 to 13) or "high disability" (ADL LFS of 14 to 27), with recognition that these are relative terms and a disability score of 12 is not "low" on an absolute scale.

Residents were classified as having balance impairment if during an admission test of balance from standing (Appendix 4.3) they were identified as either requiring partial physical support during the test, or being unable to attempt to balance from standing without help. Residents were classified as having moderate severe to severe cognitive impairment if they had RAI-MDS cognitive performance scores (range: 0 – 6) of 4, 5 or 6. Residents were classified as having daily or severe daily pain if their RAI-MDS admission assessor indicated that they were experiencing either daily pain or daily pain that was severe.

20.4 Covariates

Selection of covariates for multivariable models was guided by the evidence-based analytic framework of variables in the Disablement Process Model from Study 1. This included sociodemographic characteristics, 16 coexisting chronic conditions that had been treated or affected medical management in the five years prior to admission, and six additional geriatric syndromes present at admission; the diagnostic codes used to define these covariates are identified in Appendices 3.4 and 3.5.

20.5 Statistical Analyses

Individual residents were the unit of analysis; the outcome was repeated measures of disability measured with the 29-point ADL LFS from RAI-MDS assessments done approximately every three months over two years. The exposures were high versus low disability at admission, presence or absence of balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain at admission to long-term care. Likelihood ratio tests confirmed the need for resident and LTCH random effects and a random coefficient for time (Appendix 4.4). For each exposure variable, hierarchical linear regression models were then run containing a main effect coefficient for the exposure (e.g. balance impairment), time, and an interaction between time and the exposure, as well as random intercepts for residents and LTCHs and a random coefficient for time. In each of these models, the coefficient for time represents' average rate of disablement (change in disability score) in the reference group. Following the bivariate regressions, multivariable hierarchical linear regression models were developed sequentially as follows:

- Model 1 contained random effects for LTCHs, residents and time, and fixed effects for geriatric syndromes, chronic conditions and sociodemographic characteristics. Coefficients in this model reflect the association between variables and disability measured at admission.
- Model 2 added an interaction term between time and the dichotomous "high versus low disability at admission" variable. The coefficient for this interaction term reflects the incremental association between high disability at admission and monthly rate of disablement over two years.

- Model 3 added interaction variables between time and each of the three geriatric syndromes of interest to Model 2. The coefficients for these interaction terms reflect the incremental effect of balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain on monthly rate of disablement over two years.

Supplementary analyses verified the assumption of normally distributed random effects and residual errors (Appendix 4.5) and examined the sources of variation in disability (assessments, residents, LTCHs) using boxplots. A quadratic term for time was tested in the models to verify that it did not improve model fit or change model findings (Appendix 4.6). Analyses also examined: the association between location from which residents were admitted (i.e. home, hospital, and other residential care facilities) and disability at admission; the prevalence of the three geriatric syndromes among individuals with high disability at admission; the fate of residents who died during the observation period; and whether residents with geriatric syndromes were more likely to die during the observation period. Finally, the frequency and distribution of resident characteristics in the study sample was compared to characteristics of residents who were excluded from the sample because they had less than two post-admission RAI-MDS assessments.

Sensitivity Analyses

To test whether imputation of a final disability score of 28 among those who died during the observation period affected results, we re-ran Model 3 in the study sample without imputation. A complete case analysis (excluding all residents who died during observation) was conducted to examine the effect of mortality selection on main findings. To examine the sensitivity of our findings to coding of chronic conditions, we re-ran Model 3 using chronic condition codes from RAI-MDS admission assessments only. Descriptive analyses were done using SAS version 9.3 (SAS Institute, 2012) and regression modelling was done in STATA. This study received ethics approval from the University of Toronto Office of Research Ethics and the Sunnybrook Health Sciences Research Ethics Board (Appendix 3.6).

21 Results

21.1 Resident characteristics

A total of 12,334 residents from 633 Ontario LTCHs were included in the sample and are described in Table 4.1. The mean disability score for all residents at admission to long-term care was 13.0 (SD: 7.2); 67.7% of residents were female and their mean age was 84.1 years (SD: 7.2). The 30% of residents admitted from home had a significantly lower mean disability score (10.7, SD: 6.8) than the 30% admitted from hospital (15.9, SD: 6.9) (Appendix 4.7). Residents in the sample had a median of nine assessments (IQR: 7, 9) in the observation period, including their admission assessment. The median number of days between each assessment was 90.5 (IQR: 85.0, 91.0), suggesting that most residents were being assessed quarterly, as is provincially mandated. The boxplots in Appendix 4.8 illustrate that there was more variability in disability scores within LTCHs than between them, and that variability between residents was greater than variability within residents over time. Residents who had balance impairment at admission had significantly higher disability (15.6, SD: 6.7) than the sample as a whole, as did residents with moderate-severe to very severe cognitive impairment (17.7, SD: 6.3) and daily or severe daily pain (14.1, SD: 7.3) (Appendix 4.9a). The proportion of "high disability" residents with severe cognitive impairment and daily or severe pain at admission was similar in the proportion in the whole sample, but residents with balance impairment were particularly concentrated in the "high disability" group (Appendix 4.9a).

Table 4.1: Resident Characteristics at Admission to Long-Term Care

	N	**%**	**Mean ADL LFS (SD) at Admission**
Full Cohort	12,334	100	13.0 (7.2)
Activities of Daily Living Score at Admission			
0 – 13	6,229	50.5	6.8 (4.1)‡
14 – 27	6,105	49.5	19.2 (3.4)‡
Age (years)			
65 – 74	1,321	10.7	12.9 (7.5)
75 – 84	4,580	37.1	12.7 (7.2)
85 – 94	5,697	46.2	13.0 (7.2)

	N	%	Mean ADL LFS (SD) at Admission
95+	7,36	6.0	14.3 (7.0)
Sex			
Female	8,348	67.7	12.9 (7.2)
Male	3,986	32.3	13.0 (7.3)
Marital Status			
Married	3,713	30.1	13.5 (7.3)
Widowed	6,870	55.7	12.7 (7.2)
Never married/ Separated/Divorced	1,518	12.3	12.5 (7.3)
Missing	233	1.9	13.3 (7.2)
Pre-NH Neighborhood Income Quintile			
1 (low)	2,830	22.9	12.4 (7.3)
2	2,306	18.7	13.2 (7.2)
3	2,039	16.5	13.1 (7.2)
4	1,786	14.5	13.1 (7.2)
5 (high)	1,551	12.6	13.3 (7.1)
Missing	1,822	14.8	13.0 (7.4)
Geriatric Syndromes			
Balance impairment	7,790	63.2	15.6 (6.7)‡
Bowel incontinence	3,746	30.4	18.3 (5.6)‡
Cognition			
Intact or borderline	3,309	26.8	11.3 (7.6)‡
Moderate impairment	7,246	58.8	12.6 (6.8)‡
Moderate-Severe/very severe impairment	1,779	14.4	17.5 (6.3)‡
Hearing impaired	1,762	14.3	13.9 (6.9)‡
BMI			
BMI < 18.5	1251	10.1	14.8 (7.2)
18.5 ≤ BMI ≤ 25	5583	45.3	13.0 (7.2)
25 < BMI <30	3355	27.2	12.2 (7.2)
BMI ≥ 30	2145	17.4	13.0 (7.2)
Pain			
No pain	7,169	58.1	12.4 (7.2)‡
Less than daily pain	3,095	25.1	13.5 (7.0)‡
Daily or severe daily pain	2,070	16.8	14.1 (7.3)‡
Pressure ulcer	662	5.4	18.8 (5.7)‡
Urinary incontinence	6878	55.8	16.0 (6.2)‡
Visual impairment			
Moderate impairment	4131	33.5	13.9 (7.0)‡

	N	%	Mean ADL LFS (SD) at Admission
Severe impairment	588	4.8	16.6 (7.1)‡
Chronic Conditions			
Arthritis	5897	47.8	13.4 (7.2)‡
Asthma	688	5.6	13.4 (7.1)
Cancer	4305	34.9	12.9 (7.3)
Kidney disease	2479	20.10	14.2 (7.2)‡
Coronary artery disease	4303	34.9	13.2 (7.3)*
COPD	1974	16.0	12.9 (7.3)
Dementia	8572	69.5	13.1 (7.2)*
Diabetes	3664	29.7	13.4 (7.2)‡
Epilepsy	426	3.5	14.3 (7.2)‡
Heart failure	2703	21.9	13.9 (7.2)‡
Limb paralysis or amputation	1802	14.6	12.9 (7.0)
Mood disorders	1941	15.7	13.1 (7.4)
Parkinson's disease	896	7.3	16.0 (6.6)‡
Peripheral vascular disease	440	3.6	13.3 (7.0)
Psychiatric conditions other than depression and dementia	2661	21.6	13.4 (7.2)*
Stroke	2517	20.4	15.2 (7.1)‡

*p-value <0.05 in ANOVA
†p-value <0.01 in ANOVA
‡p-value <0.0001 in ANOVA

Appendix 4.9b shows that between admission and the end of two years observation, 4,213 (34%) of the 12,334 residents in the sample had died. Most of them (70%) died in the LTCH to which they were admitted, while 28% died in hospital. A comparable proportion of residents with daily or severe daily pain died (34%) during follow-up, whereas a larger proportion of residents with balance impairment (38%) or moderate severe to severe cognitive impairment (40%) died within two years of admission. Residents who were excluded from the sample because they had fewer than two post-admission RAI-MDS measures of disability had higher mean disability at admission (17.5, SD: 7.3) than those who were included in the sample (13.4, SD: 7.5), were more likely to be male, underweight, have balance impairment, bowel and urinary incontinence, daily or severe daily pain, cancer, kidney disease, coronary artery disease, chronic obstructive

pulmonary disease, diabetes and heart failure (Appendix 4.10). Excluded residents had lower prevalence of dementia and Parkinson's disease than sample residents and comparable levels of moderate to severe cognitive impairment (Appendix 4.10).

21.2 Unadjusted associations between disability and geriatric syndromes at admission with disablement LTCH residents

Figure 4.1 illustrates the unadjusted differences in admission disability and rate of disablement in LTCH residents with high versus low disability, cognitive impairment, balance impairment and pain at admission. These figures are based on the outputs of models of the rate of change in repeated disability measures over two years, with coefficients for the main effects of exposure variables, time, and their interaction (Table 4.2). The model of high versus low disability at admission unadjusted for covariates (Figure 4.1A), shows that residents who had low disability at admission experienced disablement at a rate of 0.44 points per month in long-term care, whereas residents who had high disability at admission acquired new disability more slowly, at a rate of only 0.18 points per month[1], unadjusted for other resident characteristics. In unadjusted models for balance impairment, moderate severe to severe cognitive impairment and pain (Figure 4.1B-D), this finding was replicated but smaller in magnitude: residents with these geriatric syndromes had higher disability at admission, but slower rates of disablement over two years.

[1] Calculated from Table 4.2 as the mean rate of change in disability in less disabled reference group 0.44 (0.42, 0.45) plus the mean rate in the more disabled group -0.26 (-0.27, -0.24) = 0.44 + (-0.26) = 0.18.

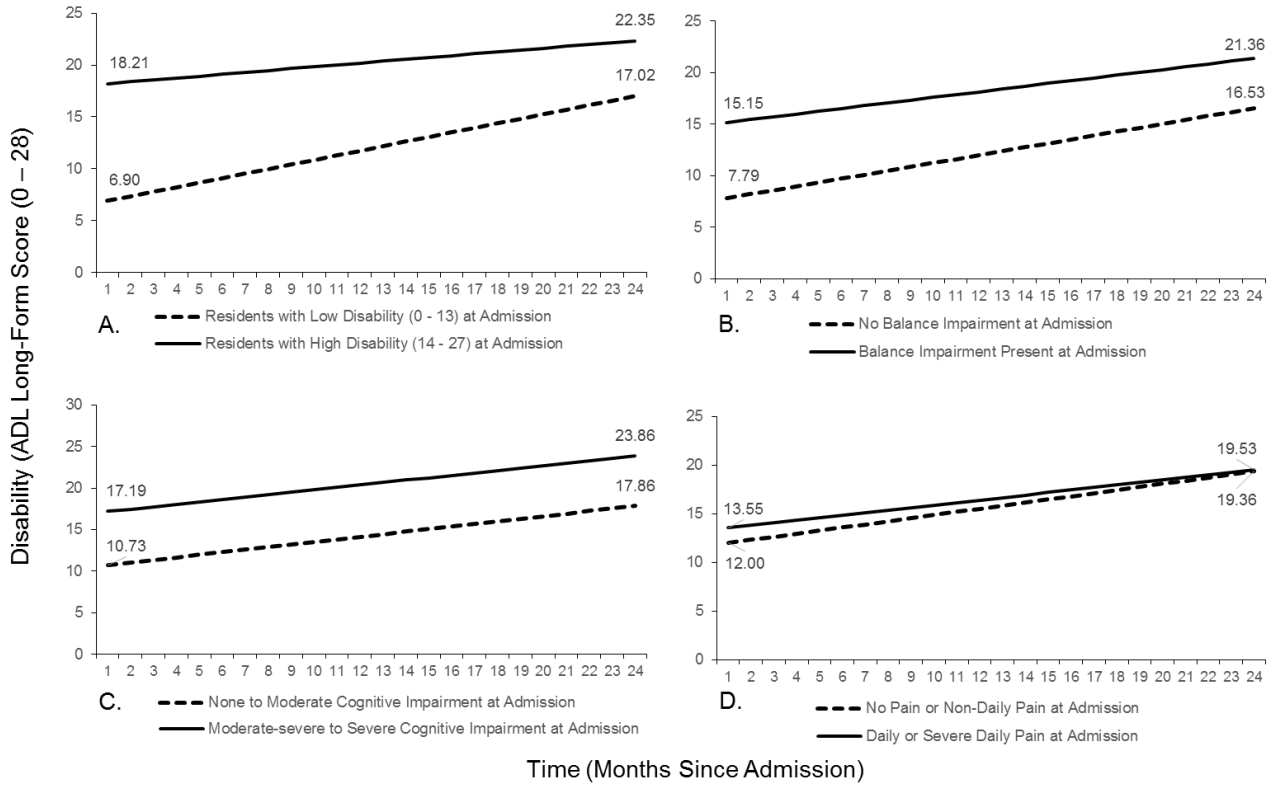

Figure 4.1: Unadjusted Differences in Admission Disability and Rate of Disablement in LTCH Residents with High versus low Disability, Cognitive Impairment, Balance Impairment and Pain at Admission.

Note: Increasing disability (ADL Long-Form Score) is undesirable; an upward sloping line indicates residents are becoming more disabled over time.

Table 4.2: Unadjusted Associations of Resident Disability and Geriatric Syndromes Present at Admission with Disablement in Newly Admitted LTC Residents

	Models for Exposure Variable at Admission Interacted with Time without Covariate Adjustment			
	ADL Score of 14-27 (vs. ADL Score of 0 -13) at Admission	Balance Impairment (vs. no balance impairment)	Moderate-severe to severe cognitive impairment (vs. none to moderate cognitive impairment)	Daily or severe daily pain (vs. no pain or non-daily pain)
Model Coefficients				
Constant	6.90 (6.72, 7.09)‡	7.79 (7.50, 8.08)‡	10.73 (10.41, 11.05)‡	12.00 (11.74, 12.28)‡
Time	0.44 (0.42, 0.45)‡	0.38 (0.36, 0.40)‡	0.31 (0.30, 0.32)‡	0.32 (0.31, 0.33)‡
Exposure§	11.31 (11.09, 11.54)‡	7.36 (7.09, 7.62)‡	6.46 (6.03, 6.89)‡	1.55 (1.16, 1.93)‡
Exposure*Time	-0.26 (-0.27, -0.24)‡	-0.11 (-0.13, -0.10)‡	-0.02 (-0.04, -0.01)†	-0.06 (-0.08, -0.04)‡
Random Effects				
$\sqrt{\psi_{11}^{(2)}}$	3.91	5.70	1.95	2.14
$\sqrt{\psi_{22}^{(2)}}$	0.33	0.34	0.35	0.35
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$	0.04	-0.21	-0.27	-0.26
$\sqrt{\psi_{11}^{(3)}}$	0.98	2.30	6.36	6.61
$\sqrt{\theta}$	3.39	3.40	3.40	3.40

†p-value <0.01
‡p-value <0.0001
§ Exposure variable either high ADL score at admission, balance impairment, moderate-severe to severe cognitive impairment or daily or severe daily pain, as indicated in top row.
$\sqrt{\psi_{11}^{(2)}}$ = Between-resident, within home variance of random intercept $\zeta_{1jk}^{(2)}$
$\sqrt{\psi_{22}^{(2)}}$ = Between-resident, within home variance in random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$ = Covariance of random intercept $\zeta_{1jk}^{(2)}$ and random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{11}^{(3)}}$ = Between-home variance of random intercept $\zeta_k^{(3)}$
$\sqrt{\theta}$ = Between-assessment, within-resident, within home variance of level-1 residuals ε_{ijk}

Each model contains the main effect of the exposure variable (disability at admission or geriatric syndromes), the main effect of time, an interaction term for the exposure variable with time, a random coefficient for time, and random intercepts for residents and LTCHs.
For example, the "bivariate" model for balance impairment*time was run as:
$y_{ijk} = \beta_1 + \beta_2 t_{ijk} + \beta_3 balance_{jk} + \beta_4 (balance*time)_{jk} + \zeta_{1jk}^{(2)} + \zeta_{2jk}^{(2)} \cdot t_{ij} + \zeta_k^{(3)} + \varepsilon_{ijk}$
Where:
y_{ijk} = ADL LFS at assessment *i* for resident *j* in long-term care home *k*
β_1 = the grand mean of ADL LFS across all n_k homes in sample.
$\beta_2 t_{ijk}$ = the effect of time (in months) on ADL LFS in resident *j*, in long-term care home *k*
$\zeta_{1jk}^{(2)}$ = the random deviation of resident *j*'s admission ADL LFS from the mean admission ADL LFS of residents within in LTCH *k*.
$\zeta_{2jk}^{(2)} \cdot t_{ij}$ = the random deviation of resident *j*'s ADL LFS slope from the mean slope of residents in LTCH *k.*
$\zeta_k^{(3)}$ = random intercept (mean ADL LFS) for all residents in LTCH *k*.
ε_{ijk} = level-1 residuals

21.3 Multivariable models of disablement in LTCH residents

The main-effect estimates in Table 4.3 indicate variables' association with disability at admission (intercepts) adjusting for all other variables in the model; exposures' adjusted effect on rate of disablement over time are determined from estimates of each variable's interaction with time (slopes). Figure 4.2 illustrates differences in admission disability and rate of disablement over two years in LTCH residents with high versus low disability, cognitive impairment, balance impairment and pain at admission. Figure 4.2 is based on outputs from Model 3 in Table 4.3; it compares level of disability at admission and rate of disablement in residents with these exposures to residents without any of these exposures (Figure 4.2, solid black line), adjusted for resident demographic characteristics and comorbid chronic conditions and geriatric syndromes.

Similar to the results of the bivariate regressions illustrated in Figure 4.1, the adjusted model in Figure 4.2 shows that residents with high disability at admission are the most different from the reference group: after adjusting for comorbidities and demographic characteristics, residents in the high disability group (dotted black line) had an average disability score 8.3 (8.07, 8.52, p <0.0001) points higher at admission than those in the reference group (solid black line), but acquired new disability at a rate of 0.17 points[2] per month, which was significantly slower than the 0.43 points per month among residents with low disability at admission. This means that holding all other variables in the model equal, residents who were in the reference group at admission added an average of 6.24 points *more* to their disability scores over the two year study period than residents who had high disability at admission.

Figure 4.2 also depicts the adjusted relationships between geriatric syndromes and repeated measures of disability from Model 3 (Table 4.3). It shows that despite its strong association with higher disability at admission to long-term care, balance impairment (black dashed line) was not significantly associated with disablement over the study period, as indicated its parallel course with the solid black reference line. Residents with moderate severe to severe cognitive

[2] Calculated as mean rate in less disabled group 0.43 (0.42, 0.45) plus the mean rate in the more disabled group -0.26 (-0.28, -0.25) = 0.43 + (-0.26) = 0.17.

impairment (grey dash-dot line) had adjusted disability scores 2.78 (95% CI: 2.49, 3.07, p<0.0001) points higher than the reference group at admission, but experienced disablement at a comparable rate over time. Similarly, residents with daily or severe daily pain (grey dotted line) had statistically (but not clinically) higher adjusted disability at admission than the reference group, but experienced disablement at a comparable rate over two years. For both cognitive impairment and pain, the difference in the rate of disablement from the reference group created less than a one point difference in disability from the reference group at the end of two years.

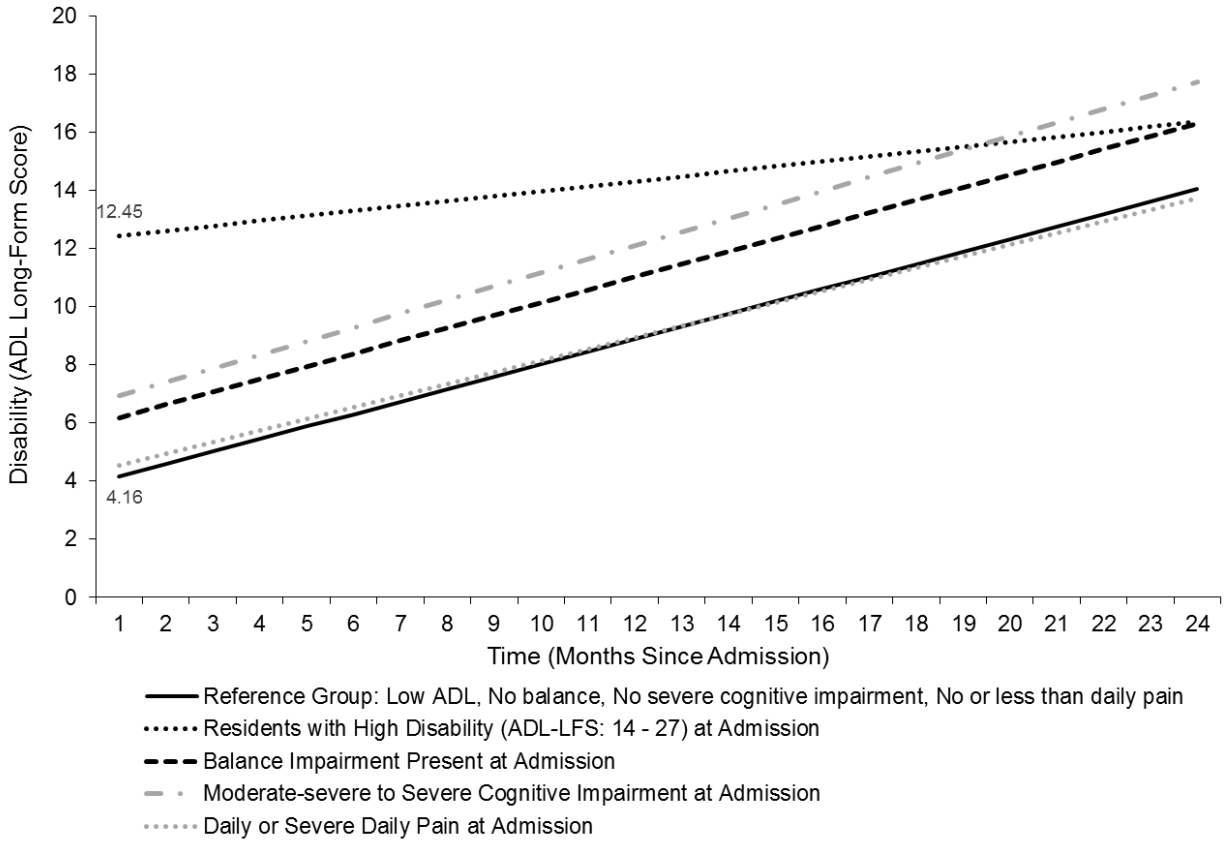

Figure 4.2: Adjusted Differences in Admission Disability and Rate of Disablement in LTCH Residents with High versus Low Disability, Cognitive Impairment, Balance Impairment and Pain at Admission

Note: Increasing disability (ADL Long-Form Score) is undesirable; an upward sloping line indicate residents are becoming more disabled over time.

In addition to the outputs of Model 3, Table 4.3 also contains Models 1 and 2, both of which are predecessors to Model 3. Model 1 contains random effects for LTCHs, residents and time, and fixed effects for geriatric syndromes, chronic conditions and sociodemographic characteristics. The coefficients for Model 1 in Table 4.3 represent the effect of variables on the 29-point disability measure measured at admission. Variables with significant positive coefficients (e.g. urinary incontinence) were associated with greater disability at admission, whereas variables with significant negative coefficients (e.g. chronic obstructive pulmonary disease) were associated with less disability at admission, adjusting for other variables in the table. Coefficient estimates for all variables in Models 1 to 3 are available in Appendix 4.11. Model 2 added to Model 1 an interaction term between time and the dichotomous "high versus low disability at admission" variable. The coefficient for the interaction between high versus low disability at admission and time is the same in Model 2 and Model 3, in which interactions between geriatric syndromes and time are also considered.

Table 4.3: Adjusted Associations of Resident Disability and Geriatric Syndromes Present at Admission with Disablement in Newly Admitted LTC Residents

	Model 1	**Model 2**	**Model 3**
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Constant	4.38 (3.89, 4.87)‡	4.15 (3.66, 4.65)‡	4.16 (3.67, 4.65)‡
Time (months since admission)	0.32 (0.31, 0.33)‡	0.44 (0.42, 0.45)‡	0.43 (0.42, 0.45)‡
Activities of Daily Living Score at Admission			
0 – 13	Reference	Reference	Reference
14 – 27	7.76 (7.54, 7.97)‡	8.28 (8.06, 8.50)‡	8.29 (8.07, 8.52)‡
Geriatric Syndromes			
Balance impairment	2.04 (1.86, 2.22)‡	2.04 (1.86, 2.22)‡	2.03 (1.84, 2.21)‡
Bowel incontinence	1.75 (1.57, 1.92)‡	1.74 (1.57, 1.92)‡	1.74 (1.57, 1.92)‡
Cognition			
Intact or borderline	Reference	Reference	Reference
Moderate impairment	1.04 (0.83, 1.24)‡	1.04 (0.84, 1.24)‡	1.04 (0.84, 1.24)‡
Moderate-Severe/very severe impairment	2.87 (2.58, 3.15)‡	2.88 (2.59, 3.16)‡	2.78 (2.49, 3.07)‡

	Model 1	Model 2	Model 3
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	-0.05 (-0.26, 0.16)	-0.05 (-0.26, 0.16)	-0.05 (-0.26, 0.16)
Body Mass Index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.13 (-0.38, 0.12)	-0.14 (-0.39, 0.12)	-0.14 (-0.39, 0.12)
25 < BMI <30	-0.23 (-0.49, 0.04)	-0.24 (-0.52, 0.03)	-0.24 (-0.50, 0.03)
BMI ≥ 30	0.03 (-0.26, 0.31)	0.01 (-0.27, 0.30)	0.01 (-0.27, 0.30)
Pain			
None	Reference	Reference	Reference
Less than daily pain	0.01 (-0.18, 0.19)	0.003 (-0.18, 0.19)	0.003 (-0.18, 0.19)
Daily or severe daily pain	0.33 (0.12, 0.54)†	0.33 (0.12, 0.53)†	0.39 (0.18, 0.60)†
Pressure ulcer	1.42 (1.12, 1.73)‡	1.44 (1.13, 1.74)‡	1.44 (1.13, 1.74)‡
Urinary incontinence	1.83 (1.65, 2.01)‡	1.83 (1.64, 2.01)‡	1.82 (1.64, 2.01)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.28 (0.12, 0.44)‡	0.28 (0.12, 0.43)‡	0.28 (0.12, 0.43)‡
Severe impairment	1.13 (0.78, 1.48)‡	1.13 (0.78, 1.48)‡	1.13 (0.78, 1.48)‡
Chronic Conditions			
Arthritis	0.02 (-0.12, 0.16)	0.02 (-0.12, 0.16)	0.02 (-0.13 0.16)
Asthma	-0.001 (-0.30, 0.30)	0.0003 (-0.30, 0.30)	-0.0001 (-0.30, 0.30)
Cancer	0.01 (-0.15, 0.16)	0.01 (-0.14, 0.17)	0.01 (-0.14, 0.17)
Coronary artery disease	-0.10 (-0.26, 0.06)	-0.10 (-0.26, 0.06)	-0.10 (-0.26, 0.06)
Chronic obstructive pulmonary disease	-0.25 (-0.45, -0.05)*	-0.24 (-0.45, -0.04)*	-0.24 (-0.45, -0.04)*
Dementia	0.08 (-0.08, 0.25)	0.08 (-0.08, 0.25)	0.08 (-0.08, 0.25)
Diabetes	0.10 (-0.05, 0.26)	0.11 (-0.05, 0.27)	0.11 (-0.05, 0.27)
Epilepsy	0.42 (0.03, 0.80)*	0.42 (0.04, 0.80)*	0.42 (0.03, 0.80)*
Heart failure	0.28 (0.09, 0.47)†	0.29 (0.10, 0.48)†	0.29 (0.10, 0.48)†
Kidney disease	0.26 (0.08, 0.43)†	0.26 (0.08, 0.44)†	0.26 (0.08, 0.44)†
Limb paralysis or amputation	-0.09 (-0.29, 0.10)	-0.10 (-0.30, 0.10)	-0.10 (-0.30, 0.10)
Mood disorder	-0.10 (-0.29, 0.08)	-0.10 (-0.29, 0.08)	-0.10 (-0.29, 0.08)
Parkinson's disease	1.11 (0.84, 1.37)‡	1.11 (0.84, 1.37)‡	1.11 (0.84, 1.37)‡

	Model 1	Model 2	Model 3
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Peripheral vascular disease	-0.22 (-0.57, 0.14)	-0.22 (-0.57, 0.14)	-0.22 (-0.57, 0.14)
Psychiatric conditions other than depression and dementia	-0.11 (-0.28, 0.06)	-0.11 (-0.28, 0.06)	-0.11 (-0.28, 0.06)
Stroke	0.48 (0.31, 0.66)‡	0.48 (0.30, 0.66)‡	0.48 (0.30, 0.66) ‡
Interaction Terms			
Activities of Daily Living Score at Admission*time	N/A	-0.26 (-0.27, -0.24)‡	-0.26 (-0.28, -0.25) ‡
Balance impairment*time	N/A	N/A	0.01 (-0.01, 0.02)
Moderate-severe to severe cognitive impairment*time	N/A	N/A	0.04 (0.03, 0.06) ‡
Daily or severe daily pain*time	N/A	N/A	-0.03 (-0.05, -0.01)†
Random Effects			
$\sqrt{\psi_{11}^{(2)}}$	3.36	3.35	3.35
$\sqrt{\psi_{22}^{(2)}}$	0.36	0.33	0.33
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$	-0.01	0.02	0.02
$\sqrt{\psi_{11}^{(3)}}$	1.10	1.10	1.10
$\sqrt{\theta}$	3.39	3.39	3.39

*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi_{11}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of random intercept $\zeta_{1jk}^{(2)}$
$\sqrt{\psi_{22}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance in random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$ = Covariance of random intercept $\zeta_{1jk}^{(2)}$ and random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{11}^{(3)}}$ = Between-home variance of random intercept $\zeta_{k}^{(3)}$
$\sqrt{\theta}$ = Between-assessment, within-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of level-1 residuals ε_{ijk}
Model 1: Contains random intercepts for residents and long-term care homes, random coefficient for time + resident demographic characteristics and morbidity burden at admission to LTC (t_1). Coefficients represent adjusted relationship between variable and resident disability at admission to long-term care.
Model 2: Contains Model 1 + interaction term for Activities of Daily Living (ADL) score at admission and time. Main effects coefficients represent adjusted relationship between variable and resident disability at admission to long-term care. Interaction terms represent association between ADL score at admission and resident disablement over two years.
Model 3: Contains Model 2 + interaction terms for balance impairment, moderate to severe cognitive impairment and daily or severe daily pain and time. Main effects coefficients represent adjusted relationship between variable

and resident disability at admission to long-term care. Interaction terms represent association between geriatric syndromes and resident disablement over two years.

21.4 Sensitivity Analyses

For the 4,213 residents who died during the observation period, a final disability measure of 28 was imputed on the date of their death. Re-running Model 3 in a sample without imputation of a final disability score among decedents did not change the relationship between high versus low disability and geriatric syndromes at admission with disablement over time (Appendix 4.12), however excluding these residents from the analysis (complete case analysis) resulted in significantly reduced adjusted rate of disablement in the sample, and reduced the differences between disablement in residents with high disability versus low disability at admission (Appendix 4.12). Use of RAI-MDS chronic condition codes instead of claims-based diagnostic codes did not change any of the study findings (Appendix 4.13).

22 Discussion

22.1 Low disability at admission predicts faster disablement over two years

In a population sample of 12,334 newly admitted Ontario LTCH residents, those residents with disability equal to or less than the sample median (ADL LFS 0 to 13) experienced disablement at a clinically and statistically faster rate than residents with admission disability greater than the median. Residents in the high disability group had an unadjusted mean disability score 12.4 points higher than those in the low disability group at admission, but low disability residents had faster rates of disablement over two years (Figure 4.2). This relationship was similar in models unadjusted for covariates (Table 4.2) and models that adjusted for all covariates except for the interaction between geriatric syndromes and time (Model 2, Table 4.3). Accounting for high versus low disability and other covariates at admission, balance impairment, moderate-severe to severe cognitive impairment and daily or severe daily pain had negligible effects on disablement. These findings indicate that high versus low disability at admission – not the presence of geriatric syndromes – is a good clinical indicator of subsequent rate of disablement in newly admitted LTCH residents.

The finding that residents with low disability at admission become disabled more rapidly has important implications. The possible mechanisms behind this finding provide necessary context for its interpretation and are explored in the proceeding sections (and summarized in Appendix 4.14), followed by consideration of this study's findings in the context of existing evidence.

22.2 Possible mechanisms behind faster disablement in residents with lower disability at admission

22.2.1 Methodological Explanations

Residents who met all other inclusion criteria but died prior having two follow-up RAI-MDS assessments completed after admission (n =3,116) were excluded from the study sample (Appendix 4.1). This mortality selection disproportionately affected residents with high disability, balance impairment, moderate-severe to severe cognitive impairment and daily or severe daily pain at admission (Appendices 4.9 and 4.10). Thus, findings regarding reduced disablement among those with high admission disability and the negligible effects of geriatric syndromes could exist because residents in whom these exposures were more strongly associated with disablement died prematurely. A sensitivity analysis that excluded sample residents who died during the observation period (n = 4,213) – in whom exposures were also over represented – showed that overall rate of disablement in the complete case sample was slower, and differences in disablement between residents with high versus low disability at admission were reduced (Appendix 4.12). This finding regarding mortality selection within the sample suggests that mortality selection to enter the sample may have also led to underestimation of disablement among high disability residents.

Other possible methodological explanations for study findings lie in the scaling of and incentives tied to this study's repeated measure of disability: the ADL LFS in the RAI MDS.
Changes in ADL LFS at the high end of the scale could represent more significant clinical changes than those at lower end of the scale (Glenny, Stolee, Thompson, Husted, & Berg, 2012). For example, it is plausible that the change from being totally independent in bathing to needing supervision three or more times a week is the same as the change from requiring extensive staff assistance for bathing to being totally dependent on staff to bath, even though these changes are both coded as one-point increases in ADL LFS. Although there is precedent for treating the ADL

LFS as a continuous variable in research (Fedecostante et al., 2015; Wang et al., 2010; Wang et al., 2009; Wolinsky et al., 2000a) and evidence of its sensitivity to changes over time in LTCH residents (Carpenter et al., 2006), we are unaware of evidence demonstrating the equivalence of changes at the lower versus higher end of the scale. Also, as discussed in Section 2.2, LTCHs are more heavily reimbursed for residents with higher disability scores (OMHLTC, 2011). Thus, residents with low disability at admission could be preferentially "coded up" to reach a higher reimbursement threshold already achieved by residents with high disability at admission. We are unaware of studies examining whether this is the case in Ontario.

22.2.2 Actual associations in Ontario LTCH Residents

While the aforementioned methodological limitations could explain the association between higher disability at admission and slower disablement over two years, it is also possible that this finding represents a "true" phenomenon in Ontario LTCH residents. We review three potential mechanisms for this explanation, each of which could operate in combination with each other and the methodological mechanisms outlined above to produce the observed results.

First, the time origin in this study is admission to LTCH, however residents were likely admitted to LTCHs at different stages of disablement. If the natural course of disablement in this population is characterized by rapid disablement at lower levels of disability, followed by a tapering off, the admission of residents at different stages of disablement could create the observed relationship between low disability and fast disablement. This mechanism in LTCH residents (70% of whom have dementia) is partially supported by findings from Gill et al's examination of different disablement trajectories in community-dwelling older adults' who died of advanced dementia, 68% of whom began their final year of life with high disability and acquired new disability at a rate much slower than individuals who had lower disability at the start of their last year of life (Gill, Gahbauer, et al., 2010). An important feature of this mechanism is that it does not imply a causal relationship between disability at admission and subsequent disablement; rather, it suggests that residents in the high versus low disability group are simply at different stages in the same disablement trajectory.

A second potential mechanism for this study's findings relates to causes of residents' high disability at admission. The 30% of residents admitted from home had a significantly lower

mean disability score (10.7, SD: 6.8) than the 30% admitted from hospital (15.9, SD: 6.9) (Appendix 4.7). High disability could thus be acting as a proxy measure for recent hospitalization. Residents admitted to long-term care post-hospitalization may be in the midst of recovery from an acute health event that temporarily increased their disability at admission, while those admitted from home may be on more stable disablement trajectories due to the cumulative effects of chronic conditions. In their sample of nursing home residents who had been admitted at least six months prior to a hospitalization, Kruse et al found that 39.2% of residents experienced worsening disability following hospitalization, and that disablement (versus stable trajectory or reduction in disability) was the most common among residents with the best (lowest) pre-hospitalization ADL LFS (Kruse et al., 2013). This potential mechanism builds on the previously identified one indicating a possible interaction between pre-admission disablement and place from which residents were admitted in predicting subsequent disablement.

A third possible explanation for our results is that they reflect unequal access to restorative and rehabilitative care services among residents with high versus low disability at admission. Restorative care is focused explicitly on slowing disablement and maintaining independence in ADLs (Resnick, Galik, & Boltz, 2013), whereas rehabilitative therapies (e.g. physiotherapy and occupational therapy) reduce disability by treating functional impairments (Forster, Lambley, & Young, 2010). Thus, restorative therapy may be more appropriate for slowing disablement in residents with minimal functional limitations, whereas rehabilitative and restorative therapy may be necessary to slow disablement residents with significant functional limitations. As outlined in Section 2.2, LTCHs receive more funding for nursing and personal care of residents who have high disability at admission (OMHLTC, 2011). This funding can be used to pay for restorative and rehabilitative therapy among highly disabled residents, meaning that residents with high disability at admission are eligible for more care than low disability residents. Not surprisingly, a study of 7,735 residents in 1,097 American nursing homes found that residents who received restorative care had significantly higher disability at baseline (mean ADL LFS = 17.9) than those who did not (mean ADL LFS = 14.0) (Talley et al., 2015). In this same study, recipients of restorative care experienced disablement at a comparable rate to non-recipients over 18 months, despite their higher disability at baseline (Talley et al., 2015). Given the link between disability at admission and allocation of resources across contexts, similar patterns of resource allocation

may be present in Ontario LTCH residents. In this case, the greater disablement seen in residents with low disability at admission may represent an untapped opportunity for intervention: perhaps if these residents received the level of restorative care allocated to high disability residents, they too would decline more slowly. This mechanism builds on the two prior to it by identifying a pathway through which level of disability at admission is causally linked to subsequent disablement. In the proceeding sections we review existing research in this area in an attempt to clarify which of the aforementioned mechanisms are driving our results.

22.3 Findings in the context of existing evidence

22.3.1 Low disability at admission is associated with accelerated disablement over time

There are few studies that examine clinical indicators of disablement using hierarchical linear modelling in LTCH residents. Kruse et al examined disablement trajectories over a year in 40,128 Medicaid-eligible long-stay nursing home residents and found that residents with low baseline disability (ADL LFS 0-4) experienced a 0.46-point worsening in disability score per month, whereas residents with high baseline disability (ADL LFS 24-28) experienced a 0.36 point reduction in disability per month; they did not report rate of disablement among those with moderate disability (ADL LFS 5-28) (Kruse et al., 2013), however their sample's mean disability score changed at a rate of -0.14 points per month, indicating net improvement (Kruse et al., 2013). This contrasts with the net increase in disability experienced by residents in our sample. Banaszak-Holl et al also examined the impact of admission disability on disablement in 3,634 newly admitted long-stay nursing home residents with stays of at least six months and found that although the sample became more disabled overall during the study period, residents with higher disability at admission experienced slower disablement (Banaszak-Holl et al., 2011). Finally, in their study of nursing home residents with moderate or severe dementia followed over six months, Carpenter et al found that residents became more disabled over the course of the study, at a rate of approximately 0.3 ADL LFS points per month (Carpenter et al., 2006).

These studies differ from ours in terms of their use of restricted (Carpenter et al., 2006) or non-admission cohorts (Kruse et al., 2013), and their use of abbreviated outcome scores for disablement (Banaszak-Holl et al., 2011), however their findings regarding the association

between low disability at baseline and accelerated disablement in LTCH residents align with ours. Unlike our study, Kruse et al found this relationship using a joint model of disablement, admission to hospital and death (Kruse et al., 2013); this suggests that while mortality selection may be contributing to our findings, it is unlikely to explain them entirely.

22.3.2 Negligible Effects of Cognitive Impairment, Balance Impairment, and Daily or Severe Daily Pain

Our findings regarding the negligible effects of geriatric syndromes are partially aligned with existing evidence, however direct comparisons across studies are difficult due to differences in adjustment for covariates. In Carpenter et al's study of LTCH residents with dementia, those with moderate cognitive impairment became disabled at a rate of 0.30 ADL LFS points per month, compared to a rate of 0.28 among residents with severe cognitive impairment (2006). Kruse et al found that each one point increase in the 7-point cognitive performance scale (collapsed into <4 and 4+ in our study) was associated with a 0.08 point worsening in disability per month (2013). In Banaszak-Holl's study of 3,634 newly admitted LTCH residents, they found a small but not clinically or statistically significant increased rate of disablement among residents with cognitive impairment (2011). Thus, studies that adjusted for baseline disability and had similar samples to ours found similarly small effects of baseline cognitive impairment on disablement (Banaszak-Holl et al., 2011).

The two reviewed studies that found significant effects of balance and pain on disablement did not adjust for disability at baseline. Burge et al examined predictors of a two-point reduction in the 7-point ADL hierarchy score in 10,199 LTCH residents of 90 Swiss nursing homes; they found that both balance and cognitive impairment were associated with increased hazard of the dichotomous "decline" outcome over a mean 1.1 years of follow-up (Burge et al., 2013).Wang et al found that balance dysfunction was independently associated with loss of early (personal hygiene) and mid-loss ADLs (toileting), but not late-loss ADLs (eating) over six months, in 4,942 Minnesota nursing home residents, while pain was not associated with disablement in any ADLs (Wang et al., 2009). These inconsistent findings from studies with follow-up periods of six months suggest that our finding of negligible effects of balance and pain is unlikely due to our failure to capture their acute effects on short-term of disablement. We build on these studies

by showing that there is not a clinically significant association between pain and balance impairment at admission and subsequent disablement when baseline disability is adjusted for.

22.4 Strengths

This study used data from a large population cohort of LTCH residents to study the relationship between disability and geriatric syndromes at admission with disablement over two years, adjusting for multiple confounders. We used robust statistical methods to examine a validated measure of disability over multiple time points. Unlike other studies of these relationships (Carpenter et al., 2006; Kruse et al., 2013; Talley et al., 2015), ours tracked residents from their admission onwards and did not exclude residents based on comorbidities. We also used validated administrative claims data to adjust for the effects og comorbidities, but showed that our findings were consistent when the commonly used RAI-MDS chronic condition codes were used. As a result of these strengths, our findings provide novel insight on the association between clinical indicators present at admission and subsequent disablement over two years in a representative sample of LTCH residents.

22.5 Limitations

A brief review of study limitations is provided here, as *Section 22.2.1* already identified major methodological limitations that may have impacted results. As with most studies of longitudinal outcomes in very old adults, our study was subject to informative censoring due to mortality. Our requirement that residents have at least two subsequent assessments after their admission assessment is similar to inclusion criteria in other studies (Banaszak-Holl et al., 2011; Carpenter et al., 2006; Kruse et al., 2013; Talley et al., 2015), however we also provide information on the characteristics of these residents so that the likely effects of their exclusion can be assessed. In contrast with trajectory research done among older adults with no disability at baseline (Gill, 2014), the current study likely captured residents at various stages of disablement, thus examination of the natural history of disablement was not possible. We also posit that our findings may be in part attributable to relative insensitivity of the higher ranges of our outcome measure to changes in disability (Glenny et al., 2012). While this may be the case, the 29-point ADL LFS scale is still far more sensitive to small changes in disability over time than more abbreviated scales or dichotomous outcome measures that are often used. We also did not adjust

for the effect of rehabilitation or restorative care services received at the resident level, as these variable are confounded by indication. Receipt of rehabilitation is also suspected to be coded up due to its role in increasing LTCH reimbursements for resident care (CIHI, 2014a). Finally, the link between disability measured in the RAI MDS and funding for LTCHs may have incentivized coding of residents as being more disabled than they were; this limitation is present in most existing evidence on disablement in LTCH residents and requires further study to understand the breadth of its impact.

22.6 Directions for future research

Future research is needed to elaborate on the mechanisms driving our findings. Descriptive analyses of the allocation of restorative care and rehabilitative services among LTCH residents with high versus low disability at admission are needed. Similar research in Ontario home care recipients has revealed important insights (Armstrong, Zhu, Hirdes, & Stolee, 2015; Cheng et al., 2015). A recent Cochrane review of 67 physical rehabilitation interventions in LTCH residents found that their small protective effect against disablement was not consistent across residents (Crocker, Forster, et al., 2013). Paired with our study findings, the results of this meta-analysis suggest that research is needed to enhance our understanding of the modifiability of disablement trajectories in residents with high versus low disability. Examination of disablement among community-dwelling older adults who have no disability at baseline and are eventually admitted to LTCH would provide important insight on the role of admission to LTCH in the natural history of disablement.

23 Conclusions

Our findings show that LTCH residents with lower disability at admission experience disablement more rapidly over two years than those with high disability at admission. Despite their strong association with disability in cross-sectional studies, balance impairment, moderate-severe to severe cognitive impairment and daily or severe daily pain at admission do not have clinically significant independent effects on residents' disablement over two years. Care planners in LTCHs may examine whether resource allocation to more disabled residents may be driving these patterns. Communicating likely disablement trajectory based on admission disability level can be used to help residents and their families make decisions about shifting care goals. Further

research is warranted to examine the mechanisms driving the relationship between disability and disablement in LTCH residents.

Chapter 5
Synthesis

24 Overview

Disability is difficulty with or dependence on others to conduct activities of daily living, such as bathing, eating and dressing measured at one point in time (Gill, 2010); disablement is intensifying disability measured over two or more time points (Verbrugge & Jette, 1994). The three preceding papers sought to contribute to the evidence on determinants of these outcomes in older adults and long-term care residents through the following related studies:

- Study 1: Operationalizing the Disablement Process Model for Empirical Research
- Study 2: Association of Resident and Long-Term Care Home Characteristics with Resident Disability
- Study 3: Low Disability at Admission Predicts Disablement in Long-Term Care Residents

Each of these studies provide novel insights into disability and the disablement process in older adults, particularly those residing in long-term care homes. In this concluding chapter, key findings from each of these three studies are revisited and interpreted in the context of overall findings from this dissertation. A review of this dissertations' limitations precedes a discussion of its implications for theory and research, as well as policy and clinical practice. This chapter concludes with suggested directions for future research.

25 Summary and Interpretation of Key Findings

This dissertation began with an overview of how long-term care is structured in Ontario and abroad. The major message from this section was that while eligibility, funding, delivery and accountability policies vary, governments around the world are striving to control costs of long-term care in an aging population. Reductions in disability and disablement among older adults were identified as a patient-centered means of doing so.

The Disablement Process Model was introduced as heavily used and readily understood conceptual framework that identifies a pathway through which pathologies lead to impairments, then limitations in functional capacity, and ultimately disability in the context of people's social and physical world (Verbrugge & Jette, 1994). We noted that such a framework was necessary but not sufficient to guide empirical research and synthesis without first being operationalized. This was the aim of Study 1, summarized below.

25.1 Study 1 Summary and Application

Study 1 operationalized the Disablement Process Model (DPM) by summarizing the contents of 94 studies on characteristics of older adults and their environments associated with disability and disablement (Tables 2.3 and 2.4). Researchers in gerontology, geriatrics and long-term care are the target users of outputs from Study 1. They can use the analytic framework and summary of construct measures to inform either empirical studies or systematic reviews as illustrated in Figure 2.1. Study 1 also identified common methodological pitfalls of disability and disablement research in older adults and made recommendations to address them in future research. These recommendations are summarized below, alongside an indication of which subsequent dissertation studies they were applied to.

Table 5.1: Study 1 Recommendations for Future Work and their Application to Studies 2 and 3

Recommendation for future work	Applied Recommendation in Study 2 or 3?
Study Sample Recommendations	
Conduct empirical research on disability and disablement in long-term care residents.	Yes: Study 2 and 3
Measurement Recommendations	
Use validated measure to assess disability and disablement	Yes: Study 2 and Study 3
Use construct definitions in the Disablement Process Model as defined by Verbrugge and Jette to reduce bedlam vocabulary of disability research.	Yes: Study 2 and Study 3
Study different types of broad disability outcomes (i.e. ADLs, IADLs, mobility) as separate outcomes.	Yes: Study 2 and Study 3
Include more than two time points in studies of disablement to reduce sensitivity of associations to impermanent fluctuations in disability.	Yes: Study 3
Consider constructs specific to nursing home residents.	Yes: Study 2 and Study 3

Recommendation for future work	Applied Recommendation in Study 2 or 3?
Analysis Recommendations	
Conduct hypothesis-driven analyses of specific exposure-outcome relationships.	Yes: Study 3
Use the analytic framework provided as a starting point for causal diagrams of relationships between exposures and disability prior to study conduct.	Yes: Study 2 and Study 3 See Appendix 5.1
Reflect nested nature of extra-individual characteristics in measurement and analysis.	Yes: Study 2 and Study 3
Recognize (and test whether) constructs within the DPM mediate the relationships between constructs distal to them and disability.	Yes: Study 2
Recognize (and test whether) constructs within the DPM moderate the relationships between other constructs and disability. Consider stratification of results of intra- and extra-individual effect modifiers.	Yes: Study 2 and Study 3
Examine or adjust for the effect of disability on subsequent disablement.	Yes: Study 3
Examine differences in disablement among individuals with and without common chronic conditions and geriatric syndromes.	Yes: Study 3

25.2 Study 2 Summary and Interpretation

Study 2 had three aims: (1) to identify geriatric syndromes and chronic conditions strongly associated with disability in LTCH residents; (2) to examine whether these relationships were moderated by residents sex, age or cognitive status; and (3) to determine the proportion of variance in resident disability explained by resident characteristics versus LTCH characteristics. Study 2 found that in a population sample of 77,164 residents of 614 Ontario LTCHs, geriatric syndromes such as balance impairment, urinary and bowel incontinence, pressure ulcer, severe visual impairment and severe cognitive impairment were strongly associated with disability and explained half of the variation in disability scores across residents. This important finding regarding the proportion of variation in disability explained by geriatric syndromes was made following the recommendation of Study 1 to run analyses with and without putative mediators to examine their effects.

Another recommendation of Study 1 was to examine for potential effect modification by age, sex and cognitive status, which informed Aim (2) above. This recommendation yielded null findings for the effects of age and sex and small differences in correlates of disability based on level of cognition. Although the impact of cognition on disablement over time was tested and shown to be statistically but not clinically significant in Study 3, the effect of age and sex on disablement in LTCH residents was not studied in this dissertation. However, given their lack of association with disability in cross-section, a strong effect on disablement seems unlikely.

An important finding from Study 2 is the lack of association between characteristics of LTCHs and resident disability. Accounting for the characteristics of residents, LTCHs explain only 2% of the variation in resident disability. Multiple sensitivity analyses (Appendices 3.10-3.12, 3.14) were run to determine whether this finding changed under various measurement and analytic assumptions but it did not. Appendix 4.15 from Study 3 further supports this null effect of LTCHs, demonstrating that that the addition of dummy variables for LTCHs to models of repeated disability measures did not significantly affect the proportion of variation explained.

25.3 Study 3 Summary and Interpretation

Study 3 applied many of the recommendations of Study 1 to build on the cross-sectional findings of Study 2. In contrast with the broad set of exposures in Study 2, Study 3 study focused on testing of specific hypotheses related to longitudinal effects of clinical indicators present at admission to long-term care. It aimed to determine: (1) whether high versus low disability at admission to long-term care was associated with increased rate of disablement over two years and (2) if balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain present at admission were associated with disablement over two years. The findings from this study are most relevant to care planners in LTCHs, residents and their families.

The major finding of Study 3 was that in a population sample of 12,334 residents who were newly admitted to one of 633 Ontario LTCHs, having disability equal to or below the sample median was associated with a higher rate of disablement over the two subsequent years. An inverse relationship between disability at baseline and disablement over time has been found in other studies (Banaszak-Holl et al., 2011; Carpenter et al., 2006; Kruse et al., 2013) and could

reflect greater resource allocation to residents who have higher disability at admission (Talley et al., 2015). We reviewed several possible methodological limitations that also could have caused this finding, as well as several mechanisms through which this finding could represent a real and clinically important relationship in Ontario LTCH residents (Appendix 4.14).

Study 3 also found that balance and cognitive impairment and pain at admission had negligible effects of on subsequent disablement. This finding has several important implications. Study 1 concluded that "variables associated with disablement (measured longitudinally) also tend to be associated with disability (measured at one time point)," but that "contradictory findings for the independent association of variables with disability and disablement were extremely common." The findings of Study 3 shed light on this conclusion, demonstrating that very strong correlates of disability are not necessarily predictive of disablement when measured in similar samples, adjusting for the same confounders. This finding relates to another recommendation of Study 1: to adjust for baseline level of disability to assess for direct effects of exposures over time. Study 3 showed that pain, cognitive impairment and balance impairment were associated with disablement in unadjusted models (Table 4.2), but that this was likely due to their association with disability at admission. A clinical implication of these findings is that – counter to the conclusions drawn in Study 2 – these geriatric syndromes are not the strongest clinical indicators of subsequent disablement in LTCH residents.

26 Limitations

This dissertation is subject to some limitations. These limitations and strategies to minimize or quantify their effects are discussed in Sections 9.4, 16.6, 22.2.1 and 22.5. The proceeding sections reviews overarching limitations of Study 1 and how they may have carried forward into Studies 2 and 3. Limitations common to measurement and analysis in Studies 2 and 3 but not discussed in individual study chapters are also reviewed.

Due the non-systematic search and appraisal techniques used in Study 1, findings regarding the proportion of studies that do or do not measure constructs a certain way or in a given population may not reflect the complete body of evidence in this field. This could have resulted from an unintended oversampling of studies from North America, the omission of important findings that were not in English or the overlooking of evidence not picked up by our selected search terms,

key words and snowballing. Cessation of study search and appraisal were guided by perceived saturation of DPM constructs with evidence on their measurement; this subjective judgement may have been made prematurely for some constructs, measures or populations, resulting in their reported under-representation in the evidence. Although these limitations may affect reported Study 1 results, they do not render them obsolete. As illustrated in Figure 2.1, critical literature reviews are necessary intermediaries between conceptual frameworks and systematic reviews. Thus, even if the sample of 94 reviewed studies is not a precise representation of all existing evidence, Study 1 still achieves the useful aims of creating an evidence-informed analytic framework and identifying common measures of DPM constructs.

Because the analytic framework developed in Study 1 was used to guide covariate selection and modelling in Studies 2 and 3, the non-systematic nature of Study 1 may have led to under-adjustment for confounders in Studies 2 and 3. Although this is possible, Studies 2 and 3 adjusted for more covariates than similar publications in high impact geriatrics and gerontology journals, suggesting that under-identification of covariates in Study 1 did not bias Studies 2 and 3.

One set of variables that Studies 2 and 3 did not adjust for despite their presence in the Study 1 analytic framework are acute pathologies and hospitalization. Characterized by a *single episode of relatively rapid onset and short duration* (WHO, 2004), acute pathologies such as lower respiratory tract infections and are associated with disablement in LTCH residents (Mody, Sun, & Bradley, 2006; Neuman et al., 2014). They are also frequent causes of hospitalization in LTCH residents, so their direct effects are difficult to distinguish from those of hospitalizations. Acute health events and hospitalizations were omitted from Study 2 because they are incident events, not suitably studied in cross-section. They were also omitted from Study 3, along with incident chronic conditions and geriatric syndromes that occurred during the course of residents' stay. The effects of these incident health events, chronic conditions and geriatric syndromes likely exist – at least partly – along the causal pathway between many of the variables measured at admission and ongoing disablement. They may also have independent effects that were unaccounted for. For example, not adjusting for acute pathologies in Study 3 could have caused some of the association between high disability at admission and slower disablement: residents with more disability may be less likely to ambulate and engage with other residents, reducing

their risk for injurious falls or infections. Although these are undoubtedly important exposures to consider, their examination constitutes additional studies beyond the scope of this dissertation.

Similarly, neither Study 2 nor Study 3 measured all clinical signs and symptoms residents' experienced (i.e. dyspnea, nausea) that could affect their disability or disablement. Although some of these unmeasured variables could act as confounders in the relationship between measured diseases or syndromes and disability outcomes, many of them are more likely mediators of these relationships. Study 1 suggested testing whether covariates with unclear roles in the causal pathway were mediators or moderators and this yielded important findings in Study 2. However, the impetus to include and test the role of all possible mediators and moderators had to be balanced with an overall goal of model parsimony in this dissertation.

Implications

The findings from this work have several important implications for theory and research. These implications are discussed briefly below and summarized in Tables 5.2 to 5.4.

26.1 Theory and Research

This dissertation was grounded in the widely used Disablement Process Model published by Verbrugge and Jette in 1994. This framework was used in Study 1 to guide a critical literature review, the results of which informed the development of an Analytic Framework for Application of the Disablement Process Model for Older Adults (*Figure 2.2*). This conceptually-grounded, evidence-based framework can be used to guide future studies of disability in older adults, whether or not they live in the community or long-term care. Study 1 also identifies common limitations of what is known about disability and disablement in older adults; filling these research gaps should be prioritized as a means of simultaneously improving older adults quality of life and reducing health care expenditures.

The role of LTCH characteristics in association with residents' disability outcomes is under-studied in existing research. Hierarchical linear regression models are well-suited to model outcomes for residents nested within long-term care homes, however these models were infrequently used in reviewed studies. Study 2 provides a readily understood example of how to

use conceptually-driven hierarchical models to answer policy-relevant questions about resident outcomes.

26.2 Policy and Clinical Practice

Study 2 provides novel insight on the negligible proportion of variance in Ontario LTC residents' disability explained by LTCH versus resident characteristics. This null relationship is likely relevant to the Ontario population at large. A 2014 study that compared the causes and consequences of LTCH media scandals in Canada, the United States, the United Kingdom, Sweden and Norway found that the link between long-term care home characteristics (especially ownership type) and resident outcomes was a common focus of large scandals that shifted public opinion and policy (Lloyd, Banerjee, Harrington, Jacobsen, & Szebehely, 2014). The heavy and ongoing coverage of these scandals suggests that the association between resident outcomes and LTCH characteristics is important to the general public (Lloyd et al., 2014).

Findings from Study 3 are the most relevant to frontline care providers in LTCHs, residents and their families. It is the first study that we are aware of to examine the effect of disability level and select geriatric syndromes at admission on residents' rate of disablement over two years. It shows that high versus low disability at baseline – not geriatric syndromes that are strongly associated with disability in cross-section – is associated with more rapid disablement over two years. Research is needed to elucidate why residents with relatively low disability at admission become disabled more rapidly, particularly the potential influence of reimbursement models that allocate more care to residents admitted with the highest disability.

Table 5.2: Study 1 Outputs, Generalizability, Target Audience and Use

Study Outputs	Generalizability	Target Audience	How Target Audience Can Use Evidence
• Summary of variables commonly used to measure each DPM construct in 94 studies. • Summary of how variables representing different constructs were classified in different studies (i.e., exposure, adjustment or unclassified variables). • Summary of whether included studies examined association of different DPM variables with disability, disablement or both. • Summary of proportion of studies done on specific constructs in community-dwelling versus nursing home residents. • Identification of DPM constructs for which measures specific to nursing home residents exist and examples of such measures. • Identification of common methodologic pitfalls in existing evidence on disability and disablement in older adults. • Creation of an evidence-based analytic framework to inform measurement and analysis in future studies of disability and disablement in older adults. • Recommendations on how to strengthen future research on disability and disablement.	Majority of English language studies are from USA with minor representation from Canadian and European countries. Generalizable to research on older adults living in community or long-term care homes in jurisdictions indicated above.	Gerontology, geriatrics and long-term care researchers.	• Sharpen focus of research questions in empirical studies or evidence syntheses. • Test hypotheses generated regarding effect mediators and moderators. • Align construct measures with commonly used measures. • Identify different levels of measurement for relevant extra-individual variables. • Identify possible confounders that should be adjusted for in analyses. • Evidence-based justification for application of DPM in cross-sectional studies. • Design studies to fill identified research gaps.

Table 5.3: Study 2 Findings, Generalizability, Target Audience and Use

Study Findings	Generalizability	Target Audience	How Target Audience Can Use Evidence
• Specific geriatrics syndromes and chronic conditions are associated with disability in confounder-adjusted models, in large, representative sample. • Adjustment for geriatrics syndromes changes effect size of chronic conditions but not and vice versa.	Generalizable to long-term care residents living in Ontario and other Canadian provinces, as well as long-stay nursing home residents in the United States, all of whom have similar demographic characteristics and morbidity.	Gerontology, geriatrics and long-term care researchers.	• Consider whether geriatric syndromes mediate effects of select chronic condition exposures in future studies. • Test hypotheses regarding geriatric syndromes as mediators of effects of certain chronic diseases. • Test whether identified relationships between geriatric syndromes and chronic conditions exist longitudinally.
• Neither age nor sex modify the cross-sectional relationship between disability and chronic conditions or geriatric syndromes.			• Update conceptual frameworks regarding effect modification of relationships between chronic conditions, geriatric syndromes and disability. • Examine whether effect modification of relationships exists in longitudinal studies.
• The relationship between some chronic conditions or geriatric syndromes and disability is different between LTCH residents with cognitive impairment.		LTCH managers	• Consider tailoring interventions to reduce disability based on cognitive functioning.
• Long-term care homes do not explain a significant proportion of variation in resident disability	Ontario and Canadian provinces with comparable LTCH accountability structures.	Residents and family members	• Issues related to quality of care in association with LTCH characteristics are of significant importance to the public (Lloyd et al., 2014) • Can inform choice of whether to select LTCH based on publicly reported disability outcomes.

Table 5.4: Study 3 Findings, Generalizability, Target Audience and Use

Study Findings	Generalizability	Target Audience	How Target Audience Can Use Evidence
• Low disability at admission to long-term care is associated with faster disablement over two years in adjusted models. • Balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain present at admission were not associated with disablement over two years in adjusted models	Generalizable to long-term care residents living in Ontario and other Canadian provinces, as well as long-stay nursing home residents in the United States, all of whom have similar demographic characteristics and morbidity.	Care planners	• Examine clinical practice; reflect on whether allocation of restorative care or rehabilitation services to residents with high versus low disability at admission could contribute to this disablement disparity.
		Residents and family members	• Understanding likely disablement trajectory could help inform care goals.
• Despite their strong association with disability in Study 2, balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain were not associated with disablement.		Gerontology, geriatrics and long-term care researchers.	• Strong correlates of disability are not necessarily predictive of disablement. Attention to distinction between correlates of disability versus determinants of disablement is needed. • Examine mechanisms driving association between low disability at admission and faster disablement over two years.

27 Directions for Future Research

The goal of this dissertation was to operationalize a conceptual framework for disability research in older adults and apply it to empirical research in the understudied long-term care population. This work provides several novel insights, but also raises questions to be answered in future research. We outline key directions and questions for future research below, ordered from highest to lowest priority.

- **Describe the LTCH resident characteristics associated with receipt of services that may prevent or slow disability.** Do Ontario LTCH residents with relatively high disability at admission get significantly more rehabilitative or restorative care services

than those with relatively low disability at admission? Is receipt of rehabilitation or restorative care services associated with slowed disablement in residents (with high or low disability at admission)?

- **Determine the effect of incident chronic conditions and geriatric syndromes on disablement in LTCH residents**. Do incident chronic conditions and geriatric syndromes accelerate disablement in LTCH residents, independent of the effects of pre-existing chronic conditions and geriatric syndromes? What is the role of hospitalization in mediating or moderating these effects?

- **Examine the effect of acute pathologies on disablement in LTCH residents**. Kruse et al found that hospitalizations change the course of disablement in LTCH residents (2013) but to what extent is this change due to the effects of hospitalization versus the detrimental effects of specific acute pathologies?

- **Examine whether variables related to increased reimbursement in LTCH residents are being coded up**. Do trajectories of disablement level out after the threshold needed to increase classification into a highly reimbursed RUG group? What about the trajectories of other RAI-MDS measures (i.e. amount of rehabilitation received)?

- **Track disablement from onset of disability in community-dwelling older adults** and examine how LTCH admission affects trajectory. Is admission to LTCH associated with increased disability in long-term care residents? Does rate of disablement in older adults admitted to LTCH differ significantly prior to and following their admission?

- **Determine the role of location from which residents are admitted in disablement among LTCH residents.** Does disablement differ for newly admitted residents admitted from hospital versus home? Is there an interaction between disablement trajectory prior to admission and location of admission in predicting disablement following admission?

- **Understand LTCH eligibility, funding, delivery and accountability structures responsible for the negligible association of LTCH characteristics with resident disability in Ontario, versus larger effects elsewhere**. If the design and analysis of

Study 2 were replicated in a sample of American long-stay nursing home residents, what would the proportion in resident disability attributable to LTCHs be? What if it were replicated in other Canadian provinces?

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References

Abizanda, P., Romero, L., Sanchez-Jurado, P. M., Martinez-Reig, M., Alfonso-Silguero, S. A., & Rodriguez-Manas, L. (2014). Age, frailty, disability, institutionalization, multimorbidity or comorbidity. Which are the main targets in older adults? *J Nutr Health Aging, 18*(6), 622-627. doi: 10.1007/s12603-014-0033-3

Allison, L. K., Painter, J. A., Emory, A., Whitehurst, P., & Raby, A. (2013). Participation restriction, not fear of falling, predicts actual balance and mobility abilities in rural community-dwelling older adults. *J Geriatr Phys Ther, 36*(1), 13-23. doi: 10.1519/JPT.0b013e3182493d20

Andersen, C. K., Wittrup-Jensen, K. U., Lolk, A., Andersen, K., & Kragh-Sorensen, P. (2004). Ability to perform activities of daily living is the main factor affecting quality of life in patients with dementia. *Health Qual Life Outcomes, 2*, 52. doi: 10.1186/1477-7525-2-52

Arling, G., Kane, R. L., Lewis, T., & Mueller, C. (2005). Future development of nursing home quality indicators. *Gerontologist, 45*(2), 147-156.

Armstrong, J. J., Zhu, M., Hirdes, J. P., & Stolee, P. (2015). Rehabilitation therapies for older clients of the Ontario home care system: regional variation and client-level predictors of service provision. *Disabil Rehabil, 37*(7), 625-631. doi: 10.3109/09638288.2014.935494

Atun, R. (2015). Transitioning health systems for multimorbidity. *Lancet*. doi: 10.1016/s0140-6736(14)62254-6

Banaszak-Holl, J., Liang, J., Quiñones, A., Cigolle, C., Lee, I. C., & Verbrugge, L. M. (2011). Trajectories of functional change among long stayers in nursing homes: Does baseline impairment matter? *Journal of Aging and Health, 23*(5), 862-882.

Barker, W. H., Borisute, H., & Cox, C. (1998). A study of the impact of influenza on the functional status of frail older people. *Archives of Internal Medicine, 158*(6), 645-650.

Barnes, D. E., Mehta, K. M., Boscardin, W. J., Fortinsky, R. H., Palmer, R. M., Kirby, K. A., & Landefeld, C. S. (2013). Prediction of recovery, dependence or death in elders who become disabled during hospitalization. *Journal of General Internal Medicine, 28*(2), 261-268.

Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet, 380*(9836), 37-43. doi: 10.1016/s0140-6736(12)60240-2

Bayliss, E. A., Ellis, J. L., & Steiner, J. F. (2007). Barriers to self-management and quality-of-life outcomes in seniors with multimorbidities. *Ann Fam Med, 5*(5), 395-402. doi: 10.1370/afm.722

Bellows, N. M., & Halpin, H. A. (2008). MDS-based state medicaid reimbursement and the ADL-decline quality indicator. *Gerontologist, 48*(3), 324-329.

Berry, S. D., Ngo, L., Samelson, E. J., & Kiel, D. P. (2010). Competing risk of death: an important consideration in studies of older adults. *J Am Geriatr Soc, 58*(4), 783-787. doi: 10.1111/j.1532-5415.2010.02767.x

Berta, W., Laporte, A., & Valdmanis, V. (2005). Observations on institutional long-term care in Ontario: 1996-2002. *Can J Aging, 24*(1), 70-84.

Berta, W., Laporte, A., & Wodchis, W. P. (2014). Approaches to Accountability in Long-Term Care. *Healthc Policy, 10*(Sp), 132-144.

Boeckxstaens, P., Vaes, B., Van Pottelbergh, G., De Sutter, A., Legrand, D., Adriaensen, W., . . . Degryse, J. (2014). Multimorbidity measures were poor predictors of adverse events in patients aged ≥80 years: A prospective cohort study. *Journal of clinical epidemiology*.

Bolin, J. N., Phillips, C. D., & Hawes, C. (2006). Differences between newly admitted nursing home residents in rural and nonrural areas in a national sample. *Gerontologist, 46*(1), 33-41.

Bond, J., Dickinson, H. O., Matthews, F., Jagger, C., & Brayne, C. (2006). Self-rated health status as a predictor of death, functional and cognitive impairment: A longitudinal cohort study. *European Journal of Ageing, 3*(4), 193-206.

Boockvar, K., Signor, D., Ramaswamy, R., & Hung, W. (2013). Delirium During Acute Illness in Nursing Home Residents. *Journal of the American Medical Directors Association, 14*(9), 656-660.

Boström, G., Conradsson, M., Rosendahl, E., Nordström, P., Gustafson, Y., & Littbrand, H. (2014). Functional capacity and dependency in transfer and dressing are associated with depressive symptoms in older people. *Clinical Interventions in Aging, 9*, 249-257. doi: 10.2147/CIA.S57535

Bowling, C. B., Sawyer, P., Campbell, R. C., Ahmed, A., & Allman, R. M. (2011). Impact of chronic kidney disease on activities of daily living in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci, 66*(6), 689-694. doi: 10.1093/gerona/glr043

Boyd, C. M., Landefeld, C. S., Counsell, S. R., Palmer, R. M., Fortinsky, R. H., Kresevic, D., . . . Covinsky, K. E. (2008). Recovery of activities of daily living in older adults after hospitalization for acute medical illness. *J Am Geriatr Soc, 56*(12), 2171-2179. doi: 10.1111/j.1532-5415.2008.02023.x

Boyd, C. M., Ricks, M., Fried, L. P., Guralnik, J. M., Xue, Q. L., Xia, J., & Bandeen-Roche, K. (2009). Functional decline and recovery of activities of daily living in hospitalized, disabled older women: The women's health and aging study. *Journal of the American Geriatrics Society, 57*(10), 1757-1766.

Boyd, C. M., Xue, Q. L., Guralnik, J. M., & Fried, L. P. (2005). Hospitalization and development of dependence in activities of daily living in a cohort of disabled older women: the Women's Health and Aging Study I. *J Gerontol A Biol Sci Med Sci, 60*(7), 888-893.

Branch, L. G., & Jette, A. M. (1982). A prospective study of long-term care institutionalization among the aged. *Am J Public Health, 72*(12), 1373-1379.

Brotman, D. J., Walker, E., Lauer, M. S., & O'Brien, R. G. (2005). In search of fewer independent risk factors. *Arch Intern Med, 165*(2), 138-145. doi: 10.1001/archinte.165.2.138

Bula, C. J., Ghilardi, G., Wietlisbach, V., Petignat, C., & Francioli, P. (2004). Infections and functional impairment in nursing home residents: a reciprocal relationship. *J Am Geriatr Soc, 52*(5), 700-706. doi: 10.1111/j.1532-5415.2004.52205.x

Burge, E., von Gunten, A., & Berchtold, A. (2013). Factors favoring a degradation or an improvement in activities of daily living (ADL) performance among nursing home (NH) residents: a survival analysis. *Arch Gerontol Geriatr, 56*(1), 250-257. doi: 10.1016/j.archger.2012.09.001

Buttar, A., Blaum, C., & Fries, B. (2001). Clinical characteristics and six-month outcomes of nursing home residents with low activities of daily living dependency. *J Gerontol A Biol Sci Med Sci, 56*(5), M292-297.

Caljouw, M. A. A., Cools, H. J. M., & Gussekloo, J. (2014). Natural course of care dependency in residents of long-term care facilities: Prospective follow-up study. *BMC Geriatr, 14*(1).

Caljouw, M. A. A., Kruijdenberg, S. J. M., De Craen, A. J. M., Cools, H. J. M., Den Elzen, W. P. J., & Gussekloo, J. (2013). Clinically diagnosed infections predict disability in activities of daily living among the oldest-old in the general population: The Leiden 85-plus Study. *Age and Ageing, 42*(4), 482-488.

Canada Health Act, 6 C.F.R. (1984).

Carpenter, G. I., Hastie, C. L., Morris, J. N., Fries, B. E., & Ankri, J. (2006). Measuring change in activities of daily living in nursing home residents with moderate to severe cognitive impairment. *BMC Geriatr, 6*, 7. doi: 10.1186/1471-2318-6-7

Carrière, I., Gutierrez, L. A., Pérès, K., Berr, C., Barberger-Gateau, P., Ritchie, K., & Ancelin, M. L. (2011). Late life depression and incident activity limitations: Influence of gender and symptom severity. *Journal of Affective Disorders, 133*(1-2), 42-50.

Carriere, I., Villebrun, D., Peres, K., Stewart, R., Ritchie, K., & Ancelin, M. L. (2009). Modelling complex pathways between late-life depression and disability: evidence for mediating and moderating factors. *Psychol Med, 39*(10), 1587-1590. doi: 10.1017/s0033291709005273

Challiner, Y., Carpenter, G. I., Potter, J., & Maxwell, C. (2003). Performance indicators for hospital services for older people. *Age Ageing, 32*(3), 343-346.

Chaudhry, S. I., McAvay, G., Ning, Y., Allore, H. G., Newman, A. B., & Gill, T. M. (2011). Risk factors for onset of disability among older persons newly diagnosed with heart failure: The cardiovascular health study. *Journal of cardiac failure, 17*(9), 764-770.

Chen, B., Covinsky, K. E., Cenzer, I. S., Adler, N., & Williams, B. A. (2012). Subjective social status and functional decline in older adults. *Journal of General Internal Medicine, 27*(6), 693-699.

Chen, C. C. H., Yen, C. J., Dai, Y. T., Wang, C., & Huang, G. H. (2011). Prevalence of geriatric conditions: A hospital-wide survey of 455 geriatric inpatients in a tertiary medical center. *Arch Gerontol Geriatr, 53*(1), 46-50.

Chen, C. M., Mullan, J., Su, Y. Y., Griffiths, D., Kreis, I. A., & Chiu, H. C. (2012). The longitudinal relationship between depressive symptoms and disability for older adults: A population-based study. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 67 A*(10), 1059-1067.

Chen, L. Y., Liu, L. K., Liu, C. L., Peng, L. N., Lin, M. H., Chen, L. K., . . . Chang, P. L. (2013). Predicting Functional Decline of Older Men Living in Veteran Homes by Minimum Data Set: Implications for Disability Prevention Programs in Long Term Care Settings. *Journal of the American Medical Directors Association, 14*(4), 309.e309-309.e313.

Cheng, L., Zhu, M., Poss, J. W., Hirdes, J. P., Glenny, C., & Stolee, P. (2015). Opinion versus practice regarding the use of rehabilitation services in home care: an investigation using machine learning algorithms. *BMC Med Inform Decis Mak, 15*, 80. doi: 10.1186/s12911-015-0203-1

Chin, H. J., Ahn, S. Y., Ryu, J., Kim, S., Kim, K. Y. N., Chae, D. W., . . . Kim, K. I. (2014). Renal function and decline in functional capacityin older adults. *Age and Ageing, 43*(6), 833-838. doi: 10.3389/fneur.2014.00246

Chu, L. W., Chiu, A. Y., & Chi, I. (2006). Impact of falls on the balance, gait, and activities of daily living functioning in community-dwelling Chinese older adults. *J Gerontol A Biol Sci Med Sci, 61*(4), 399-404.

Cigolle, C. T., Langa, K. M., Kabeto, M. U., Tian, Z., & Blaum, C. S. (2007). Geriatric conditions and disability: The health and retirement study. *Annals of Internal Medicine, 147*(3), 156-164.

CIHI. (2014a). Continuing Care Reporting System: Case Mix Resource Utilization Groups version 3 and RUG Weighted Patient Days—Resource Materials and FAQ, 2014–2015. Toronto, ON: CIHI.

CIHI. (2014b). Differences between RUG-III 44-Group and 34-Group Methodologies. Toronto, ON: CIHI.

CIHI. (2005). Exploring the 70/30 Split: How Canada's Health Care System is Financed. Ottawa, ON: CIHI.

CIHI. (2015). Your Health System. Retrieved June 12, 2015, from http://yourhealthsystem.cihi.ca/hsp/indepth?lang=en#/

CIHI. (2013). When a nursing home is home: how do Canadian nursing homes measure up on quality. Toronto, ON: Canadian Institute of Health Information

Ciol, M. A., Shumway-Cook, A., Hoffman, J. M., Yorkston, K. M., Dudgeon, B. J., & Chan, L. (2008). Minority disparities in disability between Medicare beneficiaries. *Journal of the American Geriatrics Society, 56*(3), 444-453.

Clark, D. O., Stump, T. E., Tu, W., & Miller, D. K. (2012). A comparison and cross-validation of models to predict basic activity of daily living dependency in older adults. *Medical care, 50*(6), 534-539.

Clark, S., & Horton, R. (2010). Putting research into context--revisited. *Lancet, 376*(9734), 10-11. doi: 10.1016/s0140-6736(10)61001-x

Clarke, P., & Nieuwenhuijsen, E. R. (2009). Environments for healthy ageing: a critical review. *Maturitas, 64*(1), 14-19. doi: 10.1016/j.maturitas.2009.07.011

Cohen, M. A., Tell, E. J., & Wallack, S. S. (1986). Client-related risk factors of nursing home entry among elderly adults. *J Gerontol, 41*(6), 785-792.

Comondore, V. R., Devereaux, P. J., Zhou, Q., Stone, S. B., Busse, J. W., Ravindran, N. C., . . . Guyatt, G. H. (2009). Quality of care in for-profit and not-for-profit nursing homes: Systematic review and meta-analysis. *BMJ (Online), 339*(7717), 381-384.

Covinsky, K. E., Palmer, R. M., Fortinsky, R. H., Counsell, S. R., Stewart, A. L., Kresevic, D., . . . Landefeld, C. S. (2003). Loss of independence in activities of daily living in older adults hospitalized with medical illnesses: increased vulnerability with age. *J Am Geriatr Soc, 51*(4), 451-458.

Covinsky, K. E., Pierluissi, E., & Johnston, C. B. (2011). Hospitalization-associated disability "She was probably able to ambulate, but i'm not sure". *JAMA - Journal of the American Medical Association, 306*(16), 1782-1793.

Covinsky, K. E., Wu, A. W., Landefeld, C. S., Connors, A. F., Jr., Phillips, R. S., Tsevat, J., . . . Fortinsky, R. H. (1999). Health status versus quality of life in older patients: does the distinction matter? *Am J Med, 106*(4), 435-440.

Crocker, T., Forster, A., Young, J., Brown, L., Ozer, S., Smith, J., . . . Greenwood, D. C. (2013). Physical rehabilitation for older people in long-term care. *Cochrane Database Syst Rev, 2*, Cd004294. doi: 10.1002/14651858.CD004294.pub3

Crocker, T., Young, J., Forster, A., Brown, L., Ozer, S., & Greenwood, D. C. (2013). The effect of physical rehabilitation on activities of daily living in older residents of long-term care facilities: Systematic review with meta-analysis. *Age and Ageing, 42*(6), 682-688. doi: 10.1093/ageing/aft133

Defending Public Healthcare. (2014). For-profit LTC homes attract fewer applicants than not-for-profit homes. *Defending Public Healthcare.* from http://ochuleftwords.blogspot.ca/2014/09/for-profit-ltc-beds-attract-fewer.html

de Meijer, C. A., Koopmanschap, M. A., Koolman, X. H., & van Doorslaer, E. K. (2009). The role of disability in explaining long-term care utilization. *Med Care, 47*(11), 1156-1163. doi: 10.1097/MLR.0b013e3181b69fa8

Drewes, Y. M., den Elzen, W. P. J., Mooijaart, S. P., de Craen, A. J. M., Assendelft, W. J. J., & Gussekloo, J. (2011). The effect of cognitive impairment on the predictive value of multimorbidity for the increase in disability in the oldest old: The Leiden 85-plus study. *Age and Ageing, 40*(3), 352-357.

Dutcher, S. K., Rattinger, G. B., Langenberg, P., Chhabra, P. T., Liu, X., Rosenberg, P. B., . . . Zuckerman, I. H. (2014). Effect of medications on physical function and cognition in nursing home residents with dementia. *Journal of the American Geriatrics Society, 62*(6), 1046-1055.

Enders, C. K. (2010). *Applied Missing Data Analysis*. New York, NY: Guilford Press.

European Commission. (2008). Long-term care in the European Union.

Fedecostante, M., Dell'Aquila, G., Eusebi, P., Volpato, S., Zuliani, G., Abete, P., . . . Cherubini, A. (2015). Predictors of Functional Changes in Italian Nursing Home Residents: The U.L.I.S.S.E. Study. *Journal of the American Medical Directors Association*. doi: 10.1016/j.jamda.2015.11.004

Feil, D. G., Zhu, C. W., & Sultzer, D. L. (2012). The relationship between cognitive impairment and diabetes self-management in a population-based community sample of older adults with Type 2 diabetes. *J Behav Med, 35*(2), 190-199. doi: 10.1007/s10865-011-9344-6

Ferrucci, L., Guralnik, J. M., Simonsick, E., Salive, M. E., Corti, C., & Langlois, J. (1996). Progressive versus catastrophic disability: a longitudinal view of the disablement process. *J Gerontol A Biol Sci Med Sci, 51*(3), M123-130.

Finlayson, E., Zhao, S., Boscardin, W. J., Fries, B. E., Landefeld, C. S., & Dudley, R. A. (2012). Functional status after colon cancer surgery in elderly nursing home residents. *J Am Geriatr Soc, 60*(5), 967-973. doi: 10.1111/j.1532-5415.2012.03915.x

Flacker, J. M. (2003). What is a geriatric syndrome anyway? *J Am Geriatr Soc, 51*(4), 574-576.

Forster, A., Lambley, R., & Young, J. B. (2010). Is physical rehabilitation for older people in long-term care effective? Findings from a systematic review. Age Ageing, 39(2), 169-175. doi: 10.1093/ageing/afp247

Fortin, M., Hudon, C., Haggerty, J., Akker, M., & Almirall, J. (2010). Prevalence estimates of multimorbidity: a comparative study of two sources. *BMC Health Serv Res, 10*, 111. doi: 10.1186/1472-6963-10-111

Frederiksen K., Tariot P., & E., D. J. (1996). Minimum Data Set Plus (MDS+) scores compared with scores from five rating scales. *Journal of the American Geriatrics Society, 44*(3), 305-309.

Fried, L. P., Bandeen-Roche, K., Kasper, J. D., & Guralnik, J. M. (1999). Association of comorbidity with disability in older women: the Women's Health and Aging Study. *J Clin Epidemiol, 52*(1), 27-37.

Friedman, E. M., Christ, S. L., & Mroczek, D. K. (2015). Inflammation Partially Mediates the Association of Multimorbidity and Functional Limitations in a National Sample of Middle-Aged and Older Adults: The MIDUS Study. *J Aging Health, 27*(5), 843-863. doi: 10.1177/0898264315569453

Frytak, J. R., Kane, R. A., Finch, M. D., Kane, R. L., & Maude-Griffin, R. (2001). Outcome trajectories for assisted living and nursing facility residents in Oregon. *Health Serv Res, 36*(1 Pt 1), 91-111.

Fultz, N. H., Ofstedal, M. B., Herzog, A. R., & Wallace, R. B. (2003). Additive and interactive effects of comorbid physical and mental conditions on functional health. *J Aging Health, 15*(3), 465-481.

Garin, N., Olaya, B., Miret, M., Ayuso-Mateos, J. L., Power, M., Bucciarelli, P., & Haro, J. M. (2014). Built environment and elderly population health: a comprehensive literature review. *Clin Pract Epidemiol Ment Health, 10*, 103-115. doi: 10.2174/1745017901410010103

Gill, T. M. (2010). Assessment of function and disability in longitudinal studies. *Journal of the American Geriatrics Society, 58*(SUPPL. 2), S308-S312.

Gill, T. M. (2014). Disentangling the disabling process: insights from the precipitating events project. *Gerontologist, 54*(4), 533-549. doi: 10.1093/geront/gnu067

Gill, T. M., Allore, H. G., Gahbauer, E. A., & Murphy, T. E. (2010). Change in disability after hospitalization or restricted activity in older persons. *JAMA, 304*(17), 1919-1928. doi: 10.1001/jama.2010.1568

Gill, T. M., Allore, H. G., Holford, T. R., & Guo, Z. (2004). Hospitalization, restricted activity, and the development of disability among older persons. *JAMA, 292*(17), 2115-2124. doi: 10.1001/jama.292.17.2115

Gill, T. M., Gahbauer, E. A., Han, L., & Allore, H. G. (2010). Trajectories of disability in the last year of life. *N Engl J Med, 362*(13), 1173-1180. doi: 10.1056/NEJMoa0909087

Gill, T. M., Hardy, S. E., & Williams, C. S. (2002). Underestimation of disability in community-living older persons. *J Am Geriatr Soc, 50*(9), 1492-1497.

Gillen, P., Spore, D., Mor, V., & Freiberger, W. (1996). Functional and residential status transitions among nursing home residents. *J Gerontol A Biol Sci Med Sci, 51*(1), M29-36.

Gitlin, L. N. (2003). Conducting research on home environments: lessons learned and new directions. *Gerontologist, 43*(5), 628-637.

Glenny, C., Stolee, P., Thompson, M., Husted, J., & Berg, K. (2012). Underestimating physical function gains: comparing FIM motor subscale and interRAI post acute care activities of daily living scale. Arch Phys Med Rehabil, 93(6), 1000-1008. doi: 10.1016/j.apmr.2011.12.027

Gopinath, B., Russell, J., Flood, V. M., Burlutsky, G., & Mitchell, P. (2014). Adherence to dietary guidelines positively affects quality of life and functional status of older adults. *Journal of the Academy of Nutrition and Dietetics, 114*(2), 220-229. doi: 10.1016/j.jand.2013.09.001

Gozalo, P. L., Pop-Vicas, A., Feng, Z., Gravenstein, S., & Mor, V. (2012). Effect of influenza on functional decline. *J Am Geriatr Soc, 60*(7), 1260-1267. doi: 10.1111/j.1532-5415.2012.04048.x

Grabowski, D. C., Stewart, K. A., Broderick, S. M., & Coots, L. A. (2008). Review: Predictors of nursing home hospitalization - A review of the literature. *Medical Care Research and Review, 65*(1), 3-39.

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J, 26*(2), 91-108. doi: 10.1111/j.1471-1842.2009.00848.x

Groll, D. L., To, T., Bombardier, C., & Wright, J. G. (2005). The development of a comorbidity index with physical function as the outcome. *J Clin Epidemiol, 58*(6), 595-602. doi: 10.1016/j.jclinepi.2004.10.018

Hawes, C., Morris, J. N., Phillips, C. D., Fries, B. E., Murphy, K., & Mor, V. (1997). Development of the nursing home Resident Assessment Instrument in the USA. *Age Ageing, 26 Suppl 2*, 19-25.

Hawes, C., Morris, J. N., Phillips, C. D., Mor, V., Fries, B. E., & Nonemaker, S. (1995). Reliability estimates for the Minimum Data Set for nursing home resident assessment and care screening (MDS). *Gerontologist, 35*(2), 172-178.

Health Quality Ontario, HQO. (2014). Percentage of residents with increasing difficulty carrying out normal everyday tasks. *Health Topic*. Retrieved November 5, 2014, from http://www.hqontario.ca/public-reporting/long-term-care

Helvik, A. S., Engedal, K., Benth, J. S., & Selbæk, G. (2014). A 52 month follow-up of functional decline in nursing home residents - Degree of dementia contributes. *BMC Geriatr, 14*(1).

Hillmer, M. P., Wodchis, W. P., Gill, S. S., Anderson, G. M., & Rochon, P. A. (2005). Nursing home profit status and quality of care: Is there any evidence of an association? *Medical Care Research and Review, 62*(2), 139-166.

Hirdes, J. P., Frijters, D. H., & Teare, G. F. (2003). The MDS-CHESS scale: a new measure to predict mortality in institutionalized older people. *J Am Geriatr Soc, 51*(1), 96-100.

Hirdes, J. P., Ljunggren, G., Morris, J. N., Frijters, D. H., Finne Soveri, H., Gray, L., . . . Gilgen, R. (2008). Reliability of the interRAI suite of assessment instruments: A 12-country study of an integrated health information system. *BMC Health Services Research, 8*.

Hirdes, J. P., Mitchell, L., Maxwell, C. J., & White, N. (2011). Beyond the 'iron lungs of gerontology': Using evidence to shape the future of nursing homes in Canada. *Canadian Journal on Aging, 30*(3), 371-390.

Hirdes, J. P., Poss, J. W., Caldarelli, H., Fries, B. E., Morris, J. N., Teare, G. F., . . . Jutan, N. (2013). An evaluation of data quality in Canada's continuing care reporting system (CCRS): Secondary analyses of Ontario data submitted between 1996 and 2011. *BMC Medical Informatics and Decision Making, 13*(1).

Hirdes, J. P., Poss, J. W., & Curtin-Telegdi, N. (2008). The Method for Assigning Priority Levels (MAPLe): a new decision-support system for allocating home care resources. *BMC Med, 6*, 9. doi: 10.1186/1741-7015-6-9

Hirth, R. A., Grabowski, D. C., Feng, Z., Rahman, M., & Mor, V. (2014). Effect of nursing home ownership on hospitalization of long-stay residents: An instrumental variables approach. *International Journal of Health Care Finance and Economics, 14*(1), 1-18.

Hung, W. W., Ross, J. S., Boockvar, K. S., & Siu, A. L. (2011). Recent trends in chronic disease, impairment and disability among older adults in the United States. *BMC Geriatr, 11*.

Inouye, S. K., Studenski, S., Tinetti, M. E., & Kuchel, G. A. (2007). Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. *J Am Geriatr Soc, 55*(5), 780-791. doi: 10.1111/j.1532-5415.2007.01156.x

interRAI. (2014). Scales. from http://www.interrai.org/scales.html

Jackson, C. A., Jones, M., Tooth, L., Mishra, G. D., Byles, J., & Dobson, A. (2015). Multimorbidity patterns are differentially associated with functional ability and decline in a longitudinal cohort of older women. *Age Ageing, 44*(5), 810-816. doi: 10.1093/ageing/afv095

Jette, A. M. (2006). Toward a common language for function, disability, and health. *Phys Ther, 86*(5), 726-734.

Johnston, M., & Dixon, D. (2014). Developing an integrated biomedical and behavioural theory of functioning and disability: adding models of behaviour to the ICF framework. *Health Psychol Rev, 8*(4), 381-403. doi: 10.1080/17437199.2013.855592

Katz, P. R. (2011). An international perspective on long term care: focus on nursing homes. *J Am Med Dir Assoc, 12*(7), 487-492.e481. doi: 10.1016/j.jamda.2011.01.017

Kaye, H. S., Harrington, C., & LaPlante, M. P. (2010). Long-term care: who gets it, who provides it, who pays, and how much? *Health Aff (Millwood), 29*(1), 11-21. doi: 10.1377/hlthaff.2009.0535

Kelley-Moore, J. A., & Ferraro, K. F. (2005). A 3-D model of health decline: disease, disability, and depression among Black and White older adults. *J Health Soc Behav, 46*(4), 376-391.

Kernick, D. (2012). A theoretical framework for multimorbidity: From complicated to chaotic. *British Journal of General Practice, 62*(602), e659-e662.

Keysor, J. J. (2003). Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence. *Am J Prev Med, 25*(3 Suppl 2), 129-136.

Kim, J. H., & Park, E. Y. (2015). Mediating effect of self-control in relation to depression, stress, and activities of daily living in community residents with stroke. *Journal of Physical Therapy Science, 27*(8), 2585-2589. doi: 10.1589/jpts.27.2585

Koller, D., Schon, G., Schafer, I., Glaeske, G., van den Bussche, H., & Hansen, H. (2014). Multimorbidity and long-term care dependency-a five-year follow-up. *BMC Geriatr, 14*, 70. doi: 10.1186/1471-2318-14-70

Koné Pefoyo, A. J., Bronskill, S. E., Gruneir, A., Calzavara, A., Thavorn, K., Petrosyan, Y., . . . Wodchis, W. P. (2015). The increasing burden and complexity of multimorbidity. *BMC Public Health*, 1-11. doi: 10.1186/s12889-015-1733-2

Koroukian, S. M., Schiltz, N., Warner, D. F., Sun, J., Bakaki, P. M., Smyth, K. A., . . . Given, C. W. (2016). Combinations of Chronic Conditions, Functional Limitations, and Geriatric Syndromes that Predict Health Outcomes. *J Gen Intern Med*. doi: 10.1007/s11606-016-3590-9

Koster, A., Bosma, H., Broese van Groenou, M. I., Kempen, G. I., Penninx, B. W., van Eijk, J. T., & Deeg, D. J. (2006). Explanations of socioeconomic differences in changes in physical function in older adults: results from the Longitudinal Aging Study Amsterdam. *BMC Public Health, 6*, 244. doi: 10.1186/1471-2458-6-244

Kraemer, H. C., Kiernan, M., Essex, M., & Kupfer, D. J. (2008). How and Why Criteria Defining Moderators and Mediators Differ Between the Baron & Kenny and MacArthur Approaches. *Health Psychology, 27*(2 SUPPL. 2), S101-S108.

Krein, S. L., Heisler, M., Piette, J. D., Makki, F., & Kerr, E. A. (2005). The effect of chronic pain on diabetes patients' self-management. *Diabetes Care, 28*(1), 65-70.

Kruse, R. L., Petroski, G. F., Mehr, D. R., Banaszak-Holl, J., & Intrator, O. (2013). Activity of daily living trajectories surrounding acute hospitalization of long-stay nursing home residents. *J Am Geriatr Soc, 61*(11), 1909-1918. doi: 10.1111/jgs.12511

Kurella Tamura, M., Covinsky, K. E., Chertow, G. M., Yaffe, K., Landefeld, C. S., & McCulloch, C. E. (2009). Functional status of elderly adults before and after initiation of dialysis. *N Engl J Med, 361*(16), 1539-1547. doi: 10.1056/NEJMoa0904655

Laan, W., Bleijenberg, N., Drubbel, I., Numans, M. E., De Wit, N. J., & Schuurmans, M. J. (2013). Factors associated with increasing functional decline in multimorbid independently living older people. *Maturitas, 75*(3), 276-281.

Lam, J. M. C., & Wodchis, W. P. (2010). The relationship of 60 disease diagnoses and 15 conditions to preference-based health-related quality of life in ontario hospital-based long-term care residents. Medical care, 48(4), 380-387.

Landi, F., Onder, G., Cesari, M., Zamboni, V., Russo, A., Barillaro, C., & Bernabei, R. (2006). Functional decline in frail community-dwelling stroke patients. *European Journal of Neurology, 13*(1), 17-23.

Latham, K. (2012). Progressive and accelerated disability onset by race/ethnicity and education among late midlife and older adults. *Journal of Aging and Health, 24*(8), 1320-1345.

Lawton M.P., Casten R., Parmelee P.A., Van Haitsma K., Corn J., & M.H., K. (1998). Psychometric characteristics of the minimum data set II: validity. . *Journal of the American Geriatrics Society, 46*(6), 736-744.

Lee, J., & Rantz, M. (2008). Correlates of post-hospital physical function at 1 year in skilled nursing facility residents. *J Adv Nurs, 62*(4), 479-486. doi: 10.1111/j.1365-2648.2008.04612.x

Li, C. L., Chiu, Y. C., Chang, H. Y., Hsu, K. H., Bai, Y. B., & Wang, H. H. (2013). Association of geriatric conditions and cardiovascular diseases with disability in older adults with diabetes: Findings from a nationally representative survey. *Geriatrics and Gerontology International, 13*(3), 563-570.

Li, L. W. (2005a). Predictors of ADL disability trajectories among low-income frail elders in the community. *Research on Aging, 27*(6), 615-642.

Li, L. W. (2005b). Trajectories of ADL disability among community-dwelling frail older persons. *Research on Aging, 27*(1), 56-79.

Li, L. W., & Conwell, Y. (2009). Effects of changes in depressive symptoms and cognitive functioning on physical disability in home care elders. *J Gerontol A Biol Sci Med Sci, 64*(2), 230-236. doi: 10.1093/gerona/gln023

Liang, J., Xu, X., Bennett, J. M., Ye, W., & Quinones, A. R. (2010). Ethnicity and changing functional health in middle and late life: a person-centered approach. *J Gerontol B Psychol Sci Soc Sci, 65*(4), 470-481. doi: 10.1093/geronb/gbp114

Lindholm, C., Gustavsson, A., Jonsson, L., & Wimo, A. (2013). Costs explained by function rather than diagnosis--results from the SNAC Nordanstig elderly cohort in Sweden. *Int J Geriatr Psychiatry, 28*(5), 454-462. doi: 10.1002/gps.3844

Lix, L. M., Yan, L., Blackburn, D., Hu, N., Schneider-Lindner, V., & Teare, G. F. (2014). Validity of the RAI-MDS for ascertaining diabetes and comorbid conditions in long-term care facility residents. *BMC Health Serv Res, 14*, 17. doi: 10.1186/1472-6963-14-17

Lloyd, L., Banerjee, A., Harrington, C., Jacobsen, F. F., & Szebehely, M. (2014). It is a scandal!: Comparing the causes and consequences of nursing home media scandals in five countries. *International Journal of Sociology and Social Policy, 34*(1), 2-18.

L.S.A.A. Steering Committee. (2013). *L-SAA Steering Committee Communique #5*. Toronto, ON: Ministry of Health and Long-Term Care Retrieved from http://www.lhincollaborative.ca/uploadedFiles/LHIN_Collaborative/LAPS_and_L-SAA/LSAA%20Communique%205%2011Jan13%20ENGLISH.PDF.

Mänty, M., Thinggaard, M., Christensen, K., & Avlund, K. (2014). Musculoskeletal pain and physical functioning in the oldest old. *European Journal of Pain (United Kingdom), 18*(4), 522-529.

Marcantonio, E. R., Simon, S. E., Bergmann, M. A., Jones, R. N., Murphy, K. M., & Morris, J. N. (2003). Delirium symptoms in post-acute care: prevalent, persistent, and associated with poor functional recovery. *J Am Geriatr Soc, 51*(1), 4-9.

Marengoni, A., Von Strauss, E., Rizzuto, D., Winblad, B., & Fratiglioni, L. (2009). The impact of chronic multimorbidity and disability on functional decline and survival in elderly persons. A community-based, longitudinal study. *Journal of Internal Medicine, 265*(2), 288-295.

Marquardt, G., Johnston, D., Black, B. S., Morrison, A., Rosenblatt, A., Lyketsos, C. G., & Samus, Q. M. (2011). Association of the spatial layout of the home and ADL abilities among older adults with dementia. *Am J Alzheimers Dis Other Demen, 26*(1), 51-57. doi: 10.1177/1533317510387584

Marventano, S., Ayala, A., Gonzalez, N., Rodriguez-Blazquez, C., Garcia-Gutierrez, S., & Forjaz, M. J. (2014). Multimorbidity and functional status in community-dwelling older adults. *Eur J Intern Med*. doi: 10.1016/j.ejim.2014.06.018

Mays, N., Pope, C., & Popay, J. (2005). Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. *J Health Serv Res Policy, 10 Suppl 1*, 6-20. doi: 10.1258/1355819054308576

McConnell, E. S., Branch, L. G., Sloane, R. J., & Pieper, C. F. (2003). Natural history of change in physical function among long-stay nursing home residents. *Nurs Res, 52*(2), 119-126.

McCusker, J., Cole, M., Dendukuri, N., Belzile, E., & Primeau, F. (2001). Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. *CMAJ, 165*(5), 575-583.

McGrail, K. M., McGregor, M. J., Cohen, M., Tate, R. B., & Ronald, L. A. (2007). For-profit versus not-for-profit delivery of long-term care. *CMAJ, 176*(1), 57-58. doi: 10.1503/cmaj.060591

McGregor, M. A., & Ronald, L. A. (2011). Residential Long-Term Care for Canadian Seniors: Nonprofit, For-Profit or Does It Matter? *Ideas Analysis Debate*. Montréal, Quebec: Institute for Research on Public Policy.

McGregor, M. J., Cohen, M., McGrail, K., Broemeling, A. M., Adler, R. N., Schulzer, M., . . . Beck, M. (2005). Staffing levels in not-for-profit and for-profit long-term care facilities: does type of ownership matter? *CMAJ, 172*(5), 645-649. doi: 10.1503/cmaj.1040131

McLaren, A. N., Lamantia, M. A., & Callahan, C. M. (2013). Systematic review of non-pharmacologic interventions to delay functional decline in community-dwelling patients with dementia. *Aging and Mental Health, 17*(6), 655-666.

Meade, M. A., Mahmoudi, E., & Lee, S. Y. (2015). The intersection of disability and healthcare disparities: A conceptual framework. *Disabil Rehabil, 37*(7), 632-641. doi: 10.3109/09638288.2014.938176

Mendes De Leon, C. F., & Rajan, K. B. (2014). Psychosocial influences in onset and progression of late life disability. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences, 69*(2), 287-302. doi: 10.1093/geronb/gbt130

Miller, E. A., & Nadash, P. (2014). The Affordable Care Act and long-term care: marginal advancement on the status quo. *Home Health Care Serv Q, 33*(4), 194-210. doi: 10.1080/01621424.2014.956959

Mody, L., Sun, R., & Bradley, S. F. (2006). Assessment of pneumonia in older adults: Effect of functional status. *Journal of the American Geriatrics Society, 54*(7), 1062-1067.

MOHLTH (2008). Reports on Long-Term Care Homes. Retrieved February 5, 2015, from http://publicreporting.ltchomes.net/en-ca/default.aspx

Mor, V., Gruneir, A., Feng, Z., Grabowski, D. C., Intrator, O., & Zinn, J. (2011). The effect of state policies on nursing home resident outcomes. *Journal of the American Geriatrics Society, 59*(1), 3-9. doi: 10.1111/j.1532-5415.2010.03230.x

Morris, J. N., Fries, B. E., Mehr, D. R., Hawes, C., Phillips, C., Mor, V., & Lipsitz, L. A. (1994). MDS Cognitive Performance Scale. *J Gerontol, 49*(4), M174-182.

Morris, J. N., Fries, B. E., & Morris, S. A. (1999). Scaling ADLs within the MDS. *J Gerontol A Biol Sci Med Sci, 54*(11), M546-553.

Murphy, T. E., Allore, H. G., Han, L., Peduzzi, P. N., Gill, T. M., Xu, X., & Lin, H. (2015). A longitudinal, observational study with many repeated measures demonstrated improved precision of individual survival curves using bayesian joint modeling of disability and survival. *Exp Aging Res, 41*(3), 221-239. doi: 10.1080/0361073x.2015.1021640

Nagi, S. Z. (1965). Some conceptual issues in disability and rehabilitation. In M. B. Susman (Ed.), *Sociology and Rehabilitation*. Washington, DD: Americal Sociological Association

Neuman, M. D., Silber, J. H., Magaziner, J. S., Passarella, M. A., Mehta, S., & Werner, R. M. (2014). Survival and functional outcomes after hip fracture among nursing home residents. *JAMA Intern Med, 174*(8), 1273-1280. doi: 10.1001/jamainternmed.2014.2362

Nihtilä, E. K., Martikainen, P. T., Koskinen, S. V. P., Reunanen, A. R., Noro, A. M., & Häkkinen, U. T. (2008). Chronic conditions and the risk of long-term institutionalization among older people. *European Journal of Public Health, 18*(1), 77-84.

Nusselder, W. J., Looman, C. W., & Mackenbach, J. P. (2006). The level and time course of disability: trajectories of disability in adults and young elderly. *Disabil Rehabil, 28*(16), 1015-1026. doi: 10.1080/09638280500493803

OACCAC. (2011). Long-Term Care Placement Manual (1st ed.). Toronto, ON.

OECD. (2011). Long-term Care: Growing Sector, Multifaceted Systems.

Olde Rikkert, M. G., Rigaud, A. S., van Hoeyweghen, R. J., & de Graaf, J. (2003). Geriatric syndromes: medical misnomer or progress in geriatrics? *Neth J Med, 61*(3), 83-87.

OLTCA. (2014). This is Long-Term Care 2014. Ontario, Canada: OLTCA.

OMHLTC. (2010). A Guide to the Long-Term Care Homes Act, 2007 and Regulation 79/10 (Vol. Phase 1). Toronto, ON Ontario Ministry of Health and Long-Term Care.

OMHLTC. (2011). *Long-Term Care Homes Financial Policy*. Toronto, ON: Queen's Park Press Retrieved from http://www.health.gov.on.ca/en/public/programs/ltc/docs/loc_per_diem_policy.pdf.

OMHLTC. (2014). Complex Continuing Care Co-payment 2010. Retrieved February 24, 2015, from http://www.health.gov.on.ca/en/public/publications/chronic/chronic.aspx

Park, N. S., Klemmack, D. L., Roff, L. L., Parker, M. W., Koenig, H. G., Sawyer, P., & Allman, R. M. (2008). Religiousness and longitudinal trajectories in elders' functional status. *Research on Aging, 30*(3), 279-298.

Peng, L. N., Lin, M. H., Liu, L. K., Tung, H. H., Chen, L. Y., Chu, K. H., . . . Chen, L. K. (2014). Nutritional status plays the mediating role of the functional status and comorbidity among older patients admitted to the Geriatric Evaluation and Management Unit: A Tobit model application. *European Geriatric Medicine*.

Perrin, N. A., Stiefel, M., Mosen, D. M., Bauck, A., Shuster, E., & Dirks, E. M. (2011). Self-reported health and functional status information improves prediction of inpatient admissions and costs. *Am J Manag Care, 17*(12), e472-478.

Philibert, M., Pampalon, R., & Daniel, M. (2015). Conceptual and operational considerations in identifying socioenvironmental factors associated with disability among community-dwelling adults. *International Journal of Environmental Research and Public Health, 12*(4), 3814-3834. doi: 10.3390/ijerph120403814

Phillips, C. D., Chen, M., & Sherman, M. (2008). To what degree does provider performance affect a quality indicator? The case of nursing homes and ADL change. *Gerontologist, 48*(3), 330-337.

Phillips, C. D., Shen, R., Chen, M., & Sherman, M. (2007). Evaluating nursing home performance indicators: An illustration exploring the impact of facilities on ADL change. *Gerontologist, 47*(5), 683-689.

Piernik-Yoder, B., & Ketchum, N. (2013). Rehabilitation outcomes of stroke patients with and without diabetes. *Arch Phys Med Rehabil, 94*(8), 1508-1512. doi: 10.1016/j.apmr.2013.04.014

Quagliarello, V., Ginter, S., Han, L., Van Ness, P., Allore, H., & Tinetti, M. (2005). Modifiable risk factors for nursing home-acquired pneumonia. *Clin Infect Dis, 40*(1), 1-6. doi: 10.1086/426023

Quinones, P. A., Seidl, H., Holle, R., Kuch, B., Meisinger, C., Hunger, M., & Kirchberger, I. (2014). New potential determinants of disability in aged persons with myocardial infarction: Results from the KORINNA-study. *BMC Geriatr, 14*(1). doi: 10.1186/1471-2318-14-34

Rabe-Hesketh, S., & Skronda, A. (2012). *Multilevel and Longitudinal Modeling Using Stata* (3rd ed. Vol. Volume I: Continuous Responses). College Station, Texas: Stata Press.

Rajan, K. B., Hebert, L. E., Scherr, P., Dong, X., Wilson, R. S., Evans, D. A., & Mendes De Leon, C. F. (2012). Cognitive and physical functions as determinants of delayed age at onset and progression of disability. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 67*(12), 1419-1426.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage

Resnick, B., Galik, E., & Boltz, M. (2013). Function focused care approaches: literature review of progress and future possibilities. J Am Med Dir Assoc, 14(5), 313-318. doi: 10.1016/j.jamda.2012.10.019

Reuben, D. B., Herr, K. A., Pacala, J. T., Pollack, B. G., Potter, J. F., & Semla, T. P. (2013). *Geriatrics at your Fingertips* (15th ed.). New York, NY: American Geriatrics Society.

Rhemtulla, M., Brosseau-Liard, P. E., & Savalei, V. (2012). When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions. *Psychol Methods, 17*(3), 354-373. doi: 10.1037/a0029315

Richiardi, L., Bellocco, R., & Zugna, D. (2013). Mediation analysis in epidemiology: methods, interpretation and bias. *Int J Epidemiol, 42*(5), 1511-1519. doi: 10.1093/ije/dyt127

Rist, P. M., Capistrant, B. D., Wu, Q., Marden, J. R., & Glymour, M. M. (2014). Dementia and dependence: Do modifiable risk factors. *Neurology, 82*(17), 1543-1550. doi: 10.1212/WNL.0000000000000357

Ritchie, C. S., Locher, J. L., Roth, D. L., McVie, T., Sawyer, P., & Allman, R. (2008). Unintentional weight loss predicts decline in activities of daily living function and life-space mobility over 4 years among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci, 63*(1), 67-75.

Rosso, A. L., Eaton, C. B., Wallace, R., Gold, R., Curb, J. D., Stefanick, M. L., . . . Michael, Y. L. (2011). Combined impact of geriatric syndromes and cardiometabolic diseases on measures of functional impairment. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 66 A*(3), 349-354.

Rosso, A. L., Eaton, C. B., Wallace, R., Gold, R., Stefanick, M. L., Ockene, J. K., . . . Michael, Y. L. (2013). Geriatric syndromes and incident disability in older women: Results from the women's health initiative observational study. *Journal of the American Geriatrics Society, 61*(3), 371-379.

Russo, A., Cesari, M., Onder, G., Zamboni, V., Barillaro, C., Pahor, M., . . . Landi, F. (2007). Depression and physical function: results from the aging and longevity study in the Sirente geographic area (ilSIRENTE Study). *J Geriatr Psychiatry Neurol, 20*(3), 131-137. doi: 10.1177/0891988707301865

SAS Institute, I. (2012). Cary, NC.

Schaefer, N. (2015). Disability search tips and resources. *Med Ref Serv Q, 34*(1), 60-74. doi: 10.1080/02763869.2015.986792

Sjölund, B. M., Nordberg, G., Wimo, A., & Von Strauss, E. (2010). Morbidity and physical functioning in old age: Differences according to living area. *Journal of the American Geriatrics Society, 58*(10), 1855-1862.

Smith, A. K., Walter, L. C., Miao, Y., Boscardin, W. J., & Covinsky, K. E. (2013). Disability during the last two years of life. *JAMA Internal Medicine, 173*(16), 1506-1513.

Sousa, M., Ferri, C. P., Acosta, D., Albanese, E., Guerra, M., Huang, Y., . . . Prince, M. (2009). Contribution of chronic diseases to disability in elderly people in countries with low and middle incomes: a 10/66 Dementia Research Group population-based survey. *The Lancet, 374*(9704), 1821-1830.

Spalter, T., Brodsky, J., & Shnoor, Y. (2014). Improvements and decline in the physical functioning of israeli older adults. *Gerontologist, 54*(6), 919-929. doi: 10.1093/geront/gnt084

Spector, W. D., & Takada, H. A. (1991). Characteristics of nursing homes that affect resident outcomes. *J Aging Health, 3*(4), 427-454.

Spiers, N. A., Matthews, R. J., Jagger, C., Matthews, F. E., Boult, C., Robinson, T. G., & Brayne, C. (2005). Diseases and impairments as risk factors for onset of disability in the older population in England and Wales: findings from the Medical Research Council Cognitive Function and Ageing Study. *J Gerontol A Biol Sci Med Sci, 60*(2), 248-254.

Starfield, B. (2011). Challenges to primary care from co- and multi-morbidity. *Prim Health Care Res Dev, 12*(1), 1-2. doi: 10.1017/s1463423610000484

Statistics Canada. (2011). Residential Care Facilities 2009/2010. Ottawa, ON.

Stel, V. S., Smit, J. H., Pluijm, S. M. F., & Lips, P. (2004). Consequences of falling in older men and women and risk factors for health service use and functional decline. *Age and Ageing, 33*(1), 58-65. doi: 10.1093/ageing/afh028

Stineman, M. G., Zhang, G., Kurichi, J. E., Zhang, Z., Streim, J. E., Pan, Q., & Xie, D. (2013). Prognosis for Functional Deterioration and Functional Improvement in Late Life Among Community-Dwelling Persons. *PM and R, 5*(5), 360-371.

Talley, K. M., Wyman, J. F., Savik, K., Kane, R. L., Mueller, C., & Zhao, H. (2015). Restorative Care's Effect on Activities of Daily Living Dependency in Long-stay Nursing Home Residents. *Gerontologist, 55 Suppl 1*, S88-98. doi: 10.1093/geront/gnv011

Talley, K. M. C., Wyman, J. F., Bronas, U. G., Olson-Kellogg, B. J., McCarthy, T. C., & Zhao, H. (2014). Factors associated with toileting disability in older adults without dementia living in residential care facilities. *Nursing research, 63*(2), 94-104. doi: 10.1097/NNR.0000000000000017

Tappen, R. M., & Ouslander, J. G. (2010). State-of-the-art in longitudinal studies on aging: An overview of the supplement. *Journal of the American Geriatrics Society, 58*(SUPPL. 2), S283-S286.

Taylor, M. G. (2010). Capturing transitions and trajectories: the role of socioeconomic status in later life disability. *J Gerontol B Psychol Sci Soc Sci, 65*(6), 733-743. doi: 10.1093/geronb/gbq018

Thomas, J. M., Cooney, L. M., Jr., & Fried, T. R. (2013). Systematic review: Health-related characteristics of elderly hospitalized adults and nursing home residents associated with short-term mortality. *J Am Geriatr Soc, 61*(6), 902-911. doi: 10.1111/jgs.12273

Thyberg, M., Arvidsson, P., Thyberg, I., & Nordenfelt, L. (2015). Simplified bipartite concepts of functioning and disability recommended for interdisciplinary use of the ICF. *Disabil Rehabil, 37*(19), 1783-1792. doi: 10.3109/09638288.2014.978506

Tinetti, M. E., McAvay, G. J., Chang, S. S., Newman, A. B., Fitzpatrick, A. L., Fried, T. R., & Peduzzi, P. N. (2011). Contribution of multiple chronic conditions to universal health outcomes. *Journal of the American Geriatrics Society, 59*(9), 1686-1691.

Tooth, L., Hockey, R., Byles, J., & Dobson, A. (2008). Weighted multimorbidity indexes predicted mortality, health service use, and health-related quality of life in older women. *J Clin Epidemiol, 61*(2), 151-159. doi: 10.1016/j.jclinepi.2007.05.015

USDHHS. (2003). The future supply of long-term care workers in relation to the aging baby boom generation: report to Congress. Washington, DC: DHHS.

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Soc Sci Med, 38*(1), 1-14.

Vogel, T. R., Petroski, G. F., & Kruse, R. L. (2014). Functional status of elderly adults before and after interventions for critical limb ischemia. *Journal of Vascular Surgery, 59*(2), 350-358.

Wahl, H. W., Fange, A., Oswald, F., Gitlin, L. N., & Iwarsson, S. (2009). The home environment and disability-related outcomes in aging individuals: what is the empirical evidence? *Gerontologist, 49*(3), 355-367. doi: 10.1093/geront/gnp056

Wahl, H. W., Iwarsson, S., & Oswald, F. (2012). Aging well and the environment: toward an integrative model and research agenda for the future. *Gerontologist, 52*(3), 306-316. doi: 10.1093/geront/gnr154

Wang, J., Chang, L. H., Eberly, L. E., Virnig, B. A., & Kane, R. L. (2010). Cognition moderates the relationship between facility characteristics, personal impairments, and nursing home residents' activities of daily living. *J Am Geriatr Soc, 58*(12), 2275-2283. doi: 10.1111/j.1532-5415.2010.03173.x

Wang, J., Kane, R. L., Eberly, L. E., Virnig, B. A., & Chang, L. H. (2009). The effects of resident and nursing home characteristics on activities of daily living. *J Gerontol A Biol Sci Med Sci, 64*(4), 473-480. doi: 10.1093/gerona/gln040

Warner, D. F., & Brown, T. H. (2011). Understanding how race/ethnicity and gender define age-trajectories of disability: an intersectionality approach. *Soc Sci Med, 72*(8), 1236-1248. doi: 10.1016/j.socscimed.2011.02.034

Werner, R. M., Konetzka, R. T., & Polsky, D. (2013). The effect of pay-for-performance in nursing homes: evidence from state Medicaid programs. *Health Serv Res, 48*(4), 1393-1414. doi: 10.1111/1475-6773.12035

White, A., Hurd, D., Moore, T., Warner, D., Wu, N., & Sweetland, R. (2006). Quality Monitoring for Medicare Global Payment Demonstrations: Nursing Home Quality-Based Purchasing Demonstration Final Design Report. Cambridge, MA: Abt Associates Inc.

WHO. (1980). International Classification of Impairments, Disabilities, and Handicaps. Geneva.

WHO. (2001). International Classification of Functioning, Disability and Health: ICF. Geneva, Switzerland: World Health Organization.

WHO. (2004). A Glossary of Terms for Community Health Care and Services for Older Persons. Kobe.

Wodchis, W. P., Austin, P., Newman , A., Corallo, A., & Henry, D. (2012). *The Concentration of Health Care Spending: Little Ado (yet) About Much (money)*. Paper presented at the CAHSPR, Montreal, QC. https://www.longwoods.com/articles/images/The_Concentration_of_Healthcare_Spending_from_ICES.pdf

Wolff, J. L., Boult, C., Boyd, C., & Anderson, G. (2005). Newly reported chronic conditions and onset of functional dependency. *J Am Geriatr Soc, 53*(5), 851-855. doi: 10.1111/j.1532-5415.2005.53262.x

Wolinsky, F. D., Armbrecht, E. S., & Wyrwich, K. W. (2000a). Rethinking functional limitation pathways. *Gerontologist, 40*(2), 137-146.

Wolinsky, F. D., Armbrecht, E. S., & Wyrwich, K. W. (2000b). Rethinking functional limitation pathways. *Gerontologist, 40*(2), 137-146.

Wolinsky, F. D., Bentler, S. E., Hockenberry, J., Jones, M. P., Obrizan, M., Weigel, P. A., . . . Wallace, R. B. (2011). Long-term declines in ADLs, IADLs, and mobility among older Medicare beneficiaries. *BMC Geriatr, 11*, 43. doi: 10.1186/1471-2318-11-43

Yang, M., Ding, X., & Dong, B. (2014). The Measurement of Disability in the Elderly: A Systematic Review of Self-Reported Questionnaires. *Journal of the American Medical Directors Association, 15*(2), 150.e151-150.e159. doi: 10.1016/j.jamda.2013.10.004

Yeh, K. P., Lin, M. H., Liu, L. K., Chen, L. Y., Peng, L. N., & Chen, L. K. (2014). Functional decline and mortality in long-term care settings: Static and dynamic approach. *Journal of Clinical Gerontology and Geriatrics, 5*(1), 13-17.

Yen, I. H., Michael, Y. L., & Perdue, L. (2009). Neighborhood Environment in Studies of Health of Older Adults. A Systematic Review. *Am J Prev Med, 37*(5), 455-463. doi: 10.1016/j.amepre.2009.06.022

Yu, H. W., Chen, D. R., Chiang, T. L., Tu, Y. K., & Chen, Y. M. (2015). Disability trajectories and associated disablement process factors among older adults in Taiwan. *Arch Gerontol Geriatr, 60*(2), 272-280. doi: 10.1016/j.archger.2014.12.005

Zimmerman, S., Anderson, W. L., Brode, S., Jonas, D., Lux, L., Beeber, A. S., . . . Sloane, P. D. (2013). Systematic review: Effective characteristics of nursing homes and other residential long-term care settings for people with dementia. *J Am Geriatr Soc, 61*(8), 1399-1409. doi: 10.1111/jgs.12372

Appendices

Appendix 1.1: Abbreviations Used in Dissertation

ADL – activity of daily living

CCRS - Continuous Care Reporting System

DAD - Discharge Abstract Database

HLM – Hierarchical Linear Model

ICD-9 - International Statistical Classification of Diseases and Related Health Problems, 9th Revision

ICD-10-CA – International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada

ICES – Institute for Clinical Evaluative Sciences

LHINs - Local Health Integration Networks

LTC – long-term care

LTCH – long-term care home

LTCHA – Long-Term Care Homes Act

L-SAA - Long-Term Care Home Service Accountability Agreement

MCAR – Missing Completely at Random

MOHLTC – Ministry of Health and Long-Term Care

OHIP – Ontario Health Insurance Plan

RAI – Resident Assessment Instrument

RAI-MDS – Resident Assessment Instrument Minimum Data Set

RPDB - Registered Person's Database

RUGs – Resource Utilization Groups (Measured in RAI-MDS assessment)

US – United States of America

Appendix 1.2: Definitions of Terms used in Dissertation

The table below contains a summary of variables defined in Table 1.2 and the dissertation text.

Term	Definition used in Dissertation
Activities of Daily Living (ADLs)	Consists of the following activities, performed in a social context. - *Bed mobility*: how a resident moves and turns their body position while in bed - *Transfer*: how a resident moves between surfaces such as bed and chair - *Locomotion*: how a resident moves between locations in their room and the corridor outside their room - *Dressing*: how a resident puts on, fastens and takes off all items of street clothing - *Eating*: how a resident eats and drinks, including other means of nourishment, such as tube feeding - *Toilet use*: how a resident uses a toilet, commode, bedpan or urinal and transfer on and off a toilet - *Personal hygiene*: how personal hygiene is maintained, including combing hair, brushing teeth, washing and drying face and hands. Excludes baths and showers.
Acute pathology	Health events characterized by a single episode of relatively rapid onset and short duration.
Cognitive Performance Scale	A cognitive functioning scale based on five RAI-Home Care Assessment items that reflect memory impairment, level of consciousness, and executive function: *0* - Intact, *1* - Borderline intact, *2* - Mild impairment, *3* - Moderate impairment, *4* - moderate to severe impairment, *5* - severe impairment, *6* - very severe impairment (interRAI, 2014; Morris et al., 1994). The CPS is valid (corresponds closely with clinical assessments of cognitive impairment) and reliable when recorded by trained nursing staff (Morris et al., 1994).
Changes in Health, End-stage disease and Symptoms and Signs (CHESS) Scale	A validated scale in the RAI-Homecare Assessment that predicts mortality and future health instability over a 2 year time-frame, based on recent changes in health, presence of end-stage disease, and symptoms and signs of medical problems (Hirdes, Frijters, & Teare, 2003).

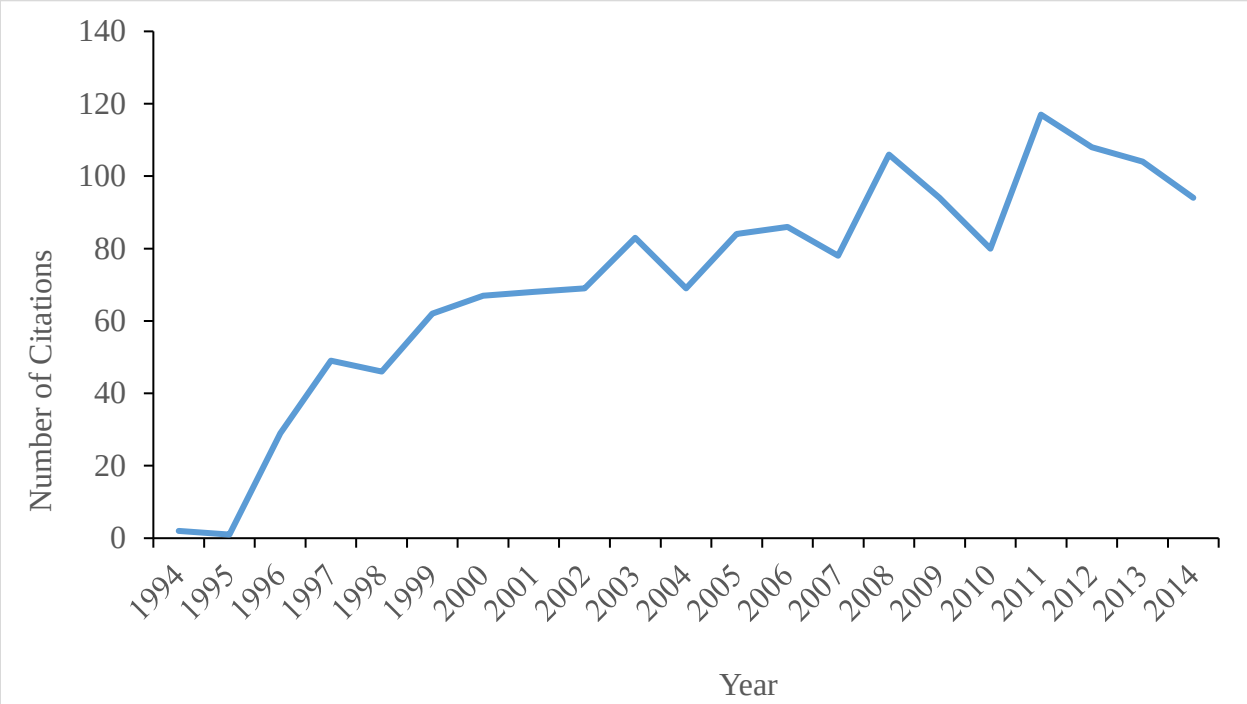
Chronic condition	Illness lasting six months or more, including past illnesses requiring continuous care, diseases with risk of recurrence, or previous health problems that continue to affect the management of residents.
Disability	Difficulty with or dependence on others to conduct activities of daily living (ADLs), measured at a single point in time.
Disablement	Intensifying disability over at least two time points.
Dysfunction loop	When a flare-up of an impairment in one organ system can cause rapid worsening of impairments in other systems, leading to substantial functional decline.
Exacerbators	Either (**1**) interventions gone awry (e.g. side effects of drugs or hospitalizations), or (**2**) behavioural changes in response to health and function problems (e.g. fear of falling, inactivity due to pain).
Extra-individual characteristics	Factors that operate outside or external to a person and affect the Disablement Process. Can be grouped into one of the following categories: - Medical Care and rehabilitation: surgery, physical therapy, speech therapy, counselling, health education, job retraining - Medications and other therapeutic regimens: drugs, recreational therapy/aquatic exercise, biofeedback/meditation, rest/energy conservation - External supports: personal assistance, special equipment and devices, standby assistance/supervision, day care, respite care, meals-on-wheels - Built physical and social environment: structural modification at job/home, access to buildings and to public transportation, improvement of air quality, reduction of noise and glare, health insurance and access to medical care, laws and regulations, employment discrimination
For-profit (FP) long-term care home	Small privately-owned facilities and large corporate chains in which excess revenues are distributed among owners or shareholders.
Functional limitation	Restrictions in performing physical and mental actions used in daily life by one's age-sex group. Refers to individual capability without reference to situational requirements.

Geriatric syndrome	A collection of signs and symptoms common in older adults but not necessarily fitting into discrete disease categories.
Grand mean	Mean of the means. For example, would be calculated by first determining the average ADL LFS score for LTC residents in each LTCH to produce LTCH-level means, then taking the mean of these means.
Home placement coordinator	A registered nurse, social worker, physiotherapist, occupational therapist, speech language pathologist or dietician employed by a Community Care Access Centre to complete eligibility assessments and manage entry into LTC in a given LHIN.
Impairment	Dysfunction and significant structural abnormalities in specific body systems that have consequences for physical, mental or social function.
Intra-individual characteristics	Factors that operate within a person and affect the Disablement Process. Can be grouped into one of the following categories: - Lifestyle and behavior changes: overt changes to alter disease activity and impact - Psychosocial attributes and coping: positive affect, emotional vigor, prayer, locus of control, cognitive adaptation to one's situation, confidant, peer support groups etc. - Activity Accommodations: changes in kinds of activities, procedures for doing them, frequency or length of time doing them
Interventions	Activities to reduce restrictions or difficulties, such as medical care, medications or modifications of the built environment; moderate the effect of risk factors and impairments on functional decline.
Instrumental Activities of Daily Living (IADL)	Consists of the following activities, performed in a social context: *meal preparation, ordinary housework, managing finances, medications, phone use, shopping, and transportation* Measured using a RAI-Homecare additive scale that assigns scores of 0 (total independence) to 6 (total dependence) to clients' based on their ability to perform each of seven IADL items in the seven days prior to RAI-HC assessment. Individual items are summed to produce a scale that ranges from 0 to 48, with higher scores indicating greater difficulty in performing instrumental activities (interRAI, 2014).

MAPLe Sclae	A RAI-Homecare scale that assigns scores from 1 to 5 based on *(1) Low (2) Mild (3) Moderate (4) High (5) Very high level of risk* for : (i) Nursing home placement (ii) Caregiver distress (iii) Client or caregiver rates as requiring alternative placement to improve outlook (Hirdes, Ljunggren, et al., 2008) The MAPLe score was developed to rank home care clients on their level of need for health care resources based on the following RAI-HC variables and scales: ADL impairment, Cognitive impairment (CPS), Behaviour disturbance, Decline in decision making, Problems with medication management, Pressure ulcers or stasis ulcers, Environmental challenges, Falls, Inadequate meals, Problems with meal preparation, Difficulty swallowing and RAI-HC's nursing home risk care-planning protocol (Hirdes, Poss, & Curtin-Telegdi, 2008). A validation study showed a clear separation of nursing home admission rates for individuals with each of the five different MAPLe score levels.(Hirdes, Poss, et al., 2008)
MAR (Missing at Random)	The probability of missing outcome data is random, conditioning on the observed variables.
Mediator	Part of the causal pathway between a given exposure and outcome. Mediators must be associated with the exposure and exist between the exposure and outcome in time (Kraemer et al., 2008).
MNAR (Missing Not at Random)	When the probability of missing outcome data is non-random, even when conditioning on the observed variables.
Moderator (or Effect Modifier)	Variable that identifies the different circumstances under which an exposure has a given level of effect on an outcome. Moderators must have a significant statistical interaction with the exposure and the moderator in predicting the outcome. A moderator is not required to be statistically associated with the exposure, exist in the causal pathway between exposure and outcome, or precede the exposure in time.
Not-for-Profit (NFP) long-term care home	Long-term care homes that are municipally owned, attached to acute care hospitals, or owned and operated by religious or community groups; in these facilities excess revenues go towards resident care.
Pathology	Biochemical and physiological abnormalities that are detected and medically labeled as disease or injury. Sub-divided into sub-clinical pathologies, acute pathologies and chronic pathologies, as defined in Table 1.2.

Risk factors	Demographic, social, lifestyle, behavioral, psychological and biological characteristics of individuals that affect their risk of impairment and functional dependence.

Appendix 2.1: Steady increase in annual number of citations of Disablement Process Model since 1994



Appendix Figure 2.1: Steady increase in annual number of citations of the Disablement Process Model since 1994

Source: Scopus.

Appendix 2.2: Summary of 94 Studies Included in Study 1

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Abizanda et al 2014 Spain	842	- Age 70+ (mean 78.6)	Mix - 15.6% institutionalized - 84.4% community-dwelling	Barthel Index		**Yes.** - Frailty[a] - Living in LTC[b] - Baseline functional dependence[b] **No.** - Multimorbidity[a] (2+ chronic conditions) - Charlson Comorbidity Index of 3+[a] - Female sex[b]	
Banaszak-Holl et al 2011 USA	3,634	- Nursing home residents in Michigan	Nursing home	ADL Hierarchy Index (RAI-MDS) - 7 item scale (0: independent, 7: totally dependent) based on independence in: - mobility in bed - transfer - locomotion - dressing - eating - toilet use - bathing			**Yes.** - Cognitive impairment (linear)[a] - Baseline ADL[a] - Married (quadratic)[b] - Age 85+(linear)[b] - Hip fracture (linear)[a] - Heart condition (linear)[a] **No.** - Cognitive impairment (quadratic)[a] - Male gender[b] - Married (linear)[b] - Age 85+ (quadratic)[b] - Education[b] - Diabetes[a] - Hip fracture (quadratic)[a] - Stroke[a] - Cancer[a] - Heart condition (quadratic)[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Barker et al 1998 USA	243	Resident in nursing home participating in Medicare Influenza Vaccine Demonstration	Nursing home	Independent, partially dependent, completely dependent for: - bathing - dressing - mobility - transfer		**Yes.** - Influenza infection at baseline[a]	
Barnes et al 2013 US	449	- Aged ≥70 years - Participants in one of 2 RCTs of Acute Care for Elders (ACE) unit versus usual care in hospitalized elders - Admitted to a general medical service of one of two study hospitals - Fully independent in all 5 basic ADLs 2 weeks prior to hospital admission - Had ≥1 ADL dependency at discharge Excluded if:	Community-dwelling	Continued dependence in ≥1 of 5 basic ADLs at 1 year post-discharge from hospital: - dressing - bathing - transferring - eating - toileting		**Yes.** - ≥3 IADL dependencies in 2 weeks prior to hospital admission (vs. 0)[c] - 2-4 ADL limitations at discharge from hospital (vs. 1)[c] **No.** - Age 80-89, ≥90 (vs. 70-79)[c] - female sex[c] - 1-2 IADL dependencies in 2 weeks prior to hospital admission (vs. 0)[c] - Chief reason for hospitalization[c] - Dementia[c] - Cancer[c] - Number of other chronic conditions[c] - Creatinine level[c] - 5 ADL limitations at discharge from hospital (vs. 1)[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Admitted to subspecialty unit - Admission elective - Length of stay less than 2 days					
Bayliss et al 2007 US	352	- Members of a not-for-profit health maintenance organization - Aged ≥65 years - Had coexisting diagnoses of diabetes, depression and osteoarthritis for 2-year period prior to study	Community-dwelling	Physical functioning measured from: "Does your (physical) health now limit you in these activities? If so, how much? - Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports. - Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf. - Lifting or carrying groceries; - Climbing several flights of stairs - Climbing one flight of stairs - Bending, kneeling or stooping;	**Yes.** - persistent depressive symptoms[c] - financial constraints[c] - lower income level[c] - higher level of patient-clinician communication[c] - compound effect of conditions[c] - disease burden * financial constraints[c] - disease burden * patient-clinician communication[c] - disease burden * compound effects of conditions[c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- Walking more than a mile; - Walking several blocks; - Walking one block; or dressing yourself. - Response choices (chose one): Yes, limited a lot; Yes, limited a little; No, not limited at all.			
Bellows et al 2008 USA	12,898 Skilled Nursing Facilities	Nursing home with >20 residents in 48 contiguous states **Excluded if**: Medicaid-only facility.	Nursing home	ADL QI from RAI-MDS: percentage of residents in a home whose need for assistance in self-feeding, transferring from one chair to another, changing positions in bed, and going to the bathroom has increased since their prior assessment		**Yes.** - state in which nursing home located uses MDS-based Medicaid reimbursement system[a] - home-level ADL acuity index[b] - home-level total licensed staff per patient day[b] - non-metro home location[b] - small home size[b] - home proportion of Medicaid residents[b] - high occupancy[b] **No.** - Mean state Medicaid nursing facility rate[b] - for-profit home ownership[b] - large facility size[b] - low occupancy[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Boeckxstaens et al 2014 Belgium	567	- Aged 80+ (mean 84.7) **Excluded if**: severe dementia, palliative situations, medical urgency	Community-dwelling	Self-reported difficulty (1: I can't do this to 5: I can do this without any problems) at: - climbing stairs - walking 5 minutes outdoors without rest - getting up and down from sitting in a chair - dressing and undressing oneself - using transportation - caring for ones toenails Scores range from 6 – 30		**No.** - simple count of 22 chronic conditions[a] - modified Charlson comorbidity index[a] - Cumulative Illness Rating Score (CIRS)[a]	
Bolin et al 2006 USA	197,589	- Only admission assessments used	Nursing home	ADL-Hierarchy score in RAI-MDS	**Yes**. - rural location (zip code indicates a population under 10,000)[a]		
Bond et al 2006 UK	8,452	- Age ≥65 years at baseline - Participant in the MRC Cognitive Function and Aging Study - Resident in one of 5 areas in England and Wales	Community-dwelling	Development of functional impairment over 10 years classified as a 1 or 2 in the following 4 categories based on ADLs and IADLs:		**Yes.** - having "good" self-rated health at baseline vs. excellent self-rated health[a] - having fair or poor self-rated health at baseline vs. good self-rated health[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- No IADL or ADL dependence at baseline		(1) ADL disability = Needed help several times a week with washing, hot meals, putting on shoes and socks, or getting around outside (2) IADL disability = needed help regularly with heavy housework or shopping and carrying heavy bags (3) Had no IADL or ADL disability (4) Unclassified because hadn't answered all questions (included many cognitively frail people)			
Boockvar et al 2013 USA	136	- Nursing home residents in metropolitan New York - Expected to remain in nursing some for ≥2 months - Receiving opioids, antidepressants, or	Nursing home	ADL-Hierarchy score in RAI-MDS		**Yes.** - transfer to hospital for treatment of acute illness[b] **No**. - delirium (assessed using CAM)[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		antipsychotics routinely **Excluded if**: had an acute illness at the time of screening					
Boström et al 2014 Sweden	391	Participants in Umeå 85+ Gerontological Regional Database Study - Age ≥ 85 years OR Participant in Frail Older People Activity and Nutrition OR Residential Care Facilities – Mobility, Activity and Nutrition Study - Age ≥ 65 years - dependency in personal ADLs - Ability to chair rise from chair with armrests with assistance from only on person - MMSE ≥10	Mix - Community-dwelling and nursing home (67%)	10-item Barthel Index Range 0 – 20 (20 = independent)	**Yes.** - higher burden of depressive symptoms, measured using the Geriatric Depression Scale (GDS-15)[a]		
Bowling et al 2011	357	- Participants in the University	Community-dwelling	Decline in BADL score over 2		**Yes.**	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	Disablement (over 2 time points)	Disablement (over 3+ time points)
US		of Alabama at Birmingham Study of Aging - Community-dwelling - African American or white - Medicare beneficiaries - Live in 5 central Alabama counties		years; given 1 point for each activity they had difficulty with: - bathing - transferring out of a bed or chair - eating - toileting - dressing		- presence of chronic kidney disease at baseline[a] - stage >3B chronic kidney at baseline[a] **No.** - stage 3A chronic kidney at baseline[a]	
Boyd et al 2008 US	799	- Age ≥ 70 - Had non-elective admissions to general medicine services - Participants in a randomized controlled trial to improve functional outcomes in older hospitalized medical patients - Discharged with new or additional disability in ADLs **Excluded if**:	Mix - hospitalized community-dwelling adults and nursing home residents	Failure to return to baseline function 1 year post-discharge, measured pre- and post with "need the help of another person to complete [following] self-care ADLs: - bathing - dressing - eating - transferring from a bed to a chair - using the toilet		**Yes.** - solitary or metastatic cancer (vs. none)[a] - presence of cardiovascular disease (stroke, myocardial infarction, peripheral vascular disease, coronary artery disease)[a] - dementia[a] - low blood albumin (<4.0 g/L) levels[a] - higher dependency in IADLs at baseline[a] age ≥ 90 [a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Expected length of stay less than 2 days - Admitted to the intensive care unit					
Boyd et al 2009 US	457	- Participants in the Women's Health and Aging Study I - Women - Live in Eastern Baltimore City and Country - Aged ≥65 years - MMSE score ≥18 - Self-report of difficulty or dependence in ≥2 functional domains: mobility, upper extremity function, higher functioning tasks, self-care tasks - Hospitalized at least once during 3 year follow-up	Community-dwelling	Functional decline = increase in number of ADLs (0 – 6) dependent in, from pre- to post-hospitalization: - toileting - bathing - transferrin - eating - dressing - walking across a small room		**Yes.** - Having 0 – 8 years of education (vs. ≥12)[c] - length of stay in hospital[c] - frailty[c] **No.** - age [c] - black race [c] - Having 9 – 11 years of education (vs. vs. ≥12) [c] - lower MMSE score [c] - prefrail [c] - live alone [c] - adequate emotional support [c] - emotional vitality [c] - depression[c] - 2 or ≥3 hospitalizations during follow-up (vs. 1)[c]	
Boyd et al 2005 US	595	- ≥65 years old - Female - Community-dwelling	Community-dwelling	ADL dependence: positive response to any of fie questions, with		**Yes.** - 1 (vs. 0) incident hospitalization over 18 months[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- ADL-independent at baseline - Participants in Women's Health and Aging Study I		the format "Do you usually receive help from another person in…" - toileting - bathing - transferring - eating - dressing		- 2 (vs. 0) incident hospitalization over 18 months[a] - 3 (vs. 0) incident hospitalization over 18 months[a] - severe walking limitation at baseline[b] - age 85+ (vs. 65 – 84)[b]	
Büla et al 2004 Switzerland	1,324	- Residents of 39 nursing homes in western Switzerland - Aged 65+ (mean 85.7)	Nursing home	Katz ADL scale or combined outcome: Katz ADL decline or death		**Yes.** - occurrence of any infection (respiratory, urinary, miscellaneous)[a] - number of infections (0, 1, 2+) during 6 month follow-up period[a] - respiratory infections[a] - miscellaneous infections[a] **No.** - urinary infections[a]	
Bürge et al 2013 Switzerland	10,199	- Residents of 90 Swiss nursing homes	Nursing home	ADL-Hierarchy Score in RAI MDS		**Yes.** - male[c] - ≥80 years old[c] - BMI <19[c] - Year of nursing home entry[c] - No daily contact with proxies[c] - moderate to severe difficulties with eye sight[c] - cognitive impairment (measured with cognitive impairment scale)[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- Slight hearing difficulties[c] - Urine or bowel incontinence[c] - Worsening balance[c] - Absence of exercise or sport activity[c] - Absence of outdoor walking or wheeling[c] - Depression (MDS depression scale)[c] - Parkinson's disease[c] - Cardiovascular disease[c] - Psychiatric diseases[c] - Endocrinopathy[c] - Neoplasia[c] **No.** - BMI ≥25[c] - No regular alcohol consumption[c] - Slight difficulties with eye sight[c] - Moderate to severe hearing difficulties[c] - Vascluar cerebral disease[c] - Musculoskeletal disease[c] - Lung disease[c]	
Buttar et al 2001 USA	3,995	- Resident in one of 254 nursing homes in 10 US states - Age ≥65 - Length of stay >60 days	Nursing home	ADL-Long Form Score (from RAI-MDS) > 8: medium to high ADL dependency or: among those with ADL LFS	**Yes.** - Female gender[c] - DNR orders on file[c] - Lived with others before admission[c] - urinary incontinence[c] - pressure ulcers[c] - balance problems[c]	**Yes.** - Age in years[c] - Pressure ulcers[c] - Diagnosis of peripheral vascular disease[c] - Decreased alertness[c] - Urinary incontinence[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				≤8, worsening ADL or death over 6 months	- moderate/severe cognitive impairment (CPS score >5)[c] - Diagnosis of seizures[c] - Vision impairment[c] - Eats ≤75% of food in tray[c] - Diagnosis of stroke[c] - Medicare insurance[c] - BMI <19[c] - Absence of antianxiety medications[c]	- Moderate to severe cognitive impairment (CPS score >5)[c] - Diagnosis of stroke[c] - Decreased appetite[c] - >6 medications[c] - Private pay[c] - Shortness of breath[c] - Did not live alone prior to admission to nursing home[c] **No.** - Anxiety diagnosis[c]	
Caljouw et al 2014 the Netherlands	890	- Resident in one of 21 Dutch long-term care homes - Participant in CRANBERRY trial - Age ≥65 years old **Excluded if**: - Life expectancy <1 month - Using Coumadin	Nursing home.	Care Dependency Score (CDS) measures dependence in 15 activities on 5 point scale: - eating - drinking continence - body posture - mobility - day and night pattern - getting (un)dressed - body temperature - hygiene - avoidance of danger - communication - contact with others		**Yes.** - female gender[c] - Age in years[c] - Baseline CDS score[c] - Cancer[c] - Urinary incontinence[c] - Dementia[c] **No**. - Dummy variable for long-term care facility[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- sense of rules and values - daily activities - recreational activities learning ability Range: 15 (completely dependent) to 75 (almost independent of care)			
Caljouw et al 2013 the Netherlands	473	- Age ≥85 years	Community-dwelling	Groningen Activity Restriction Scale (GARS) measures independence on 9 basic ADLs (1: fully independent, without any difficulty, 4: not fully independently, only with someone's help): getting around the house, getting into and out of bed, standing up from a chair, going to the toilet, dressing oneself, washing hands and face, washing whole body, preparing breakfast and		*Among those with no ADL-Dependence at baseline (n = 194) **Yes.** - Infection with UTI or LRTI.[a]	*Among those with no ADL-Dependence at baseline (n = 194) **Yes.** - Infection with UTI or LRTI.[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				drinking and feeding oneself Range: 9 to 36			
Carrière et al 2011 France	3,191	- Age ≥65 years - Citizens of three French cities	Community-dwelling	Need for assistance on Katz ADL tasks: bathing, dressing, transferring from bed to chair, toileting and eating Requires help on >1 task = "disability"			*In Men*: **No.** - depressive symptomology burden (none, mild, severe) at baseline[a] *In Women*: **Yes.** - Severe depressive symptomology at baseline[a] **No.** - Mild depressive symptomology at baseline[a]
Chaudhry et al 2011 US	461	- Participants in the Cardiovascular Health Study - Aged ≥65 years - Have newly diagnosed heart failure **Excluded if:** - Wheelchair bound - Receiving cancer or hospice treatment	Community-dwelling	Onset of disability = self-report of "a lot of difficulty" or being "unable to do" at least 1 of the following: - bathing - dressing - walking around the home - getting out of bed or a chair - eating - using the toilet		**Yes.** - slowed gait speed[c] - decreased cognition[c] **No.** - increasing age (in 5-year segments)[c] - female sex[c] - non-white race[c] - higher level of depressive symptoms[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Chen et al 2012 USA	2,523	- Age ≥50 years (mean 64) - Participant in Health and Retirement Study	Community-dwelling	Independent, has difficulty or dependent in each of 5 ADLs: - eating - dressing - transferring - toileting - bathing		**Yes.** - low subjective social status[a]	
Chen et al 2012 Taiwan	442	- Age ≥65 years	Community-dwelling	Physical Activities of Daily Living Scale – degree of difficulty reported with: - eating - dressing - grooming - walking - transferring - bathing - toileting			**Yes.** - depressive symptoms[a] - disability at baseline[a]
Chen et al 2013 Taiwan	1,045	- Male - Aged ≥65 years - Resident in one of two veteran's care homes in northern Taiwan - Participant in the Longitudinal Older Veteran's study **Excluded if:**	Nursing home	Odds of decline (increase in score more than 1 SD) in RUG-III ADL score in RAI-MDS over 18 months, based on dependence in: - bed mobility - transfer - toilet use - eating Range: 4 to 18 (where 18 =		**Yes.** - increased age[c] - sum of RAI "Resident Assessment Protocol" (RAP) Triggers (e.g. delirium, visual function, falls)[c] - cerebrovascular disease[c] - dementia[c] - long-term institutionalization[c] - absence of social engagement [c] **No.**	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Severely disabled at enrolment - Had severe communication difficulties - Could not complete the evaluations in the 18 months of follow-up - Moved out of the facilities		completely dependent)		- body mass index (continuous measure)[c]	
Chin et al 2014 Korea	984	- Participants in the Korean Longitudinal Study on Health and Aging - Not dependent on renal replacement therapy	Community-dwelling	Change in ADL score (score/# items) over ~59.4 months Seven ADL items: - dressing - washing hands and face - bathing - toileting - eating -ambulating in and out of bed - maintaining control of bladder/bowel function Scored: - 1: without any assistance - 2: with the assistance of another person		**Yes.** - having GFR<44 (vs. GFR ≥60)[a] **No.** - having GFR 45-59 (vs. GFR ≥60)[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- 3 with absolute dependence on another person Range: 7 – 21			
Chu et al 2006 Hong Kong	1,419	- Age ≥65 years - Chinese - Living at home - Able to walk independently or with walking aid - Provide informed consent	Community-dwelling	Barthel Index		**Yes.** - Incident fall in a year follow-up[a\] - Increasing age[b] - Parkinson's disease[b] - Coronary heart disease[b] - Fear of falling[b] - Slow gait speed[b]	
Cigolle et al 2007 US	11,093	- ≥65 years - Participants in the 2000 Health and Retirement Study	Mix - Community-dwelling and nursing home (2.4% of sample)	Dependence in any of the following ADLs: - bathing - eating - toileting - transferring	**Yes.** - having 1, 2, or ≥3 geriatric syndromes (cognitive impairment, injurious falls, incontinence, low BMI, dizziness, vision impairment, hearing impairment)[a] vs. 1. - having 1, 2, or ≥3 chronic conditions [b] - heart disease [b] - lung disease [b] - diabetes [b] - musculoskeletal [b] - stroke[b] - psychiatric disorder[b] **No.** - cancer[b]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Ciol et al 2008 US	10,180 – 16,788 per year	- Participants in the Medicare Current Beneficiaries survey from 1992 to 2004 - Age ≥65 years old at baseline	Community-dwelling	Change in the Number of ADLs done with difficulty over 4 years: - bathing - dressing - eating - getting in or out of bed and chairs - walking using the toilet Range: 0 – 6		**Yes.** - lower age[b] - male sex[b] - Black or Asian (vs. white non-Hispanic)[a] - age *black race[a] - age*Asian race[a] - male*white Hispanic[a] **No.** - white Hispanic race (vs. white non-Hispanic)[a] - age*white Hispanic[a] - male*black[a] - male*Asian[a]	
Clark et al 2012 USA	3,213	- Age ≥65 years - Independent in all ADLs at baseline - Participant in Health and Retirement Study	Community-dwelling	"ADL Dependency" = requiring help from another person to complete any one of following ADLs: - eating - dressing -bathing - transferring - toileting		**Yes.** - Age >80 year[c] - Diabetes[c] - Difficulty walking several blocks[c] - Need help with personal finances[c] - Difficulty lifting 10 pounds[c] - Unable to name vice president[c] - Low body mass index[c] - Incident hospitalizations[c] - Diabetes[c] - Lung disease[c] - Congestive heart failure[c] - Stroke[c] **No.** - Fall in past year[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- Arthritis[c]	
Covinsky et al 2003 USA	2,293	- Age ≥ 70 - Had non-elective admissions to general medicine services - Participants in a randomized controlled trial to improve functional outcomes in older hospitalized medical patients - Discharged with new or additional disability in ADLs **Excluded if:** - Expected length of stay less than 2 days - admitted to the intensive care unit	Mix - hospitalized community-dwelling adults and nursing home residents	ADL dependence: positive response to any of fie questions, with the format "Do you usually receive help from another person in…" - toileting - bathing - transferring - eating - dressing Five functional trajectories identified: (1) Stable course of functional dependency. (Reference group) (2) Declined between baseline and admission, recovered baseline function by discharge.			**Yes.** - age 80 – 84[a] - age 85 – 89[a] - age ≥ 90[a] (vs. 70 – 74) **No.** - age 75-79 (vs. 70-74)[a]
				(3) Did not decline between baseline and admission, but declined between baseline and discharge.			**No.** - age 75-79[a] - age 80 – 84[a] - age 85 – 89[a] - age ≥ 90[a] (vs. 70 – 74)

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				(4) Declined between baseline and admission, did not recover baseline function by discharge.			**Yes.** - age 80 – 84[a] - age 85 – 89[a] - age ≥ 90[a] (vs. 70 – 74) **No.** - age 75-79 (vs. 70-74)[a]
				(5) Declined between baseline and admission, declined further between admission and discharge.			**Yes.** - age 85 – 89[a] - age ≥ 90[a] (vs. 70 – 74) **No.** - age 75-79[a] - age 80 – 84[a] (vs. 70-74)
Drewes et al 2011 the Netherlands	594	- 85 years old at baseline - Inhabitants of Leiden	Community-dwelling	Groningen Activity Restriction Scale (GARS). Assesses an individual's competence in the following nine basic activities: - walk inside - get up out of bed - get into and out of a chair - visit the toilet - wash hands and face - wash body - dress and undress - eat and drink - make breakfast			**Yes.** - Multimorbidity (in people with optimal cognitive function, MMSE ≥28)[a] - Cognitive impairment (MMSE <19)[a] - Depressive symptoms[b] - Heart failure[b] - Myocardial infarction[b] - Stroke[b] **No.** - Multimorbidity (in people decreased cognitive function, MMSE <19)[a] - Arthritis[b] - Chronic obstructive pulmonary disease[b] - Diabetes mellitus[b]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
							- Parkinson disease[b]
Dutcher et al 2014 US	15,538	- Medicare beneficiaries with newly diagnosed Alzheimer's disease and related dementias - Aged ≥ 66 - Recipient of fee-for-service Medicare Parts A, B, D, and prescription drug plan coverage - Resident of a nursing home for at least part of the two-year study period	Nursing home	Change in ADL long-form score (RAI MDS) over two years Range: 0 – 28 (28 = complete dependence)			**Yes.** - non-use of antidepressant drugs[a] - antipsychotic drugs * sex: female users declined most quickly, followed by male non-users, female nonusers and male users[a] - mood stabilizers *sex (same trend as above: associated with faster ADL decline in women but not men)[a] - time elapsed since baseline[b] **No.** - use of anti-dementia medications[a] - use of mood stabilizers[a]
Ferrucci et al 1996 USA	6,640	- Age ≥65 years - No severe functional disability at baseline	Community-dwelling	- Severe functional disability = need help from another person or unable to perform 3+ of following ADLs: - walking across small room - bathing - dressing - eating - transferring from bed to chair		**Yes.** - Increasing age[a] **No.** - Female gender[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- using the toilet			
Finlayson et al 2012 USA	6,822	- Age ≥65 years - Nursing home residents - Underwent surgery for colon cancer in US between 1999 and 2005 - Survived a year post-surgery	Nursing home	ADL-Long Form Score (from RAI-MDS) Range: 0 – 28		**Yes.** - Colon cancer surgery[a] - Age >80[b] - Functional decline in the 6 months before surgery - Poor pre-surgery functional depenedence[b] - Lower Charlson score[b] - Hospital readmission after 30 days[b] - Surgical complications[b] **No.** - Male sex[b] - Non-white race[b]	
Fried et al 1999 USA	3,841	- Age ≥65 years - Female - Living in Baltimore - Participants in Women's Health and Aging Study	Community-dwelling	Any self-reported difficulty in one or more of the following self-care tasks: - Bathing/ showering - Dressing - Eating - Toileting	**Yes.** - Heart disease[a] - Arthritis[a] - Stroke[a] - Lung disease[a] - Cancer[a] - Hearing impairment[a] - Arthritis*Stroke[a] - Heart disease*Cancer[a] - Lung disease*Cancer[a] - Hypertension* Hearing impairment[a] **No.** - Visual impairment[a] - Diabetes[a] - Hypertension[a] - Arthritis*Visual impairment[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
					- Heart disease*Arthrits[a]		
Friedman et al 2015 US	1,229	- Participants in the Survey of Midlife Development in the United States - Non-institutionalized - English speaking adults (mean age 54.5, range 34-84)	Community-dwelling	BADL scores determined from level of dependence (1 = not at all, 4 = a lot) reported for three items: - bathing or dressing - climbing one flight of stairs - walking one block	**Yes.** - female sex[b] - lack of complete college education[b] - having 2+ chronic conditions (effect mediated by CRP)[a] - lack of regular exercise[b] - inflammation (measured via IL-6, CRP, fibrinogen levels in blood) [a] **No.** - increasing age[b] - black race[b] - some college education[b] - smoking[b]		
Fultz et al 2003 USA	5,646	- Age ≥70 years - Participant in Health and Retirement Study	Community-dwelling	Katz ADLs: - bathing -dressing -eating walking across a room - getting in and out of bed - using a toilet Score: 0 – 6		**Yes.** - Stroke[a] - Cognitive impairment[a] - Depressive symptoms[a] - Diabetes[a] - Diabetes x cognitive impairment[a] - Stroke x cognitive impairment[a] - Older age[b] - Female sex[b] - # Comorbid conditions[b] - Baseline limitations[b] - Black race[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						No. - Diabetes x depressive symptoms[a] - Hispanic race[b] - Education[b]	
Gill et al 2010 US	754	- Participants in the Precipitating Events Project - Community-dwelling - Aged ≥ 70 years - No disability at baseline **Excluded if:** - Cognitive impairment with no available proxy - Inability to speak English - Diagnosis of a terminal illness with a life expectancy less than 12 months - Plan to move out of the New Haven area during the next 12 months	Community-dwelling	Transition from non-disabled to mildly or severely disabled state (or from mildly to severely disabled) based on following activities: - bathing - dressing - walking inside the house - transferring from a chair Mild Disability: dependence in 1-2 activities Severe Disability: dependence in 3-4 activities		**Yes.** - Physical frailty[a] - Hospitalization[a] - Restricted Activity[a]	
Gill et al 2004 USA	754	- Age ≥70 years - No ADL dependence at baseline	Community dwelling	- Onset of disability, measured as self-report of needing help with any of		**Yes.** - Hospitalizations since baseline[a] - Period of restricted activity[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Members of Precipitating Events Project **Excluded if:** - Had significant cognitive impairment and no available proxy - Inability to speak English - Terminal illness with life expectancy <12 months		following activities - bathing - dressing - walking inside the house - transferring from a chair		- Increasing age[b] - Not living alone[b] - Diabetes mellitus[b] - Myocardial infarction[b] - Stroke[b] - Congestive heart failure[b] - Depressive symptoms[b] - Physical frailty[b] **No.** - Hospitalizations prior to baseline[a] - Period of restricted activity prior to baseline[a] - Female sex[b] - Non-hispanic white[b] - Years of eduation[b] - Hypertension[b] - Arthritis[b] - Cancer[b] - Fractures other than hip since age 50[b] - Chronic lung disease[b] - Hip fracture[b] - Cognitive impairment[b]	
Gopinath et al 2014 Australia	1,149	- Participant in the Blue Mountains Eye Study - Non-institutionalized residents of suburbs west of Sydney - Age ≥ 49 years	Community-dwelling	Disability = needing help with any of activities in Older American Resources and Services activities of daily living scale.		**No.** - total diet score, based on optimal food intake and sources, as well as energy balance and leisure time physical activity[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				Includes 7 BADL items: - eating - dressing - undressing - grooming - walking			
Gozalo et al 2012 USA	2,351	- Long-stay nursing home residents in 122 US cities **Excluded if**: - Had highest levels of impairment (score of 26-28)	Nursing home	Functional decline = 4 point increase ADL-Long Form Score (from RAI-MDS) over 90 days		**Yes.** - City-wide influenza death rate[a] - State-level influenza severity[a]	
Groll et al 2005 Canada	- 9,423 (derivation sample) - 28,349 (validation sample)	- Derivation sample: Non-institutionalized Canadians ≥25 years of age sampled at random with random digit dialing - Validation sample: US adults seeking treatment for spine ailment at 26 participating centers in the US	Community-dwelling	SF-36 physical function (PF) subscale - if ≤66"low" physical function - if >66 "high" physical function - SF-36 PF made up of 10 items relating to walking, climbing stairs, lifting, bathing and dressing	**Yes.** - Arthritis[c] - Osteoporosis[c] - Stroke/TIA[c] - Heart attack[c] - Hearing impairment[c] - Angina[c] - BMI > 30[c] - Vision impairment[c] - Diabetes[c] - COPD[c] - Congestive heart failure[c] - Peripheral vascular disease[c] - Anxiety[c] - Asthma[c] - Upper gastrointestinal disease[c] - Depression[c] - Back pain[c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
					- Lung disease[c] - Heart disease[c] - Nervous system disorders[c] - Neurological disease (such as multiple sclerosis or Parkinson's)[c]		
Helvik et al 2014 Norway	932	- Resident one of 26 nursing homes in 4 counties in Norway - Minimum stay of 14 days - Presence of dementia (Clinical Dementia Rating Scale ≥1)	Nursing home	Physical Self-Maintenance Scale (Range: 6 – 30) based on dependence in following six activities: - toileting - feeding - dressing - grooming - ambulation - bathing			**Yes.** - severity of dementia[a] - longer length of stay[b] - Younger age[b] - Being married[b] - Higher comorbidity burden[b] - Severe vision impairment[b] - Apathy[b] - Use of anxioltics[b] - Absence of use of cognitive enhancers[b] **No.** - female gender[b] - ≤10 years education - Severe hearing impairment[b] - Agitation sub-syndome[b] - Use of antipsychotics[b] - Use of antidepresents[b] - Use of sedatives[b]
Kelley-Moore & Ferraro 2005 USA	3,642	- Age ≥65 years old - Live in one of five counties in North Carolina	Community-dwelling	Disability, measured as being able to perform following ADLs independently (0), with some help	**Yes.** - Number of chronic conditions (of possible 7)[a] **No.**		**Yes.** - Level of disability measured at previous time point[a] **No.**

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				(1), or not at all (2): - walking - bathing - grooming - dressing - eating - transferring from bed to chair - using the toilet	- Depression[a]		- Depression measured at baseline and midpoint of follow-up[a] - Number of chronic conditions (of possible 7) measured at mid-point of follow-up[a]
Koster et al 2006 the Netherlands	2,366	- Participants in the Longitudinal Aging Study Amsterdam - Aged 55-85 years - Community-dwelling	Community dwelling	Baseline and rate of decline in ADLs according to following measure , from 1992 to 2001 Self-report of ability (0: not able to do; 1: only with help, 2: with much difficulty, 3: with some difficulty, 4: without difficulty) to carry out 6 activities: - walking up and down 15 steps without resting - getting (un)dressed - getting up from and sitting down in a chair - cutting own toenails	**Yes.** - low vs. high education (if ≥70 years old)[a] **No.** - low, medium income vs. high income [a] - low, medium education vs. high education (if <70 years old)[a] - medium vs. high education (if ≥70 years old)[a]		**Yes.** - low, medium income vs. high income (if <70 years old)[a] - low education vs. high education (if <70 years old)[a] **No.** - medium education vs. high education (if <70 years old)[a] - low, medium vs. high education (if ≥70 years old) [a] - low, medium income vs. high income (if ≥70 years old) [a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- walking 5 minutes outdoors without resting - using own or public transport			
Kruse et al 2013 US	40,128	- long-stay nursing home residents with fee-for-service Medicare eligibility who survived a hospitalization - ≥67 years old **Excluded if** - Had hospitalization in 90 days prior to index hospitalization - Had fewer than two completed RAI-MDS assessments of ADL function prior to hospitalization - Had >15 hospital stays in prior 2 years - Was member of health maintenance organization	Nursing home	ADL Long-Form Score Range 0 – 28 (where 28 = complete dependence)	**Yes.** - female sex[b] - higher[b] Charlson comorbidity index[b] - cognitive impairment[b] **No.** - age >85[b]		**Yes.** - higher functional dependence pre-hospitalization[b] - cognitive impairment[b] - baseline ADL score ≤4[b] - baseline ADL score <24[b] - hospitalization for reason other than hip fracture[a] - hospitalization for stroke[a] - hospitalization for renal failure[a] - hospitalization for septicemia[a] - hospitalization for urinary tract infection[a] - hospitalization for pneumonia[a] - hospitalization for congestive heart failure[a] **No.** - length of stay in most recent hospitalization[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		during follow-up period - Lacking Part A coverage for either follow-up year					
Kurella Tamura et al 2009 US	3,702	- Nursing home residents who started treatment with dialysis between June 1998 and October 2000 - Diagnosis of end stage renal disease occurred after admission to nursing home - Length of stay in nursing home ≥90 days - Had assessment of functional status in RAI-MDS prior to the start of dialysis	Nursing home	ADL Long-Form Score (in RAI-MDS) 12 months after initiation of dialysis Range: 0 – 28		**Yes.** - initiation of dialysis[a] - older age[b] - white race[b] - cerebrovascular disease[b] - dementia[b] - hospitalization[b] - serum albumin below 3.5g/dL[b]	**Yes.** - initiation of dialysis[a]
Laan et al 2013 The Netherlands	1,187	- Patients in one of three primary care networks in Utrecht - Age ≥60 years old - Have multimorbidity or using 5+ different types of drugs	Community-dwelling	Modified Katz-15 scale. Includes 6 ADL items from original Katz scale + 8 items from the Lawton IADL scale + whether need help with: -	**Yes.** - increasing age[c] - Annual # of medication reiumbursements[c] - Arthrits and arthrosis (women only)[c] - COPD and asthma (men and women)[c] - Hearing difficulties (women only)[c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				brushing/combing hair or shaving - walking about	- Kidney problems (men only)[c] - Psychiatric disorders (women only)[c] - TIA and CVA (men only)[c] - vision disorders (women only)[c]		
Landi et al 2006 Italy	355	- Patients with stroke - Admitted to home care programs after post-acute rehabilitation program with at least a year of follow-up	Community-dwelling	Classified as "unchanged, improved, or worsened" based on 1-year, 1 point (or more) changes in ADL-Hierarchy Score in RAI HC		**Yes.** - Cognitive impairment (CPS score ≥2)[c] - Pressure ulcerc - Urinary incontinence[c] - Hearing impairment[c] **No.** - increasing age[c] - female gende[c] - living alone[c] - Number of chronic conditions[c] - Depression[c] - Delirium[c] - Vision impairment[c] - Daily pain[c] - Swallowing problem[c]	
Latham 2012 USA	8,087	- Age ≥65 years old - Participant in Health and Retirement Survey	Community-dwelling	Progressive or accelerated development of severe disability = have difficulty completing 3+ of following ADLs (from RAND HRS): - walking across the room		**Yes.** - black or Hispanic race (vs. white)[a] - Less than high school education (vs. high school)[a] - Age[b] - Lower income[b] - Absence of physical activity[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- bathing/showing - dressing -eating - getting in/out of bed (Range 0 – 5)		- Current smoker[b] - Obese (BMI >30)[b] - No private insurance[b] - Past 2 year frequency of hospitalizations[b] - Arthritis[b] - Cancer[b] - Diabetes[b] - Lung disease[b] - Psychological problems[b] - Stroke[b] **No.** - Female sex[b] - Marital status[b] - Underweight or overweight (BMI>25)[b] - Past 2 year frequency of doctor visits[b] - Heart problems[b] - High blood pressure[b]	
Lee & Rantz 2008 US	38,591	- Medicare admissions to one of 458 short-stay skilled nursing facilities from acute care hospitals - Age ≥ 65	Nursing home (short stay)	ADL Long-form score at 3, 6, 9 and 12 months post admission Range 0 – 28		**Yes.** - pressure ulcer (all time points)[a] - urinary incontinence (all time points)[a] - weight loss (all time points)[a] - pain (all time points)[a] - history of falls (all time points)[a] - ADL score at admission[b] - cognitive impairment[b] - stroke[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- renal impairment (at 3 and 6 months)[b] - neuropathy[b] **No.** - diabetes mellitus[b] - cancer[b] - renal impairment (at 9 and 12 months)[b]	
Li et al 2013 Taiwan	2727	- Age ≥ 65 - Participant in the National Health Interview survey in Taiwan	Community-dwelling	Self-report of limitations in carrying out ≥1 of following activities: - eating - bathing - dressing - using the toilet - getting in or out of bed - walking across a small room	**Yes.** - presence of geriatric syndrome (depressive symptoms or cognitive impairment) alone[a] - presence of a geriatric syndrome + a cardiovascular disease (heart disease, hypertension or stroke)[a] - presence of diabetes + cardiovascular disease[a] - presence of diabetes + geriatric condition[a] - presence of diabetes + geriatric condition + cardiovascular disease[a] (vs. no diabetes, cardiovascular disease or geriatric syndromes) **No.** - presence of cardiovascular disease alone[a] - presence of diabetes alone[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
					(vs. no diabetes, cardiovascular disease or geriatric syndromes)		
Li 2005 USA	3,161	- Age ≥60 years old - Participants in Michigan's Home and Community-Based Medicaid Waiver Program (low income older adults at risk of institutionalization)	Community-dwelling	ALD long form score from RAI-HC; scores individuals from 0 (independent) for 4 (totally dependent) on following 8 items: - mobility in bed - transferring between surfaces - locomotion in home - dressing - eating - toilet use - personal hygiene - bathing Range: 0 – 32	**Yes.** - black race[c] - increasing age[c] - owns home[c] - living with others (spouse or non-spouse) [c] - residing in more populated area[c] - were not current smokers[c] - stroke[c] - Parkinson's disease[c] - cognitive limitation[c] - vision limitation[c] - bladder incontinence[c] - bowel incontinence[c] **No.** - self-efficacy about functional improvement[c]		**Yes.** - black race[c] - increasing age[c] - lack of self-efficacy about functional improvement[c] **No.** - owns home[c] - living with others (spouse or non-spouse) [c] - residing in more populated area[c] - current smoking[c]
Li et al 2009 USA	13,129	- Age ≥60 years old - Participants in Michigan's Home and Community-Based Medicaid Waiver Program (low income older adults at risk of institutionalization)	Community-dwelling	ALD long form score from RAI-HC; scores individuals from 0 (independent) for 4 (totally dependent) on following 8 items: - mobility in bed - transferring between surfaces - locomotion in home - dressing			**Yes.** - incident cognitive decline[a] - incident fall[b] - incident acute health episode[b] - incident flare up of chronic conditions[b] **No.** - incident depression[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- eating - toilet use - personal hygiene - bathing Range: 0 – 32 Dichotomized into: 1- needs physical help in one or more ADL or 0 – needs supervision only or independent in all ADLs			
Liang et al 2010 USA	18,486	- Age ≥50 years old - Participants in the Health and Retirement Study	Community-dwelling	Count of difficulties with 6 ADLs: - dressing - walking - bathing - showering And 5 IADLs: - preparing hot meals - grocery shopping - making phone calls - taking medications - managing own money and expenses			**Yes.** - being black or Hispanic (vs. white)[a] - female sex[b] - increasing age[b] - education[b] - baseline ADL/IADL score[b] **No.** - being black versus Hispanic[a]
Mänty et al 2014 Denmark	1,117	- Aged 92 to 93 at baseline	Mix - Community-dwelling older	Modified Katz ADL: asked about degree of	**Yes.** - pain at 1, 2 or 3 sites vs. none[a]	**Yes.** - pain at multiple sites (vs. no pain)a predicts	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Non-proxy interviews - Participants in Danish 1905 cohort study	adults and nursing home residents (32%)	independence in performing 5 ADLs - transferring from bed to chair - dressing - bathing - using the toilet - walking indoors Baseline disability: number of individual tasks with disability were summed Range 0 – 5 Follow-up: persons ranked as: - No disability - Moderate disability (in 1-2 tasks) - Severe disability (in 3-5 tasks)		onset of severe disability[a] **No**. - pain at single site[a](vs. no pain) does not predict onset of moderate or severe disability	
Marcantonio et al 2003 USA	551	- Consenting patients newly admitted to one of 85 post-acute care facilities, 55 rehabilitation hospitals and 30 skilled nursing facilities - Age ≥65 years old	Mix - Patients in post-acute care hospitals and skilled nursing facilities	ADL long-form score (Range 0 – 42) and IADL score (Range 0 – 30) MDS for Post-Acute Care		**Yes.** - delirium symptoms that persisted or worsened after admission[a]	
Marengoni et al 2009	1099	- Participants in the	Mix	Functional decline = a change in		**Yes.**	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Sweden		Kungsholmen Project: - Age ≥75 years old in October 1987	- Community-dwelling older adults and nursing home residents	functional status – from being independent or partially dependent to becoming partially or totally dependent during the follow-up period, as defined by the Katz ADL index.		- Multimorbidity with no disability[a] - Multimorbidity with disability[a] - ≥85 (vs. 77-84)[b] **No.** - single chronic condition without baseline disability[a] - single chronic condition with baseline[a] disability - female sex[b] - education[b]	
Marventano et al 2014 Spain	2,818	n = 892 - Age ≥65 years old - Living in communities across Spain n = 1903 - Age ≥65 years old - Enrolled in a multicenter study about falls in hospitals	Community-dwelling	Barthel Index: assessment of independence in performing: - feeding - moving from wheelchair to bed and back - grooming - transferring to and from a toilet - bathing - walking on a level surface - going up and down stairs - dressing - continence of bowels and bladder	**Yes.** - bone disease[a] - visual impairment[a] - hearing impairment[a] - Dementia[a] - Parkinson's disease[a] - cardiovascular disease[a] - diabetes[a] mellitus[a] - cancer[a] - bone disease x hypertension[a] - cardiovascular disease x hypertension[a] - bone disease x hypertension[a] - cardiovascular disease x bone disease[a] - cardiovascular disease x visual impairment[a] - visual impairment x hearing impairment[a] - diabetes mellitus x hypertension[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				Range: 0 to 100 where 100 = independence Dichotomized into completely independent (100) vs. not completely independent	- hearing impairment x hypertension[a] - bone disease x hearing impairment[a] - increasing age[b] - having only primary education or less[b] **No.** - pulmonary disease[a] - hypertension[a] - gastrointestinal disease[a] - visual impairment x hypertension[a] - female sex[b]		
McCusker et al 2001 Canada	315	- Age ≥65 years old (with delirium) - Age ≥70 years old (without delirium) - Admitted to hospital from Emergency Department to medical services at large academic hospital in Montreal **Excluded if:** - In a nursing home prior to hospital admission	Community-dwelling (Hospitalized)	Modified Barthel Index at 2, 6, 12 months post-enrollment Range 0 – 100, where 100 = complete independence		**Yes.** - Delirium + dementia[a] **No.** - Delirium without dementia[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Transferred to nursing home - Admitted to oncology, ICU - Language or communication barrier - Residence outside geographic area - Primary diagnosis of stroke					
Mendes de Leon et al 2014 US	5,306	- Participants in the Chicago Health and Aging Project - Age ≥ 65 years - No ADL disability at baseline - Fewer than 3 non-missing disability assessments	Community-dwelling	# of 6 Katz ADLs required assistance with or was unable to perform: - e.g. bathing, eating, dressing Range 0 – 6		(Onset of disability) **Yes.** - lower levels of social engagement (how often attended religious services, went to a museum, participated in activities or groups outside the home, whether currently worked a part-time or full-time job)[a] - more time (in years) since baseline[b] - increasing age[b] - increasing age x time in years since baseline[b] - interview done via telephone (vs. in person)[b] - higher number of medical conditions[b]	(Progression of disability among those with onset of disability n = 1,302) **Yes.** - lower levels of social engagement [a] - time (in years) since onset of disability[b] - younger age[b] - increasing age x time since onset of disability[b] - male sex[b] - interview done via telephone[b] - lower BMI[b] - lower number of medical conditions[b] - lower cognitive functioning[b] - level of education[b] - lower physical function (timed walk, chair stand, and tandem

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- lower physical function (timed walk, chair stand, and tandem stand)[b] - lower cognitive function[b] **No.** - social networks (# children, friends, and relatives a participant reported seeing on at least a monthly basis)[a] - male sex[b] - black race[b] - level of education[b] - body mass index[b]	stand)[b] **No.** - social networks[a] - black race[b]
Mor et al 2011 US	9,398 nursing homes	(For nursing home): - Free-standing, in urban counties (as defined by Area Resource File) - For each interval, had to have at least 20 residents at risk of ADL decline (ADL-Long form scores ≤24) - Only long-stay residents (had been in the nursing home for at least 90	Nursing home (long-stay)	Whether fewer than 5% of long-stay residents in each home experienced an ADL long-form score increase of 4 points or more (indicating worsening functional decline) over the past quarter (90 days), over period from 1999 – 2004 Range: 0 – 28 (where 28 = completely dependent)		**Yes.** - Absence of a $10 increase in consumer price-index adjusted[a] Medicaid rate - lower area wage index[b] - higher number of admissions per bed[b] - higher Nursing Case Mix Index on admission[b] - lower % of resident population that is Black[b] **No.** - case mix reimbursement[b] - average number of empty beds in county[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		days) were eligible for "at risk" population **Excluded if:** - Rural					
Park et al 2008 USA	784	- Age ≥65 years old - Medicare beneficiaries - Participants in the University of Alabama at Birmingham Study of Aging	Community-dwelling	Number of following ADLs individuals had difficulty with: - turning from side to side in bed - going up and down stairs - getting out of bed or a chair - bathing or showering - dressing or undressing - eating - walking - getting outside - getting to or using the toilet Range: 0 – 9	**Yes.** - irregular or non-attendance at religious services[a] - increasing age[b] - female sex[b] - rural location of dwelling[b] - regular receipt of help from others[b] - income inadequacy[b] - higher comorbidity burden[b] **No**. - frequency of prayer[a] - level of intrinsic religiousness[a] - black race[b] - black race x female sex[b] - being married[b] - perceived social support[b] - education[b] - cognitive functioning (MMSE score) [b]		**Yes.** - do not receive help from others[b] - income adequacy[b] - lower comorbidity burden[b] - lower MMSE score (more cognitive impairment)[b] - increasing age[b] - black race[b] **No.** - regular attendance at religious services[a] - frequency of prayer[a] - level of intrinsic religiousness[a] - female sex[b] - black race x female sex[b] - rural location of dwelling[b] - being married[b] - perceived social support[b] - education[b]
Peng et al 2014 Taiwan	401	- Admitted to the Geriatric Evaluation and Management Unit (GEMU)	Community-dwelling (hospitalized)	Barthel Index: score of 0 (completely dependent) to 10 (independent with	**Yes.** - Mini-Nutritional Assessment (MNA)[a] - absence of a primary caregiver[b]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		of Taipei Veterans Hospital between May 2011 and May 2012 **Excluded if:** - Had communication difficulties - Were too acutely ill to conduct functional assessments		assistance) on following activities: - feeding - grooming - bathing - dressing - bowel and bladder care - toilet use - ambulation - transfers - stair climbing Range: 0 (dependent) – 100 (independent)	- younger age[b] - lower body mass index[b] **No.** - Charlson Comorbidity[b] Index[a] - Smoking[b] - Habitual alcohol drinker[b] - sex[b] - education level[b] - waist circumference[b]		
Phillips et al 2008 US	36,584	- Admitted to US nursing home in 2002 and remained in nursing home for at least 3 months to receive follow-up RAI-MDS assessment	Nursing home	ADL Long-form score from RAI-MDS Range 0 – 28	**Yes.** - Nursing home in which they reside[a]		
Phillips et al 2007 USA	36,584	- Residents in Medicare- or Medicaid-certified nursing homes operating during 2002 - Remained in nursing home for 3 months to receive first post-admission	Nursing home	Difference in ADL Long-form score (from RAI-MDS) between admission and 3-month assessment Range 0 – 28		**Yes.** - Lower ADL impairment at baseline[c] - Lower CHESS (Changes in Health, End-stage disease and Symptoms and Signs) Score[c] - Higher level of cognitive impairment[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		RAI-MDS assessment				- Higher mortality risk score[c] - Increasing age[c] - Female sex - Black (versus non-Hispanic white) [c] - Lived with others prior to admission to nursing home[c] - Admitted to nursing home from location other than acute-care hospital[c] - Not having stayed in another nursing home in the past 5 years[c] **No.** - Depression[c] - American Indian/Alaska Native[c] - Asian/Pacific Islander[c] - Hispanic[c] - Admitted from a rehabilitation home, private residence, assisted living, nursing home, or psychiatric setting[c]	
Piernik-Yoder & Ketchum 2013 US	35,243	- Stroke patients in inpatient rehabilitation facilities - First admission to rehab facility between	Mix - Community-dwelling older adults and nursing home residents, currently	Functional Independence Measure (FIM) at discharge from rehabilitation facility.	**Yes.** - having diabetes[a] - reduced age[a] - white race[b] - higher level of functioning at admission[b]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		January 1, 2004 and December 31st, 2008	residing in inpatient rehab.	18 tasks rated on 7 point ordinal scale that ranges from total assistance (or complete dependence) to complete independence Scores range from 18 (lowest) to 126 (highest) indicating level of function Scores are generally rated at admission and discharge Dimensions assessed include: Eating Grooming Bathing Upper body dressing Lower body dressing Toileting Bladder management Bowel management Bed to chair transfer Toilet transfer Shower transfer	- lower comorbidity burden[b] **No.** - female sex[b] - presence of diabetes x age[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				Locomotion (ambulatory or wheelchair level) Stairs Cognitive comprehension Expression Social interaction Problem solving Memory			
Quinones et al 2014 Germany	333	- Participants in the KOR-INNA study - Age ≥ 65 - Home-dwelling - Discharged from hospital of Augsburg between Sept. 2008 – May 2010 after treatment for first or recurrent AMI	Community-dwelling	Stanford Health Assessment Questionnaire Disability Index (HAQ-DI); consists of 8 domains: - dressing and grooming - arising - eating - walking - hygiene - reach - grip - activities Disability = HAQ-DI score ≥0.5	**Yes.** - Did not receive percutaneous transluminal coronary angioplasty with stent[c] - female sex[c] - age in years[c] - diabetes mellitus[c] - hearing loss in both ears[c] - coronary artery bypass graft[c] - heart failure[c] - nutritional status deficiency[c]		
Rajan et at 2012 US	5,317	- Age ≥65 years old -Non-disabled at baseline - participants in the Chicago Neighborhood	Community-dwelling	Progression of disability after onset, measured as number of basic self-care tasks needs assistance with: - bathing			**Yes.** - time since onset of disability[a] - reduced cognitive function[a] - reduced physical function (tandem stand,

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		and Disability study		- dressing - eating - showering - toileting - getting out of bed to chair Range 0 – 6			measured walk, chair stand)[a] - age x time since onset of disability[a] - lower body mass index[b] - male sex[b] **No.** - number of comorbid[b] conditions[b] - black race[b] - education[b]
Rist et al 2014 US	4,932	- Participants in the Health and Retirement Study - age ≥ 50 - No ADL limitations at baseline	Community-dwelling	Self- or proxy-reported ADL difficulty, based on past-30 day difficulty with any of 5 RAND HRS ADLs: - getting across a room - dressing - bathing - eating - getting in and out of bed		(Onset of disability) **Yes.** - lower cognitive functioning[a] - no physical activity[a] - depression[a] **No.** - cognitive functioning x physical[a] activity level - cognitive functioning x depression[a] - alcohol consumption[a] - smoking[a] - low income[a]	
Ritchie et al 2008 US	983	- Participants in the University of Alabama at Birmingham Study of Aging - Medicare beneficiaries	Community-dwelling	Baseline score and rate of change over 48 months in composite ADL score based on self-report of "Do you have any	**Yes.** - BMI ≥ 30 (vs. BMI ≥ 18.5 and <25[a] - unintentional weight loss[a] **No.**		**Yes.** - unintentional weight loss[a] **No.** - BMI ≥ 25 (vs. BMI ≥ 18.5 and <25[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Age ≥ 65 - Living in 1 of 5 counties of central Alabama - Community dwelling **Excluded if:** - In nursing home - Unable to set own appointments - Height and weight could not be obtained		difficulty performing the task" (Yes: 1 = some, 2 = a lot, 3 = unable to do task; No = 0) - eating - using the toilet - dressing - transferring - bathing - walking Range: 0 – 18 Scores reversed so that 18: independence.	- intentional weight loss[a] - baseline BMI x weight loss[a] - BMI <18.5[a]		- BMI <18.5[a] - intentional weight loss[a]
Rosso et al 2011 US	62,829	- Age ≥65 years old - Female - Participant in the Women's Health Initiative	Community-dwelling	9-item physical functioning sub-scale of the SF-36 Range 0 – 100 (100 = no limitations) Dichotomized at median into low versus high functioning.	**Yes.** - coronary artery disease[a] - coronary heart failure[a] - diabetes[a] - having one of above chronic conditions[a] - having one geriatric syndrome (urinary incontinence, falls, depression)[a] - having a combination of the above chronic conditions and geriatric syndromes[a]		
Rosso et al 2013 US	29,544	- Female - Age ≥65 years old - Free of ADL disability at baseline	Community-dwelling	- development of dependence in any of following activities during 3-year follow-up: - eating		**Yes.** - 3, 4 or 5 geriatric syndromes at baseline (vs. 0)[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Participants in the Women's Health Initiative **Excluded if:** - Had conditions that predicted survival of less than 3 years - History of cancer at baseline or cancer diagnosis during the follow-up period - Died before follow-up		- dressing - getting in and out of bed - taking a bath or shower		- 3, 4 or 5 geriatric syndromes developed during follow-up (vs. 0)[a] - depressive symptoms at baseline[a] - dizziness at baseline[a] - history of falls at baseline[a] - osteoporosis at baseline[a] - polypharmacy at baseline[a] - visual impairment at baseline[a] **No**. - 1 or 2 (vs. 0) geriatric syndromes at baseline[a] - 1 or 2 (vs. 0) geriatric syndromes developed during follow-up[a] - sleep disturbance at baseline[a] - hearing impairment at baseline[a] - syncope at baseline[a] - urinary incontinence at baseline[a]	
Russo et al 2007 Italy	364	- Born before January 1, 1924 - Resident of Sirente area as of October 2003	Community-dwelling	RAI-HC ADL scale, based on dependence in following tasks: - eating - dressing - personal hygiene - mobility in bed - dressing	**No.** - presence of depression[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- transferring (from bed to chair, or stand position) Range 0 – 7 (7: highest level of disability)			
Sjölund et al 2010 Sweden	2,141	- Age ≥75 years old - Live in either urban area of central Stockholm or rural community of Nordanstig	Mix - Community-dwelling older adults and nursing home residents (<20% of sample)	Katz ADL Index – rated as: - independent: no need of assistance - partially dependent: need help with 1-2 activities - dependent: need help with 3+ activities based on independence in: - bathing - dressing - going to the toilet - transferring - continence - feeding	**Yes.** - rural location of dwelling[a] - cognitive impairment[b] - depression[b] - hearing impairment (rural)[b] - blind or almost blind (rural)[b] - stroke[b] - Parkinson's disease[b] - fractures in previous 5 years (rural)[b] - having one chronic condition[b] - have 2 or more chronic condition[b] **No**. - hearing impairment (urban)[b] - blind or almost blind (urban)[b] - cardiovascular disease[b] - diabetes mellitus[b] - fractures in previous 5 years (urban [b]		
Smith et al 2013 USA	8,232	- Age ≥50 years old	Community-dwelling	Disability during the last two years of life = need for	**Yes.** - age ≥70[c] - female sex[c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Died while enrolled in the Health and Retirement Study between 1995 and 2010		help with at least 1 of the following activities: - dressing - bathing - eating - transferring - walking across the room - using the toilet	- less than high school education[c] - low (<$17,010) or medium ($17,010 to <78,000) household net worth at enrollment[c] - Being married or partnered[c] - Hypertension[c] - Heart disease[c] - Diabetes mellitus[c] - Cancer[c] - Cognitive impairment[c] - Stroke[c] - Lung disease[c] - Arthritis[c] - Recent hospitalization[c] - Recent fall[c] **No.** - race (non-Hispanic black, Hispanic versus non-Hispanic white)[c] - high household net worth (78,000 to <192,600) at time of enrollment[c]		
Sousa et al 2009 UK	14,869	- Age ≥65 years old - Living in geographically defined catchment areas from: urban sites in Cuba, Dominican Republic and Venezuela,	Community-dwelling	Disability measured by WHODAS 2.0. Each domain rated from 0 (no difficulty) to 4 (extreme difficulty or cannot do) - understanding or communication	**Yes.** - Dementia[a] - Paralysis or weakness of limbs[a] - Depression[a] - Stroke[a] - Arthritis or rheumatism[a] - Fainting or blackouts[a] - Difficulty breathing or asthma[a]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		urban & rural sites in Mexico, Peru, China and India		- getting around - self-care - getting along with people (interpersonal interaction) - life activities - participation in society	- Skin disorders[a] - Stomach or intestine problems[a] - Diabetes[a] - Eyesight problems[a] - Hearing difficulties[a] - Persistent cough[a] - Heart problems[a] **No.** - myocardial infarction or angina[a] - chronic obstructive pulmonary disease[a] - hypertension[a]		
Spalter et al 2014 Israel	982	- Participants in the Survey of Health, Ageing and Retirement in Europe - Hebrew, Arabic and Russian speaking residents - born in 1955 or earlier **Excluded if:** - Live in residential facilities or prisons	Community-dwelling	Change over 4 years in ADL score, based on the number of activities individuals reported difficulty with: - getting dressed - cross the room - bathe - eat get into and out of bed - use the toilet		**Yes.** - higher functional status at baseline[c] - Being Arabic (vs. immigrant from the former Soviet Union or Jewish)[c] - having more chronic diseases at baseline[c] - development of new diseases after baseline[c] - cognitive impairment at baseline[c] - living with people other than spouse (vs. living alone)[c] - receipt of home assistance[c] - receipt of informal support[c] **No.** - age[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- sex[c] - years of education[c] - income[c] - mental health at baseline[c] - recreation and social activities measure[c] - living with spouse or with spouse and others (vs. alone)[c] - receipt of personal assistance[c]	
Spector & Takada 1991 US	2,603	- Residents of 80 Rhode Island nursing homes participating in Medicaid or Medicare programs	Nursing home	Functional decline over 6-7 months: 1 or more unit decrease in Katz Index Of Activities of Daily Living scale		**Yes.** - 1 – 10% of residents have catheters (vs. 0% with catheters)[a] - <20 of residents receive skin care (vs. 20 – 40% of residents)[a] - <3 mean organized activity days/resident/month (vs. 3-6)[a] - smaller proportion of resident days that are private pay[a] - receipt of fewer federal citations for serious deficiencies[a] **No.** - staff level + mean resident ADL dependency level[a] - >10% of residents have catheters (compared to 0% with catheters)[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- > 40% of residents require skin care (vs. <20% of residents require skin care)[a] - % of residents with more than 1 psychoactive drug[a] - >6 mean organized activity days/resident/month (vs. <3)[a]	
Spiers et al 2005 UK	7,913	- Nondisabled at baseline - Age ≥65 years old - Residents of 5 urban and rural centers in England and Wales, randomly selected from the National Health Service primary care lists	Mix - Community-dwelling older adults and nursing home residents	Onset of disability, measured as individuals being unable to perform at least one of the following ADLs without help at least several times a week: - transfer to and from a chair - put on shoes and socks - prepare a hot meal - get around outside - have a bath or all-over wash		**Yes.** - stroke[a] - coronary heart disease (angina and heart attack)[a] - treated hypertension[a] - arthritis[a] - treated diabetes[a] - chronic airways obstruction[a] - Parkinson's disease[a] - Eyesight problems[a]-Cognitive impairment[a] - Increasing age[b] - Female gender[b] - current smoker[b] **No** - peripheral vascular disease[a] - Hearing problems[a] - Years of education[b] - Living status (lives with spouse, others, alone)[b] - Social class[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
Stel et al 2004 the Netherlands	204	- Age ≥65 years old - Participants in the Longitudinal Aging Study Amsterdam - Experienced a fall in the year prior to third wave of study follow-up in 1999/2000	Community-dwelling	Functional decline following fall, based on self-report of "some more difficulty" or "much more difficulty" performing any of the following activities as a consequence of the fall: - climbing stairs - dressing oneself - rising from a chair - cutting toenails - walking outside - using public transport		**Yes.** - female sex[c] - use of 2.5+ medications[c] - depression[c] **No.** - increasing age (+6.5 years)[c] - physical activity[c] - location of fall[c] - performance score for walking test, chair stands and tandem stand[c]	
Stineman et al 2013 US	9,447	- Age ≥70 years old - Participants in the Second Longitudinal Study of Aging	Mix Community-dwelling at baseline, but included institutionalized at follow-up	Improvement or worsening of ADL stage or death, where in ADL stage defined by: Activity of Daily Living Hierarchy: - Stages 0 (independent) to IV (completely dependent) based on degree of assistance required with following activities: - eating		**Yes.** - increasing age[c] - black or other race (vs. white) [c] - married[c] - high school graduate[c] - diabetes[c] - arthritis[c] - stroke[c] - use of a proxy due to cognitive impairment[c] - chronic bronchitis or emphysema[c] - having no or severe disability at baseline[c] **No.** - male gender[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- toileting - dressing - transferring - bathing - walking		- previous nursing home use[c] - unmet need for home accessibility services[c] - osteoporosis[c] - cancer[c] - coronary artery disease[c] - other heart disease[c] - having moderate disability at baseline[c]	
Talley et al 2015 US	7,735	- Aged ≥65 years - Living in nursing home for at least 6 months **Excluded if:** - Bedfast - In a persistent vegetative state - Had six or fewer months to live - Had end stage disease - Residents receiving occupational, physical, or speech therapy	Nursing home	Change in ADL long-form score (from RAI-MDS) measured over 18 months			**Yes.** - higher degree of cognitive impairment[b] - higher degree of frailty[b] - increasing number of chronic conditions[b] - poorer mood[b] - lower level of social[b] engagement - severe pain (vs. mild pain, or no pain)[b] - increasing number of physical impairments[b] - ADL long-form score at baseline[b] - Nurse indicated resident had the ability to improve ADL independence[b] - Nursing home: Medical director has no certification[b] **No.** - age (years)[b] - length of stay (years)[b]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
							- severe pain (vs. moderate pain)[b] - received any restorative care over time (e.g. skill practice with ADLs, active/passive range of motion)[a] - Nursing home: percentage of residents with Medicare reimbursement[b] - Nursing home: percentage of residents with Medicaid reimbursement[b] - Nursing home: Hours of patient contact with nursing staff[b] - Nursing home: Director of Nursing has no certification[b] - Facility has no accredication[b]
Talley et al 2014 US	2,395	- Had potential to improve incontinence using conservative treatment - Aged ≥65 years - Resident in one of 2,302 licensed residential care facilities that participated in	Nursing home ("residential care facility")	Toileting disability = yes to question "Does the resident currently receive any assistance using the bathroom?"	**Yes.** - poor or fair self-rated health (vs. excellent)[c] - small facility size (4 – 10 beds) (vs. extra-large: >100 beds)[c] - for-profit facility[c] - bowel incontinence[c] - bladder incontinence[c] - physical impairments[c] - absence of visual impairments (even when wearing glasses)[c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		the 2010 National Survey of Residential Care Facilities: had 4+ beds, provided room + board and ≥2 meals per day, provided, provision of personal care **Excluded if:** - Had dementia or Alzheimer's diagnosis - Significant cognitive impairment - Had intellectual or developmental disability - Muscular dystrophy - partial or total paralysis - Schizophrenia - spinal cord injury - Traumatic brain injury or a stroke within the past year - Blind - Bed or chair bound			- no trouble hearing (vs. a severe hearing impairment[c] - receives any assistance walking[c] - needs assistance going outside[c] - dependent in bathing[c] - dependent in dressing[c] - dependent in transferring[c] **No.** - marital status[c] - good or very good self-rated health (vs. excellent)[c] - place admitted from (rehab facility, nursing home, none of the above)[c] - medium facility size (11-25) or large facility size (26-100) (vs. extra-large: >100 beds)[c] - has bathroom inside room/apartment[c] - depression[c] - stroke[c] - a little trouble hearing (vs. no trouble hearing)[c] - use of a cane or walker [c]		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Presence of ostomy - Nursing home (unless met above criteria and individuals could be counted separately) - Facilities serving mentally ill or developmentally disabled populations exclusively					
Taylor 2010 US	3,955	- Age ≥65 years old - Participants in the Established Populations for Epidemiologic Studies of the Elderly (EPESE) in North Carolina - Community-dwelling	Community-dwelling	Disability = summed index of following ADLs and IADLs require assistance with: - walking - bathing - grooming - dressing - eating - transferring - toileting - using the telephone - driving/ travelling - shopping - preparing meals - housework - taking medication		**(**Disability Onset) **Yes.** - female sex[b] - increasing age[b] - lower education (if age 65-84)[a] - lower income (if age 65 – 84) [a] **No.** - white race [a] - lower education (if age 85 – 105)[a] - lower income (if age 85 – 105) [a]	**Yes.** - female sex (if age 75-84)[b] - white race (if age 65-74)[a] - increasing age (if age 65 – 84)[b] - lower income (if age 65-74)[a] **No.** - female sex (if age 65-74, 85-105)[b] - white race (if age 75-105)[a] - lower income (if age 75- 105)[a] - increasing age (if age 85 – 105)[b] - lower education[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				- handling finances Range 0 – 14 (14 = total dependence) Outcomes: disability onset and rate of decline following onset.			
Tinetti et al 2011 US	5,654	- Participants in (CHS) - ≥65 years old - Medicare eligible individuals - Community-dwelling - Expected to remain in the area for 3 years - Able to provide informed consent **Excluded**: - Need wheelchair, hospice care, radiation treatment or chemotherapy	Community-dwelling	Number of ADLs and IADLs performed with difficulty Range 0 – 12 in CHS data	**Yes.** - heart failure[a] - heart failure + symptoms of heart failure[a] - COPD + dyspnea[a] - osteoarthritis + pain[a] - cognitive impairment[a] **No.** - ejection fraction[a] - forced ejection fraction[a]		
	2,706	- Participants in (Health ABC)		Range 0 – 9 in Health ABC data			

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Medicare-eligible - Community-dwelling - Age 70-79 - No life-threatening cancer - No difficulties with ADLs or IADLs, walking 400 m, climbing 10 steps at baseline					
Tooth et al 2008 Australia	5,217	- Female - Aged 73 – 83 years - Participant in the Australian Longitudinal Study of Women's Health in 1999	Community-dwelling	Physical function subscale of the SF-36	Yes. - heart disease[c] - chest pain[c] - stroke[c] - hypertension[c] - fall resulting in fracture[c] - fall resulting in serious injury[c] - urinary incontinence[c] - low iron[c] - arthritis[c] - osteoporosis[c] - bronchitis/emphysema[c] - asthma[c] - diabetes[c] - cancers (other than skin) c - depression[c] - anxiety[c] - Alzheimer's disease[c] **No.**		

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
					- fall resulting in medical attention[c] - skin cancer[c]		
				ADL dependence: "Do you regularly NEED help with daily tasks because of long-term illness, disability or frailty? (Yes/No)?	**Yes.** - heart disease[c] - chest pain[c] - stroke[c] - fall resulting in fracture[c] - urinary incontinence[c] - Arthritis[c] - osteoporosis[c] - bronchitis/emphysema[c] - diabetes[c] - cancers (other than skin)[c] - depression[c] - anxiety[c] - Alzheimer's disease[c] **No.** - hypertension[c] - fall resulting in serious injury[c] - fall resulting in medical attention[c] - asthma[c] - skin cancer[c]		
Vogel et al 2014	702	- Patients with an elective hospital admission for critical limb ischemia for which either an open or endovascular	Nursing home	ADL long-form score (from RAI-MDS) Range 0 – 28 (28 = complete dependence)		**Yes.** (decline immediately post-hospitalization) - receipt of an endovascular (vs. open) procedure for critical limb ischemia[a]	**Yes.** (poorer functional trajectory in 6 months post-hospitalization) - receipt of open (vs. endovascular) procedure for critical limb ischemia[a]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		lower extremity procedure was performed - Age ≥67 years old - At least one proceeding MDS assessment within 60 days of hospital admission - Hospital length of stay less than 31 days - Admission date before June 1, 2006 and discharge date before August 1, 2007 **Excluded if:** - No Medicare Part A coverage - More than 20 hospital stays in 2006-2007 - Died in hospital					
Wang et al 2009 US	4,942	- Age ≥65 years old at admission - Admitted to one of 3777 Minnesota	Nursing home	Odds of early-loss ADLs defined as dependence in personal hygiene a		**Yes.** - baseline personal hygiene dependence[a] - bowel incontinence[a] - bladder incontinence[a] - balance dysfunction[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		nursing homes in 2004 - Administered a MDS admission assessment and a follow-up assessment in the same facility approximately 6 months after the admission assessment - Not comatose, bedridden, quadriplegic or on a feeding tube at baseline				- fall within 31-190 days[a] - cognitive impairment[b] - admission from a hospital[b] - more days between assessment and follow-up[b] - nursing home of residence[a] **No.** - depression[a] - frequency and severity of pain[a] - fall within 30 days[a] - age[b] - gender[b] - race[b] - educational level[b] - LTC characteristics (ownership type, hospital affiliation, urban/rural location, total bed size, number of participants per facility, hours staffing per resident day, percentage of Medicare days, total ADL change score, community discharge rates)[a]	
				Odds of mid-loss ADLs, defined as dependence in toileting		**Yes.** - baseline toileting dependence[a] - bowel incontinence[a] - bladder incontinence[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- balance dysfunction[a] - cognitive impairment[b] - admission from a hospital[b] - more days between assessment and follow-up[b] - nursing home of residence[a] **No.** - depression[a] - frequency and severity of pain[a] - fall within 30 days[a] - fall within 31-190 days[a] - age[b] - gender[b] - race[b] - educational level[b] - LTC characteristics (ownership type, hospital affiliation, urban/rural location, total bed size, number of participants per facility, hours staffing per resident day, percentage of Medicare days, total ADL change score, community discharge rates)[a]	
				Odds of late-loss ADLs, defined as dependence in eating		**Yes.** - baseline eating dependence[a] - bladder incontinence[a]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
						- cognitive impairment[b] - admission from a hospital[b] - more days between assessment and follow-up[b] - nursing home of residence[a] **No.** - depression[a] - frequency and severity of pain[a] - bowel incontinence[a] - balance dysfunction[a] - fall within 30 days[a] - fall within 31-190 days[a] - age[b] - gender[b] - race[b] - educational level[b] - LTC characteristics (ownership type, hospital affiliation, urban/rural location, total bed size, number of participants per facility, hours staffing per resident day, percentage of Medicare days, total ADL change score, community discharge rates)[a]	
Wolff et al 2005 US	4,968	- Participants in the Medicare Current Beneficiary	Community-dwelling	Composite measure (at 24, 36 months) of:		**Yes.** - increasing age[b] - ≤high school education[b]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		Survey in 1997 or 1998 and completed all subsequent interviews through 2000 or 2001 - Community-dwelling - Age ≥ 65 years old - Free of disability at baseline		- functional disability = receiving health or not performing because of a health or physical problem any of the following ADLs: - bathing - dressing - eating - transferring - walking - using the toilet OR - residence in a long-term care facility at 24- or 26- month follow-up		- higher number of chronic conditions at baseline[b] - increasing number of newly diagnosed chronic conditions at 12 months[a] - Specific diagnoses newly reported at 12 months: - dementia[a] - stroke[a] - psychiatric disorder[a] - Parkinson's disease[a] - low body mass index[a] - obesity[a] **No.** - female sex[b] - Newly diagnosed chronic conditions at 12 months: - coronary artery disease[a] - cancer[a] - hypertension[a] - diabetes mellitus[a] - emphysema, asthma or chronic obstructive pulmonary disease[a] - osteoarthritis[a] - other heart condition[a] - osteoporosis[a] - rheumatoid arthritis[a] - hip fracture[a]	
Wolinsky et al 2011 US	5,656	- Medicare beneficiaries	Community-dwelling	Decline in ADLs, defined as development of two or more new		**Yes.** - higher ADL dependence at baseline (floor effect)[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		- Participants in the AHEAD study		difficulties in simple count of difficulties in performing 5 activities: - getting across room - dressing - bathing - showering - eating - getting in or out of bed		- centered number of years between interviews[c] - use of a proxy respondent at baseline or follow-up[c] - increasing number of hospitalization episodes post-baseline[c] - died within a year of baseline measures[c] **No.** - baseline ADL dependence * use of proxy at baseline[c] - obese or underweight (vs. normal weight)[c] - current or former smoker (vs. never smoked cigarettes)[c] - ≤1 alcoholic drink daily[c] - continuity of primary care after baseline[c] - ever in Managed Care[c]	
Yeh et al 2014 Taiwan	1125	- Male - Residents of Banciao and Taipei Veterans Homes in northern Taiwan from January 2006 to December 2010 - Participants in the Longitudinal	Nursing home	Functional decline = increase in RUG-III ADL score from MDS by at least 1 point over 6 months. Range of 4 – 18 (where 4 = completely independent)		**Yes.** - Parkinsonism[c] - cognitive loss[c] - declining mood[c] - sum of indicators of overall decline[c] **No.** - increasing age[c] - body mass index[c]	

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
		Older Veteran's study - Age ≥ 65 years old - Under regular assessment for 18 consecutive months Excluded if: - In a completely dependent state					
Yu et al 2015 Taiwan	3,186	- Participants in the Taiwan Longitudinal Study on Aging - Age ≥50 years of age - Alive at baseline in 1996 and follow-up in 2007 - Completed at least three of four surveys	Mix - Community- and institution-dwelling older adults	Predictors of being on a progressive disability trajectory (versus a consistent disability or maintained function) trajectory over 10 year follow-up. Disability = sum of following ADL and IADL items in which respondent was dependent - bathing - eating - dressing - standing up from a chair and bed - indoor walking - toileting			**Yes.** - increasing age[c] - fewer years of education[c] - high number of comorbidities[c] - absence of use of assistive devices[c] **No.** - female sex[c] - burden of depression symptoms[c] - regular exercise[c] - no smoking[c] - no drinking[c] - recreational leisure time activities[c] - physical leisure time activities[c] - living alone[c] - social network[c] - social support[c]

Author/Year/ Country	Sample Size	Sample Inclusion	Location of Dwelling	Measure of ADL	Variables independently associated with disability outcomes controlling for major confounders:		
					Disability (1 time point)	**Disablement (over 2 time points)**	**Disablement (over 3+ time points)**
				managing money - shopping - taking public transportation - doing light housework - doing heavy housework - telephoning Range 0 – 12 (where 12 = completely dependent)			

Legend:
***** indicates interaction term between two covariates
For variables significantly independently related with disability outcomes, the following code was used to indicate the role of variables in each study:
a: exposure variable
b: adjustment variable
c: variable entered as part of predictive model or role unspecified

Appendix 2.3: Pathologies Associated with Disability and Disablement in Older Adults

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Sub-Acute Pathologies					
Anemia	**Yes.** (Tooth, Hockey, Byles, & Dobson, 2008)	.	.	1	Community: 1
Low glomerular filtration rate (<44)	.	**Yes**. (Chin et al., 2014)	.	1	Community: 1
High concentration of pro-inflammatory molecules (e.g. IL-6, CRP, fibrinogen) in blood	**Yes**. (Friedman, Christ, & Mroczek, 2015)	.	.	1	Community: 1
Low serum albumin (<3.5g/dL)	.	**Yes**. (Boyd et al., 2008; Kurella Tamura et al., 2009)	.	2	Nursing Home: 1 Hospital: 1
Acute pathologies					
Incident acute health episode or chronic pathology exacerbation	.	**Yes**. (Rosso et al., 2013; Spalter, Brodsky, & Shnoor, 2014; Wolff, Boult, Boyd, & Anderson, 2005)	**Yes**. (Li & Conwell, 2009)	4	Community: 4
Delirium	.	**Yes**. (Marcantonio et al., 2003) **No**.(Boockvar, Signor, Ramaswamy, & Hung, 2013; Landi et al., 2006; McCusker, Cole, Dendukuri, Belzile, & Primeau, 2001)	.	4	Community: 1 Nursing Home: 1 Hospitalized: 1 Mix: 1
Fall	**Yes.** (Smith, Walter, Miao, Boscardin, & Covinsky, 2013; Tooth et al., 2008)	**Yes.**(Chu, Chiu, & Chi, 2006){Lee, 2008 #6753}(Rosso et al., 2013; Wang et al., 2009)	**Yes**. (Li & Conwell, 2009)	8	Community: 6 Nursing Home: 2

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
		No. (Clark et al., 2012)			
Fracture, hip	.	**No**. (Gill, Allore, Holford, & Guo, 2004; Wolff et al., 2005)	**Yes**. (Banaszak-Holl et al., 2011) **No**. (Banaszak-Holl et al., 2011)	3	Community: 2 Nursing Home: 1
Fractures, past 5 years.	**Yes.** (Sjölund, Nordberg, Wimo, & Von Strauss, 2010; Tooth et al., 2008) **No.** (Sjölund et al., 2010)	.	.	2	Community: 1 Mix: 1
Infection, any (respiratory, urinary, miscellaneous)	.	**Yes**. (Bula, Ghilardi, Wietlisbach, Petignat, & Francioli, 2004; Caljouw et al., 2013)	**Yes**. (Caljouw et al., 2013)	2	Community: 1 Nursing Home: 1
Infection, higher number during follow-up	.	**Yes**. (Bula et al., 2004)	.	1	Nursing Home: 1
Infection, respiratory	.	**Yes**. (Barker, Borisute, & Cox, 1998; Bula et al., 2004)	.	2	Nursing Home: 2
Chronic Pathologies					
Higher number of chronic conditions	**Yes**. (Bayliss, Ellis, & Steiner, 2007; Cigolle, Langa, Kabeto, Tian, & Blaum, 2007; Friedman et al., 2015; Kelley-Moore & Ferraro, 2005; Kruse et al., 2013; Park et al., 2008; Rosso et al., 2011; Sjölund et al., 2010) **No**. (Peng et al., 2014)	**Yes**. (Fultz et al., 2003; Marengoni et al., 2009; Mendes De Leon & Rajan, 2014; Spalter et al., 2014; Wolff et al., 2005) **No**. (Abizanda et al., 2014; Barnes et al., 2013; Boeckxstaens et al., 2014; Landi et al., 2006)	**Yes**. (Drewes et al., 2011; Helvik, Engedal, Benth, & Selbæk, 2014; Talley et al., 2015; Yu, Chen, Chiang, Tu, & Chen, 2015) **No**. (Drewes et al., 2011; Kelley-Moore & Ferraro, 2005; Rajan et al., 2012)	23	Community: 13 Nursing Home: 3 Hospital: 2 Mix: 5

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Lower number of chronic conditions.	**Yes**. (Piernik-Yoder & Ketchum, 2013)	**Yes**. (Finlayson et al., 2012)	**Yes**. (Mendes De Leon & Rajan, 2014; Park et al., 2008)	4	Community: 2 Nursing Home: 1 Mix: 1
Alzheimer's disease	**Yes**. (Tooth et al., 2008)	.	.	1	Community: 1
Angina	**Yes**. (Groll, To, Bombardier, & Wright, 2005) **No**. (Sousa et al., 2009)	**.**	.	2	Community: 2
Anxiety	**Yes.** (Groll et al., 2005; Tooth et al., 2008)	**No**. (Buttar et al., 2001)	.	3	Community: 2 Nursing Home: 1
Arthritis (type unspecified) or joint impairment	**Yes**. (Fried et al., 1999; Groll et al., 2005; Laan et al., 2013; Smith et al., 2013; Sousa et al., 2009; Tooth et al., 2008) **No.** (Laan et al., 2013)	**Yes.** (Latham, 2012; Spiers et al., 2005; Stineman et al., 2013) **No**. (Clark et al., 2012; Gill et al., 2004; Wolff et al., 2005)	**No**. (Drewes et al., 2011)	13	Community: 11 Mix: 2
Asthma	**Yes**. (Groll et al., 2005; Laan et al., 2013; Sousa et al., 2009; Tooth et al., 2008)	**Yes**. (Spiers et al., 2005)	.	5	Community: 4 Mix: 1
Bone disease	**Yes.** (Marventano et al., 2014)	.	.	1	Community: 1
Cancer, unspecified type	**Yes**. (Fried et al., 1999; Marventano et al., 2014; Smith et al., 2013; Tooth et al., 2008) **No**. (Cigolle et al., 2007)	**Yes**. (Boyd et al., 2008; Caljouw, Cools, & Gussekloo, 2014; Latham, 2012) **No.** (Barnes et al., 2013; Gill et al., 2004; Lee & Rantz, 2008; Stineman et	**No**. (Banaszak-Holl et al., 2011)	14	Community: 7 Nursing Home: 3 Hospital: 2 Mix: 2

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
		al., 2013; Wolff et al., 2005)			
Cancer, neoplasia	.	**Yes**. (Burge et al., 2013)	.	1	Nursing Home: 1
Cardiovascular disease (type unspecified)	**Yes**. (Cigolle et al., 2007; Fried et al., 1999; Groll et al., 2005; Marventano et al., 2014; Smith et al., 2013; Sousa et al., 2009; Tooth et al., 2008) **No.** (C. L. Li et al., 2013; Sjölund et al., 2010)	**Yes.** (Boyd et al., 2008; Burge et al., 2013) **No**. (Latham, 2012; Stineman et al., 2013; Wolff et al., 2005)	**Yes**. (Banaszak-Holl et al., 2011) **No. (**Banaszak-Holl et al., 2011)	15	Community: 9 Nursing Home: 2 Hospital: 1 Mix: 3
Cough, persistent	**Yes.** (Sousa et al., 2009)	**.**	.	1	Community: 1
Chronic heart failure	**Yes.** (Groll et al., 2005; Quinones et al., 2014; Rosso et al., 2011; Tinetti et al., 2011)	**Yes.** (Clark et al., 2012; Gill et al., 2004)	**Yes**. (Drewes et al., 2011)	7	Community: 7
Chronic obstructive pulmonary disease	**Yes.** (Groll et al., 2005; Laan et al., 2013; Tooth et al., 2008) **No.** (Sousa et al., 2009)	**Yes.** (Stineman et al., 2013) **No**. (Wolff et al., 2005)	**No**. (Drewes et al., 2011)	7	Community: 6 Mix: 1
Coronary artery disease	**Yes**. (Rosso et al., 2011)	**Yes**. (Chu et al., 2006; Spiers et al., 2005) **No**. (Stineman et al., 2013; Wolff et al., 2005)	.	5	Community: 3 Mix: 2
Dementia	**Yes**. (Marventano et al., 2014; Sousa et al., 2009)	**Yes**. (Boyd et al., 2008; Caljouw et al., 2014; Chen et al., 2013; Kurella Tamura et al., 2009; Wolff et al., 2005) **No**. (Barnes et al., 2013)	.	8	Community: 3 Nursing Home: 3 Hospital: 2

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Depression	**Yes**. (Bayliss et al., 2007; Boström et al., 2014; Groll et al., 2005; Sjölund et al., 2010; Sousa et al., 2009; Tooth et al., 2008) **No**. (Kelley-Moore & Ferraro, 2005; Russo et al., 2007; K. M. C. Talley et al., 2014)	**Yes**. (Burge et al., 2013; Fultz et al., 2003; Gill et al., 2004; Rist, Capistrant, Wu, Marden, & Glymour, 2014; Rosso et al., 2013; Stel, Smit, Pluijm, & Lips, 2004) **No**. (Boyd et al., 2009; Chaudhry et al., 2011; Landi et al., 2006; Phillips et al., 2007) (Wang et al., 2009)	**Yes**. (Carrière et al., 2011; C. M. Chen et al., 2012; Drewes et al., 2011) **No**. (Carrière et al., 2011; Kelley-Moore & Ferraro, 2005; Li & Conwell, 2009; Yu et al., 2015)	25	Community: 18 Nursing Home: 4 Mix: 3
Diabetes, unspecified type	**Yes**. (Cigolle et al., 2007; Groll et al., 2005; Piernik-Yoder & Ketchum, 2013; Rosso et al., 2011; Sousa et al., 2009; Tooth et al., 2008) **No**. (Fried et al., 1999; C. L. Li et al., 2013)	**Yes**. (Clark et al., 2012; Fultz et al., 2003; Latham, 2012; Spiers et al., 2005; Stineman et al., 2013)	**No**. (Banaszak-Holl et al., 2011)	14	Community: 9 Nursing Home: 1 Mix: 4
Diabetes mellitus	**Yes**. (Marventano et al., 2014; Quinones et al., 2014; Smith et al., 2013) **No.** (Sjölund et al., 2010)	**Yes.** (Gill et al., 2004) **No**. (Lee & Rantz, 2008; Wolff et al., 2005)	**No**. (Drewes et al., 2011)	8	Community: 6 Nursing Home: 1 Mix: 1
Endocrinopathy	.	**Yes.(**Burge et al., 2013)	.	1	Nursing Home: 1
Hypertension	**Yes.** (Smith et al., 2013; Tooth et al., 2008)	**Yes.** (Spiers et al., 2005) **No**. (Gill et al., 2004; Latham, 2012; Wolff et al., 2005)	.	9	Community: 8 Mix: 1

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
	No. (Fried et al., 1999; Marventano et al., 2014; Sousa et al., 2009)				
Kidney disease	**Yes.** (Laan et al., 2013) **No.** (Laan et al., 2013)	**Yes**. (Bowling, Sawyer, Campbell, Ahmed, & Allman, 2011; Lee & Rantz, 2008)	.	3	Community: 2 Nursing Home: 1
Limb paralysis or amputation	**Yes**.(Sousa et al., 2009)	.	.	1	Community: 1
Lung disease, unspecified type	**Yes**. (Cigolle et al., 2007; Fried et al., 1999; Groll et al., 2005; Smith et al., 2013) **No**. (Marventano et al., 2014)	**Yes**. (Clark et al., 2012; Latham, 2012) **No**. (Burge et al., 2013; Gill et al., 2004)	.	9	Community: 7 Nursing Home: 1 Mix: 1
Musculoskeletal disease, unspecified type	**Yes**. (Cigolle et al., 2007)	**No**. (Burge et al., 2013)	.	2	Nursing Home: 1 Mix: 1
Myocardial infarction	**Yes**. (Groll et al., 2005) **No**. (Sousa et al., 2009)	**Yes**. (Gill et al., 2004)	**Yes.** (Drewes et al., 2011)	4	Community: 4
Neuropathy, unspecified type	**Yes**. (Groll et al., 2005)	**Yes**. (Lee & Rantz, 2008)	.	2	Community: 1 Nursing Home: 1
Osteoporosis	**Yes.** (Groll et al., 2005; Tooth et al., 2008)	**Yes**. (Rosso et al., 2013) **No**. (Stineman et al., 2013; Wolff et al., 2005)	.	5	Community: 4 Mix: 1
Parkinson's disease	**Yes**. (Groll et al., 2005; Li, 2005a; Marventano et al., 2014; Sjölund et al., 2010)	**Yes**. (Burge et al., 2013; Chu et al., 2006; Spiers et al., 2005; Wolff et al., 2005; Yeh et al., 2014)	**No**. (Drewes et al., 2011)	10	Community: 6 Nursing Home: 2 Mix: 2

Pathology	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Peripheral vascular disease	**Yes**. (Groll et al., 2005)	**Yes**. (Buttar et al., 2001) **No**. (Spiers et al., 2005)	.	3	Community: 1 Nursing Home: 1 Mix: 1
Psychiatric conditions, unspecified type	**Yes**. (Cigolle et al., 2007; Laan et al., 2013) **No.** (Laan et al., 2013)	**Yes**. (Burge et al., 2013; Latham, 2012; Wolff et al., 2005) **No.** (Spalter et al., 2014)	.	6	Community: 4 Nursing Home: 1 Mix: 1
Seizure disorders	**Yes**. (Buttar et al., 2001)	.	.	1	Nursing Home:1
Skin disorders, unspecified type	**Yes**. (Sousa et al., 2009)	.	.	1	Community: 1
Stroke	**Yes**. (Buttar et al., 2001; Cigolle et al., 2007; Fried et al., 1999; Groll et al., 2005; Li, 2005a; Sjölund et al., 2010; Smith et al., 2013; Sousa et al., 2009; Tooth et al., 2008) **No**. (Laan et al., 2013; K. M. C. Talley et al., 2014)	**Yes**. (Buttar et al., 2001; Chen et al., 2013; Clark et al., 2012; Fultz et al., 2003; Gill et al., 2004; Kurella Tamura et al., 2009; Latham, 2012; Lee & Rantz, 2008; Spiers et al., 2005; Stineman et al., 2013; Wolff et al., 2005) **No**. (Burge et al., 2013)	**Yes.** (Drewes et al., 2011) **No.** (Banaszak-Holl et al., 2011)	24	Community: 13 Nursing Home: 7 Mix: 4

Appendix 2.4: Impairments Associated with Disability and Disablement in Older Adults

Impairment	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Higher number of geriatric syndromes	**Yes**. (Cigolle et al., 2007; C. L. Li et al., 2013; Rosso et al., 2011)	**Yes**. (Chen et al., 2013; Rosso et al., 2013)	**Yes**. (Talley et al., 2015)	6	Community: 3 Nursing Home: 2 Mix: 1
BMI, overweight (BMI >25) or obese (BMI >30)	**Yes**. (Groll et al., 2005; Ritchie et al., 2008)	**Yes.** (Latham, 2012; Wolff et al., 2005) **No**. (Burge et al., 2013; Chen et al., 2013; Mendes De Leon & Rajan, 2014; Wolinsky et al., 2011; Yeh et al., 2014)	**No**. (Ritchie et al., 2008)	9	Community: 6 Nursing Home: 3
BMI, underweight (<19)	**Yes**. (Buttar et al., 2001; Peng et al., 2014) **No**. (Ritchie et al., 2008)	**Yes**. (Burge et al., 2013; Clark et al., 2012; Wolff et al., 2005) **No**. (Latham, 2012; Wolinsky et al., 2011)	**Yes**. (Mendes De Leon & Rajan, 2014; Rajan et al., 2012) **No**. (Ritchie et al., 2008)	10	Community: 7 Nursing Home: 2 Hospitalized: 1
Balance impairment	**Yes**. (Buttar et al., 2001)	**Yes**. (Burge et al., 2013; Wang et al., 2009)	.	3	Nursing Home: 3
Bladder incontinence	**Yes**. (Buttar et al., 2001; Li, 2005a; K. M. C. Talley et al., 2014; Tooth et al., 2008)	**Yes**. (Burge et al., 2013; Buttar et al., 2001; Caljouw et al., 2014; Landi et al., 2006; Lee & Rantz, 2008) **No**. (Rosso et al., 2013)	.	9	Community: 4 Nursing Home: 5
Bowel incontinence	**Yes.** (Li, 2005a; K. M. C. Talley et al., 2014)	**Yes**. (Burge et al., 2013)	.	3	Community: 1 Nursing Home: 2
Cognitive impairment	**Yes**. (Buttar et al., 2001; Kruse et al., 2013; Li, 2005a; Sjölund et al., 2010; Smith et al., 2013; Tinetti et al., 2011)	**Yes**. (Burge et al., 2013; Buttar et al., 2001; Chaudhry et al., 2011; Clark et al., 2012; Fultz et al., 2003; Lee & Rantz, 2008; Mendes De	**Yes**. (Banaszak-Holl et al., 2011; Drewes et al., 2011; Kruse et al., 2013; Li & Conwell, 2009; Mendes De Leon & Rajan, 2014;	27	Community: 15 Nursing Home: 9 Mix: 3

Impairment	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
	No. (Park et al., 2008)	Leon & Rajan, 2014; Phillips et al., 2007) (Landi et al., 2006; Rist et al., 2014; Spalter et al., 2014; Spiers et al., 2005; Stineman et al., 2013; Wang et al., 2009; Yeh et al., 2014) **No**. (Boyd et al., 2009)	Park et al., 2008; Rajan et al., 2012; Talley et al., 2015) **No**. (Banaszak-Holl et al., 2011)		
Decreased alertness	.	**Yes**.(Buttar et al., 2001)	.	1	Nursing Home: 1
Dizziness	.	**Yes**. (Rosso et al., 2013)	.	1	Community: 1
Fainting or blackouts.	**Yes**. (Sousa et al., 2009)	.	.	1	Community: 1
Frailty	.	**Yes**. (Abizanda et al., 2014; Boyd et al., 2009; Gill, Allore, Gahbauer, & Murphy, 2010; Gill et al., 2004)	**Yes**. (Talley et al., 2015)	5	Community: 3 Nursing Home: 1 Mix: 1
Gastrointestinal impairment, unspecified type	**Yes**. (Groll et al., 2005; Sousa et al., 2009) **No**. (Marventano et al., 2014)	.	.	3	Community: 3
Hearing impairment	**Yes**. (Fried et al., 1999; Groll et al., 2005; Marventano et al., 2014; Quinones et al., 2014; Sousa et al., 2009; K. M. C. Talley et al., 2014) (Laan et al., 2013; Sjölund et al., 2010) **No.** (Laan et al., 2013; Sjölund et al., 2010)	**Yes**. (Burge et al., 2013; Landi et al., 2006) **No**. (Rosso et al., 2013; Spiers et al., 2005)	**No**. (Helvik et al., 2014)	13	Community: 8 Nursing Home: 3 Mix: 2

Impairment	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Pain in chest	**Yes**. (Tooth et al., 2008)	**.**	.	1	Community: 1
Pain, chronic or severe	**Yes.** (Groll et al., 2005; Mänty, Thinggaard, Christensen, & Avlund, 2014)	**Yes.** (Lee & Rantz, 2008; Mänty et al., 2014) **No**. (Landi et al., 2006; Mänty et al., 2014; Wang et al., 2009)	**Yes**. (Talley et al., 2015)	6	Community: 2 Nursing Home: 3 Mix: 1
Pressure ulcers	**Yes**. (Buttar et al., 2001)	**Yes**. (Buttar et al., 2001; Landi et al., 2006; Lee & Rantz, 2008)	.	3	Community: 1 Nursing Home: 2
Shortness of breath	.	**Yes**. (Buttar et al., 2001)	.	1	Nursing Home: 1
Visual impairment	**Yes**. (Buttar et al., 2001; Groll et al., 2005; Marventano et al., 2014; Sousa et al., 2009) (Laan et al., 2013; Li, 2005a; Sjölund et al., 2010; K. M. C. Talley et al., 2014) **No**. (Fried et al., 1999; Laan et al., 2013; Sjölund et al., 2010)	**Yes**. (Burge et al., 2013; Rosso et al., 2013; Spiers et al., 2005) **No**. (Landi et al., 2006)	**Yes**. (Helvik et al., 2014)	14	Community: 8 Nursing Home: 4 Mix: 2
Weight loss/malnutrition	**Yes**. (Buttar et al., 2001; Peng et al., 2014; Quinones et al., 2014; Ritchie et al., 2008) **No.** (Ritchie et al., 2008)	**Yes**. (Buttar et al., 2001; Lee & Rantz, 2008) **No. (**Gopinath, Russell, Flood, Burlutsky, & Mitchell, 2014)	**Yes.** (Ritchie et al., 2008) **No.** (Ritchie et al., 2008)	6	Community: 3 Nursing Home: 2 Hospitalized: 1

Appendix 2.5: Functional Limitations Associated with Disability and Disablement in Older Adults

Functional Limitation	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Lower physical functioning (combined measure of timed walk, chair stand and tandem stand)	**Yes**. (K. M. C. Talley et al., 2014)	**Yes**. (Mendes De Leon & Rajan, 2014) **No**. (Stel et al., 2004)	**Yes**. (Mendes De Leon & Rajan, 2014; Rajan et al., 2012)	4	Community: 3 Nursing Home: 1
Difficulty lifting 10 pounds	.	**Yes**. (Clark et al., 2012)	.	1	Community: 1
Difficulty walking several blocks	.	**Yes**. (Clark et al., 2012)	.	1	Community: 1
Slowed gait speed	.	**Yes.** (Chaudhry et al., 2011; Chu et al., 2006)	.	2	Community: 2

Appendix 2.6: Intra-Individual Factors Associated with Disability and Disablement in Older Adults

Intra-Individual Factor	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Demographic Characteristics					
Age, older	**Yes**. (Laan et al., 2013; Li, 2005a; Marventano et al., 2014; Park et al., 2008; Quinones et al., 2014; Smith et al., 2013) **No**. (Friedman et al., 2015; Kruse et al., 2013)	**Yes.** (Boyd et al., 2005; Burge et al., 2013; Buttar et al., 2001; Caljouw et al., 2014; Chen et al., 2013; Chu et al., 2006; Clark et al., 2012) (Boyd et al., 2008; Ferrucci et al., 1996; Finlayson et al., 2012; Fultz et al., 2003; Gill et al., 2004; Kurella Tamura et al., 2009; Latham, 2012; Marengoni et al., 2009; Mendes De Leon & Rajan, 2014; Phillips et al., 2007; Spiers et al., 2005; Stineman et al., 2013; Taylor, 2010; Wolff et al., 2005) **No**. (Barnes et al., 2013; Boyd et al., 2009; Chaudhry et al., 2011) (Landi et al., 2006; Spalter et al., 2014; Stel et al., 2004; Wang et al., 2009; Yeh et al., 2014)	**Yes**. (Banaszak-Holl et al., 2011; Covinsky et al., 2003; Li, 2005a; Liang, Xu, Bennett, Ye, & Quinones, 2010; Park et al., 2008; Taylor, 2010; Yu et al., 2015) **No**.(Banaszak-Holl et al., 2011; Talley et al., 2015; Taylor, 2010)	42	Community: 23 Nursing Home: 12 Hospitalized: 3 Mix: 4
Age, younger	**Yes.** (Peng et al., 2014; Piernik-Yoder & Ketchum, 2013)	**Yes**. (Ciol et al., 2008)	**Yes.** (Helvik et al., 2014; Mendes De Leon & Rajan, 2014)	5	Community: 2 Nursing Home: 1

Intra-Individual Factor	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
					Hospitalized: 1 Mix: 1
Education, fewer years	**Yes.** (Friedman et al., 2015; Marventano et al., 2014) (Koster et al., 2006; Smith et al., 2013) **No**. (Koster et al., 2006; Park et al., 2008; Peng et al., 2014)	**Yes**. (Boyd et al., 2009; Latham, 2012) (Taylor, 2010; Wolff et al., 2005) **No**. (Boyd et al., 2009; Fultz et al., 2003; Gill et al., 2004; Marengoni et al., 2009; Mendes De Leon & Rajan, 2014; Spalter et al., 2014; Spiers et al., 2005; Wang et al., 2009)	**Yes** (Koster et al., 2006; Liang et al., 2010; Mendes De Leon & Rajan, 2014; Yu et al., 2015) **No**. (Banaszak-Holl et al., 2011; Helvik et al., 2014; Koster et al., 2006; Park et al., 2008; Rajan et al., 2012; Taylor, 2010)	22	Community: 15 Nursing Home: 4 Hospitalized: 1 Mix: 2
Education, more years	.	**Yes.** (Stineman et al., 2013)	.	1	Mix: 1
Ethnicity/race, minority	**Yes.** (Li, 2005a) **No**. (Friedman et al., 2015; Park et al., 2008; Smith et al., 2013)	**Yes**. (Ciol et al., 2008; Fultz et al., 2003; Latham, 2012; Phillips et al., 2007; Spalter et al., 2014; Stineman et al., 2013) **No**. (Boyd et al., 2009; Chaudhry et al., 2011; Finlayson et al., 2012; Gill et al., 2004; Mendes De Leon & Rajan, 2014; Wang et al., 2009) (Phillips et al., 2007)	**Yes**. (Li, 2005a; Liang et al., 2010; Park et al., 2008) **No**. (Mendes De Leon & Rajan, 2014; Rajan et al., 2012)	18	Community:14 Nursing Home: 3 Mix: 1
Ethnicity/race, white	**Yes.** (Piernik-Yoder & Ketchum, 2013)	**Yes**. (Kurella Tamura et al., 2009) **No.** (Taylor, 2010)	**Yes**. (Taylor, 2010)	3	Community: 1 Nursing Home: 1 Mix: 1
Married.	**Yes.** (Smith et al., 2013)	**Yes**. (Stineman et al., 2013) **No**. (Latham, 2012)	**Yes**. (Banaszak-Holl et al., 2011; Helvik et al., 2014)	7	Community: 3 Nursing Home: 3 Mix: 1

Intra-Individual Factor	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
	No. (Park et al., 2008; K. M. C. Talley et al., 2014)		**No**. (Banaszak-Holl et al., 2011; Park et al., 2008)		
Sex, female	**Yes**. (Buttar et al., 2001; Friedman et al., 2015; Kruse et al., 2013; Park et al., 2008; Quinones et al., 2014; Smith et al., 2013) **No**. (Marventano et al., 2014) (Peng et al., 2014; Piernik-Yoder & Ketchum, 2013)	**Yes**. (Caljouw et al., 2014; Fultz et al., 2003; Phillips et al., 2007; Spiers et al., 2005; Stel et al., 2004; Taylor, 2010) **No**. (Abizanda et al., 2014; Barnes et al., 2013; Chaudhry et al., 2011; Ferrucci et al., 1996; Gill et al., 2004; Landi et al., 2006; Latham, 2012; Marengoni et al., 2009; Spalter et al., 2014; Wang et al., 2009; Wolff et al., 2005)	**Yes**. (Liang et al., 2010; Taylor, 2010) **No**. (Helvik et al., 2014; Park et al., 2008; Taylor, 2010; Yu et al., 2015)	29	Community: 16 Nursing Home: 6 Hospitalized: 1 Mix: 5
Sex, male	.	**Yes**. (Burge et al., 2013; Ciol et al., 2008) **No**. (Finlayson et al., 2012; Mendes De Leon & Rajan, 2014; Stineman et al., 2013)	**Yes**. (Mendes De Leon & Rajan, 2014; Rajan et al., 2012) **No. (**Banaszak-Holl et al., 2011)	7	Community: 3 Nursing Home: 3 Mix: 1
Lifestyle and Behavioral Factors					
Alcohol consumption, habitual	**No**. (Peng et al., 2014)	**No.** (Rist et al., 2014; Wolinsky et al., 2011)	.	3	Community: 2 Hospitalized: 1
Alcohol consumption, low	.	**No**. (Burge et al., 2013)	**No**. (Yu et al., 2015)	2	Nursing Home: 1 Mix: 1
Period of restricted activity (bedrest)	.	**Yes**. (Gill, Allore, et al., 2010; Gill et al., 2004)	.	2	Community: 2
Physical activity level, low	**Yes.** (Friedman et al., 2015)	**Yes**. (Burge et al., 2013; Latham, 2012; Rist et al., 2014)	**No**. (Yu et al., 2015)	6	Community: 4 Nursing Home: 1 Mix: 1

Intra-Individual Factor	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
		No. (Stel et al., 2004)			
Smoker, current or former	**Yes.** (Li, 2005a) **No**. (Friedman et al., 2015; Peng et al., 2014)	**Yes**. (Latham, 2012; Spiers et al., 2005) **No**. (Rist et al., 2014; Wolinsky et al., 2011)	**No**. (Li, 2005a; Yu et al., 2015)	8	Community: 5 Hospitalized: 1 Mix: 2
Psychosocial Attributes					
Apathy	.	.	**Yes**. (Helvik et al., 2014)	1	Nursing Home: 1
Fear of falling	.	**Yes**. (Chu et al., 2006)	.	1	Community: 1
Home ownership	**Yes**. (Li, 2005a)	**.**	**No**. (Li, 2005a)	1	Community:1
Income, low	**Yes.** (Bayliss et al., 2007; Park et al., 2008; Smith et al., 2013) **No**. (Koster et al., 2006)	**Yes**. (Latham, 2012; Taylor, 2010) **No**. (Rist et al., 2014; Spalter et al., 2014; Taylor, 2010)	**Yes**.(Koster et al., 2006; Taylor, 2010) **No.** (Taylor, 2010)	8	Community: 8
Income, adequate or high	**No**. (Smith et al., 2013)	**.**	**Yes**. (Park et al., 2008)	2	Community: 2
Intrinsic religiousness, high	**No**. (Park et al., 2008)	.	**No**. (Park et al., 2008)	1	Community: 1
Optimism or mood, low	.	**Yes**.(Yeh et al., 2014)	**Yes**. (Talley et al., 2015)		Nursing Home: 2
Prayer, higher frequency	**No**. (Park et al., 2008)	.	**No**. (Park et al., 2008)	1	Community: 1
Irregular or non-attendance at religious services.	**Yes**.(Park et al., 2008)	.	**No.** (Park et al., 2008)	1	Community: 1
Self-efficacy about functional improvement, low	**No**. (Li, 2005a)	.	**Yes**. (Li, 2005a)	1	Community: 1
Self-rated health, low	**Yes**. (K. M. C. Talley et al., 2014)	**Yes**. (Bond, Dickinson, Matthews, Jagger, & Brayne, 2006)	.	2	Community: 1 Nursing Home: 1

Intra-Individual Factor	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Subjective social status, low	.	**Yes**. (B. Chen, Covinsky, Cenzer, Adler, & Williams, 2012)	.	1	Community: 1
DNR order on file	**Yes**. (Buttar et al., 2001)	.	.	1	Nursing Home: 1
Nursing Home Resident Characteristics					
Higher case-mix score at admission	.	**Yes.** (Mor et al., 2011)	.	1	Nursing Home: 1
Longer period of time since admission to nursing home	.	**Yes**. (Burge et al., 2013; Chen et al., 2013)	**Yes.** (Dutcher et al., 2014; Helvik et al., 2014) **No.** (Talley et al., 2015)	5	Nursing Home: 1
Lived with others prior to nursing home admission	**Yes**.(Buttar et al., 2001)	**Yes**. (Buttar et al., 2001; Phillips et al., 2007)	.	2	Nursing Home: 1
Resident pays privately for nursing home services	.	**Yes**.(Buttar et al., 2001)	.	1	Nursing Home: 1

Appendix 2.7: Extra-Individual Factors Measured in Individuals Associated with Disability and Disablement in Older Adults

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Medical Care					
Hospitalization(s) prior to start of study period	.	**Yes.** (Latham, 2012) **No.** (Gill et al., 2004)	.	2	Community: 2
Any hospitalization(s) during study period	**Yes**. (Smith et al., 2013)	**Yes**. (Boockvar et al., 2013; Boyd et al., 2005; Clark et al., 2012; Finlayson et al., 2012; Gill, Allore, et al., 2010; Gill et al., 2004; Kurella Tamura et al., 2009)	**Yes**. (Kruse et al., 2013)	9	Community: 5 Nursing Home: 4
Higher number of hospitalizations during follow-up	.	**Yes.** (Boyd et al., 2005; Wolinsky et al., 2011) **No**. (Boyd et al., 2009)	.	3	Community: 3
Specific cause of hospitalization	.	**No**. (Barnes et al., 2013)	**Yes**. (Kruse et al., 2013)	2	Hospital: 1 Nursing Home: 1
Increased length of stay during hospitalization.	.	**Yes**. (Boyd et al., 2009)	**No**. (Kruse et al., 2013)	2	Community: 1 Nursing Home: 1
Patient-clinician communication, high	**Yes**. (Bayliss et al., 2007)	**.**	.	1	Community: 1
Specific Clinical Interventions					
Colon cancer surgery	.	**Yes**. (Finlayson et al., 2012)	.	1	Nursing Home: 1
Surgical complications of colon cancer surgery	.	**Yes.** (Finlayson et al., 2012)	.	1	Nursing Home: 1
Did *not* receive percutaneous transluminal	**Yes**. (Quinones et al., 2014)	.	.	1	Community: 1

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
coronary angioplasty following first myocardial infarction					
Receipt of coronary artery bypass graft following first myocardial infarction	**Yes**. (Quinones et al., 2014)	.	.	1	Community: 1
Receipt of an endovascular (vs. open) procedure for critical limb ischemia	.	**Yes**. (Vogel, Petroski, & Kruse, 2014)	.	1	Nursing home: 1
Receipt of an open (vs. endovascular) procedure for critical limb ischemia	.	.	**Yes**. (Vogel et al., 2014)	1	Nursing home: 1
Initiation of renal dialysis	.	**Yes**. (Kurella Tamura et al., 2009)	**Yes**. (Kurella Tamura et al., 2009)	1	Nursing Home: 1
Medications and Other Therapeutic Regimens					
Polypharmacy	**Yes**. (Laan et al., 2013)	**Yes**. (Buttar et al., 2001; Rosso et al., 2013; Stel et al., 2004)	.	4	Community: 3 Nursing Home: 1
Takes anti-anxiety medications.	**.**	**.**	**Yes**. (Helvik et al., 2014)	1	Nursing Home: 1
Does *not* take anti-anxiety medications.	**Yes**. (Buttar et al., 2001)	.	.	1	Nursing Home: 1
Does *not* take anti-depressant drugs.	.	.	**Yes**. (Dutcher et al., 2014)	1	Nursing Home: 1
Takes anti-psychotic drugs	.	.	**Yes.** (Dutcher et al., 2014) **No**. (Dutcher et al., 2014; Helvik et al., 2014)	2	Nursing Home: 2
Does *not* take cognitive enhancers.	.	.	**Yes.** (Helvik et al., 2014)	1	Nursing Home: 1
Takes mood stabilizers	.	.	**Yes.** (Dutcher et al., 2014)	1	Nursing Home: 1

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
			No. (Dutcher et al., 2014)		
External Support					
Contacts with proxies or social engagement low	.	**Yes**. (Burge et al., 2013; Chen et al., 2013; Mendes De Leon & Rajan, 2014)	**Yes**. (Mendes De Leon & Rajan, 2014; Talley et al., 2015)	4	Community: 1 Nursing Home: 3
Living alone	.	**No**. (Boyd et al., 2009; Landi et al., 2006)	**No**. (Yu et al., 2015)	3	Community: 2 Mix: 1
Living with other people	**Yes**. (Li, 2005a)	**Yes**.(Gill et al., 2004; Spalter et al., 2014) **No**. (Spiers et al., 2005)	**No**. (Li, 2005a)	4	Community: 3 Mix: 1
Receipt of help from others, regular	**Yes**. (Park et al., 2008; K. M. C. Talley et al., 2014)	**Yes.** (Spalter et al., 2014)	.	3	Community: 2 Nursing Home: 1
Receipt of help from others, none/infrequent	**Yes**. (Peng et al., 2014)	.	**Yes.** (Park et al., 2008)	2	Community: 1 Hospitalized: 1
Use of assistive devices, none	.	.	**Yes**. (Yu et al., 2015)	1	Mix: 1
Medicare insured	**Yes**. (Buttar et al., 2001)	**Yes**. (Latham, 2012)	.	2	Community: 1 Nursing Home: 1
Living in nursing home (versus community)	.	**Yes.** (Abizanda et al., 2014)	.	1	Mix: 1
Nursing Home Resident Characteristics					
Admitted to nursing home from hospital	.	**Yes**. (Wang et al., 2009)	.	1	Nursing Home: 1
Admitted to nursing home from location *other than* hospital	**No**. (K. M. C. Talley et al., 2014)	**Yes**. (Phillips et al., 2007)	.	2	Nursing Home: 2
No residence in another nursing home within past five years.	.	**Yes**. (Phillips et al., 2007) **No**. (Stineman et al., 2013)	.	2	Nursing Home: 1 Mix: 1

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Staff belief in resident potential for ADL improvement	.	.	**Yes.** (Talley et al., 2015)	1	Nursing Home: 1

Appendix 2.8: Extra-Individual Factors Measured at the in Institutional or Area Level Associated with Disability and Disablement in Older Adults

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Nursing Home Level Aggregate Measures of Resident Characteristics					
<20% of residents receive skin care (vs. 20-40% of residents)	.	**Yes**. (Spector & Takada, 1991)	.	1	Nursing Home: 1
<3 mean organized activity days per resident per month (vs. 3-6)	.	**Yes**. (Spector & Takada, 1991)	.	1	Nursing Home: 1
High proportion of Medicaid residents in nursing home	.	**Yes**. (Bellows & Halpin, 2008)	.	1	Nursing Home: 1
Higher nursing home-level ADL acuity index	.	**Yes**. (Bellows & Halpin, 2008) **No**. (Spector & Takada, 1991; Wang et al., 2009)	.	3	Nursing Home: 3
Lower proportion of black residents in nursing home population	.	**Yes**. (Mor et al., 2011)	.	1	Nursing Home: 1
Moderate (1-10%) proportion of residents with catheters	.	**Yes**. (Spector & Takada, 1991)	.	1	Nursing Home: 1
Smaller proportion of resident days that are private pay	.	**Yes**. (Spector & Takada, 1991) **No**. (Wang et al., 2009)	**No**. (Talley et al., 2015)	3	Nursing Home: 3

Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Nursing Home Built Physical and Social Environment					
Dwelling in specific nursing home (indicated by dummy variable for each facility)	**Yes**. (Phillips et al., 2008)	**Yes**. (Wang et al., 2009) **No**. (Caljouw et al., 2014)	.	3	Nursing Home: 3
Case mix reimbursement used in nursing home	.	**No**. (Mor et al., 2011)	.	1	Nursing Home: 1
For-profit nursing home ownership	**Yes**. (K. M. C. Talley et al., 2014)	**No**. (Bellows & Halpin, 2008; Wang et al., 2009)	.	3	Nursing Home: 3
Higher number of admissions per bed	.	**Yes**. (Mor et al., 2011)	.	1	Nursing Home: 1
High bed occupancy in nursing home	.	**Yes**. (Bellows & Halpin, 2008)	.	1	Nursing Home: 1
Nursing home size, small	**Yes**. (K. M. C. Talley et al., 2014)	**Yes**. (Bellows & Halpin, 2008)	.	2	Nursing Home: 2
Nursing home medical director has no certification	.	**.**	**Yes**. (Talley et al., 2015)	1	Nursing Home: 1
Receipt of fewer federal citations for serious deficiencies.	.	**Yes.** (Spector & Takada, 1991)	.	1	Nursing Home: 1
Total licensed staff per day in nursing home	.	**Yes**. (Bellows & Halpin, 2008) **No**. (Spector & Takada, 1991; Wang et al., 2009)	.	3	Nursing Home: 3
Location of nursing home, rural	.	**Yes**. (Bellows & Halpin, 2008) **No**. (Wang et al., 2009)	.	2	Nursing Home: 2

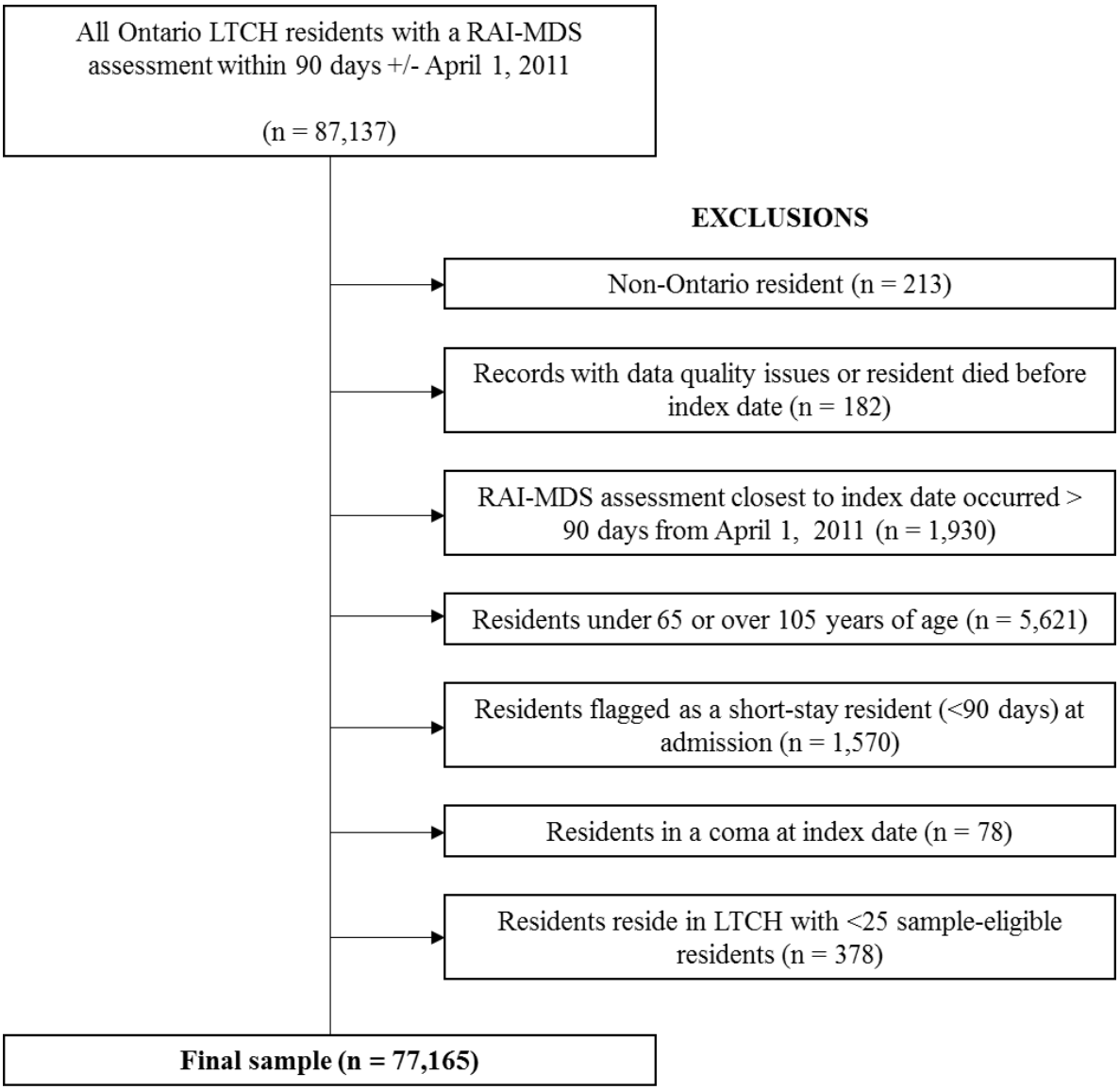
Extra-Individual Factors (Measured in Individuals)	Associated with disability	Associated with disablement (pre-post?)	Associated with disablement (3+ time points)	Number of studies	Proportion of cited studies by setting
Location of nursing home, urban	**Yes**. (Bolin, Phillips, & Hawes, 2006)	.	.	1	Nursing Home: 1
City or State/Province Built Physical and Social Environment					
Place of residence, rural	**Yes. (**Park et al., 2008; Sjölund et al., 2010)	**.**	**No**. (Park et al., 2008)	2	Community: 1 Mix: 1
Place of residence in the community, urban	**Yes.** (Li, 2005a)	**.**	**No**. (Li, 2005a)	1	Community: 1
City-wide influenza death rate	.	**Yes**. (Gozalo, Pop-Vicas, Feng, Gravenstein, & Mor, 2012)	.	1	Nursing Home: 1
Lower area wage index for nursing homes	.	**Yes**. (Mor et al., 2011)	.	1	Nursing Home: 1
State in which nursing home located uses MDS-based Medicaid reimbursement system	.	**Yes.** (Bellows & Halpin, 2008)	.	1	Nursing Home: 1
State-level influenza severity	.	**Yes**. (Gozalo et al., 2012)	.	1	Nursing Home: 1
Absence of a $10 increase in consumer-adjusted Medicaid rate	**.**	**Yes**. (Mor et al., 2011)	.	1	Nursing Home: 1

Appendix 2.9: Frequency of Different Measures of Self-Care Disability across Study Populations

Self-Care Disability Measure Used	Study Population			
	Community-Dwelling	Nursing Home	Mix	Total
RAI ADL-Long Form Score*	2	12	1	15
RAI ADL-Hierarchy*	2	4	1	7
Barthel	6	0	2	8
Care Dependence Score	0	1	0	1
Count of activities person dependent in	34	4	4	42
Functional Independence Measure	0	0	1	1
Groningen Activity Restriction Scale	2	0	0	2
Katz	4	2	3	9
Physical self-maintenance scale	0	1	0	1
RAND HRS ADLS	1	0	0	1
RUG-III ADL Score	0	2	0	2
SF 36 Physical Subscale	3	0	0	3
Stanford Health Assessment Questionnaire Disability Index	1	0	0	1
WHODAS 2.0	1	0	0	1
Total	56	26	12	94

*The components of these measures vary across populations. For example in community-dwelling older adults, they might be derived from the RAI-HC or the RAI-AC, whereas in nursing home residents they are derived from the RAI-MDS.

Appendix 3.1: Study 2 Cohort Creation



Appendix 3.2: Items and Possible Responses in the RAI-MDS ADL Long Form Scale

Item	Description
Bed mobility	Includes how a resident moves and turns their body position while in bed.
Transfer	Includes how a resident moves between surfaces such as bed and chair.
Locomotion	Includes how a resident moves between locations in their room and the corridor outside their room.
Dressing	Includes how a resident puts on, fastens and takes off all items of street clothing.
Eating	Relates to how a resident eats and drinks, including other means of nourishment intake, such as tube feeding.
Toilet use	This includes how a resident uses a toilet, commode, bedpan or urinal and transfer on and off a toilet.
Personal hygiene	Relates to how personal hygiene is maintained, including combing hair, brushing teeth, washing and drying face and hands. Excludes baths and showers.

Categories of response to each item include:
0: total independence or no or little help with activity.
1: supervision provided 3 or more times during last 7 days.
2: limited assistance by staff with the resident highly involved in the activity.
3: extensive assistance by staff with the resident performing part of the activity.
4: total dependence/full staff participation in activity during the entire 7 days OR activity did not occur during past 7 days.

Appendix 3.3: Definitions of Chronic Conditions and Geriatric Syndromes in this Dissertation

Chronic conditions are defined *as illnesses lasting six months or more, including past illnesses requiring continuous care, diseases with risk of recurrence, or previous health problems that continue to affect the management of residents* (Kernick, 2012). This definition was selected because it includes "acute" conditions such as stroke that – despite being acute events – typically require chronic treatment (Reuben et al., 2013; Stineman et al., 2013). It also captures episodic conditions such as depression that have chronic effects despite their fluctuating course. Given that the goal of this thesis to understand how such pathologies are associated with disability and disablement, this inclusion of prevalent and impactful conditions is important.

There is lack of agreement among thought leaders as to what constitutes a geriatric syndrome (Flacker, 2003), and even whether they should be called syndromes (versus conditions) (Chen, Yen, Dai, Wang, & Huang, 2011). A summary of commonly used definitions is provided below. The definition of a geriatric condition from Chen et al will be used in this thesis to define a **geriatric syndrome** as: *a collection of signs and symptoms common in older residents but not necessarily fitting into discrete disease categories* (Chen et al., 2011). This definition is preferable to others in that it is aligned with other recently used definitions (Rosso et al., 2013), does not make assumptions about etiology of geriatric syndromes (Inouye, Studenski, Tinetti, & Kuchel, 2007; Olde Rikkert, Rigaud, van Hoeyweghen, & de Graaf, 2003) and is inclusive of impairments such as pressure ulcers and malnutrition that impact disability but do not meet more stringent "geriatric syndrome" criteria (Cigolle et al., 2007).

Table 3.3: Commonly Used Definitions of Geriatric Syndromes and Examples

Study	Definition	Impairments Included
(Olde Rikkert et al., 2003)	**Geriatric syndrome**: *a pattern of symptoms and signs with a single underlying cause that may not yet be known.*	- delirium - dizziness - falls - urinary incontinence
(Cigolle et al., 2007)	**Geriatric syndrome**s: **(i)** *occur in older, especially vulnerable adults,* (**ii**) *are precipitated by a variety of acute insults,* (**iii**) *are typically episodic in nature, and* (**iv**) *are often followed by functional decline*.	- falls - urinary incontinence - vision impairment - weight loss
(Inouye et al., 2007)	**Geriatric syndrome**: *multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render an older person vulnerable to situational challenges*. - Central to this definition is the notion of multiple causation with unified manifestation, such that a geriatric syndrome shares common ground with a **phenotype.**	- delirium - falls - *functional decline* - incontinence - pressure ulcers
(Chen et al., 2011)	**Geriatric condition**: *a collection of signs and symptoms common in older inpatients but not necessarily fitting into discrete disease categories*.	- anemia - chewing and swallowing difficulties - cognitive impairment - dehydration - depression - *functional dependence (Barthel ADL)* - hearing impairment - malnutrition - sleep disturbance - visual impairment
(Rosso et al., 2013)	**Geriatric syndrome**: *a group of conditions that are common in older adults and are the result of multifactorial impairments of bodily systems*. - Note: presence of multiple geriatric syndromes may indicate general physiologic vulnerability whereas those occurring in isolation may have localized etiology	- depressive symptoms - dizziness - falls - hearing/visual impairment - osteoporosis - polypharmacy - sleep disturbance - syncope - urinary incontinence

Appendix 3.4: Chronic Conditions and Diagnostic Criteria Used to Identify Them in Claims and Health Assessment Databases

Chronic conditions	ICD-9 *OHIP or CIHI-DAD*	ICD-10 *CIHI-DAD*	RAI-MDS *CCRS_LTC*
Arthritis: osteo, rheumatoid and others	274, 710, 711, 714-16, 718, 720, 727-729, 739	M00-M03, M05-M07,M10-M25, M30-M36, M65-M73, M75-M77, M79	I1L: arthritis
Asthma	493	J45	I1JJ: asthma
Cancer	140-165, 170-176, 179-208, 210-239	C00-C26, C30-C34, C37-C41, C43-C58, C60-86, C88, C91-97	I1RR: cancer
Coronary artery disease, (including myocardial infarction)	410-414	I20-I25	I1D: arteriosclerotic heart disease
Chronic obstructive pulmonary disease	491, 492, 496	J41-J44	I1KK: emphysema/COPD
Dementia (including Alzheimer's)	**OHIP**: 290, 331, 797 **DAD**: 290, 294.1, 294.8, 294.9, 331.0, 331.1, 331.2, 797	F000, F001, F002, F009-F013, F018-F024, F028, F03, F051, F065, F066, F068, F069, F09, G300 -G301, G308-G311, R54	I1R: Alzheimer's disease I1V: Dementia other than Alzheimer's disease
Diabetes (Type 1 and 2)	250	E10-E14	I1A: Diabetes mellitus
Epilepsy	345	G40-G41	I1CC: Seizure disorder
Heart failure	428	I500, I501, I509	I1F: Congestive heart failure
Limb paralysis or amputation	896, 897	G82, G83, S48, S58, S68.3, S68.4, S68.8, S68.9, S78, S88, T05, T116, T136	I1N: Missing limb (e.g. amputation) I1W: hemiplegia/hemiparesis I1Z: Paraplegia I1BB: Quadriplegia
Mood disorders	**OHIP:** 296 311 **DAD:** 296.2, 296.3, 296.5. 311	F30-F34 F38 F39	I1GG: depression I1HH: manic depressive (bipolar)
Parkinson's disease	332	G20-G22	I1AA: Parkinson's disease
Peripheral vascular disease	**OHIP**: 440 **DAD**: 440.2	I70.2	I1J: Peripheral vascular disease
Psychiatric conditions other than depression and dementia	291-292, 295, 297-298, 300-301, 303-310, 312, 315-319	F04, F06, F07, F10-F25, F28-F29, F40-F45, 48 50-55, F59-F63, F68-F73, F78-F84, F88-F91, F94-F95, F98-F99 **EXCEPT:** F063, F065, F066, F068, F069	I1FF: anxiety disorder I1II: schizophrenia
Renal disease	583-586, 592, 593	N00-N08, N11, N13-14, N16-N23	I1UU: renal failure
Stroke	430-432, 434, 436	I60-I64	I1U: Cerebrovascular accident (stroke)

Appendix 3.5: Geriatric Syndromes and Diagnostic Criteria Used to Identify Them in the CCRS Database

Geriatric Syndromes	CCRS_LTC Variable	Re-Coding of Variable for Study
Balance impairment	**G3A**	**Based on a test for balance while standing.** **0**: **Not balanced impaired** - G3A = 0 or 1 G3A =0: Maintained position as required during test G3A =1: Unsteady, but able to rebalance self without physical support **1**: **Balance Impaired** - G3A = 2 or 3 G3A =2: Partial physical support during test; or stands but does not follow directions for test G3A = 3: Not able to attempt test without physical help
Bowel incontinence	**H1A**	**0**: Continent - H1A = 0 or 1 **1**: Bowel incontinent - H1A = 2, 3, 4
Cognitive impairment	**CPS_CC**	**0**: Intact/ Borderline Intact - CPS_CC = 0 or 1 **1**: Mild or mod. Impaired - CPS_CC = 2 or 3 **2**: Mod. severely Impaired - CPS_CC = 4 **3**: Severely Impaired - CPS_CC = 5 or 6
Hearing impairment	**C1**	**0**: Not highly impaired - C1 = 0, 1 **1**: Impaired C1 = 2, 3
Obesity	**K2A:** Resident's height in centimeters. **K2B**: Resident's weight in kilograms (measured within 30 days of assessment).	Derived variable: BMI = bodyweight in kg/(height in meters)^2 = **K2B/(K28/100)^2** Resident **K2B/(K28/100)^2** ≥30: **0**: No **1**: Yes.
Underweight	**K2A:** Resident's height in centimeters. **K2B**: Resident's weight in kilograms (measured within 30 days of assessment).	Derived variable: BMI = bodyweight in kg/(height in meters)^2 = **K2B/(K28/100)^2** Resident **K2B/(K28/100)^2** <18: **0**: No **1**: Yes.
Pain	**PAIN_CC**	**0**: No pain **1**: Less than daily pain **2**: Daily pain but not severe **3**: Severe daily pain
Pressure ulcer	**M2A**	**0:** No pressure ulcer - M2A = 0 or 1 **1:** Pressure ulcer present - M2A = 2, 3 or 4
Urinary incontinence	**H1B**	**0**: Continent - H1B = 0, 1 **1**: Urine incontinent - H1B = 2, 3, 4
Visual impairment	**D1**	**0** – Adequate vision - D1 = 0 **1** – Impaired to mod. Impaired - D1 = 1, 2 **2** – Highly or severely *impaired* - D1 = 3, 4

Appendix 3.6: Ethics Approval

Note that at the time of the application to ethics, the term “functional limitation” was used in the place of “disability” and “functional decline” was used in the place of “disablement.”

UNIVERSITY OF TORONTO

OFFICE OF THE VICE-PRESIDENT, RESEARCH AND INNOVATION

PROTOCOL REFERENCE # 31821

August 4, 2015

Dr. Walter Wodchis
INST OF HEALTH POLICY, MANAGEMENT & EVALUATION
DALLA LANA SCHOOL OF PUBLIC HEALTH

Ms. Natasha E. Lane
INST OF HEALTH POLICY, MANAGEMENT & EVALUATION
DALLA LANA SCHOOL OF PUBLIC HEALTH

Dear Dr. Wodchis and Ms. Natasha E. Lane,

Re: Your research protocol entitled, "Functional dependence and decline in Ontario long-term care residents"

ETHICS APPROVAL	**Original Approval Date: August 4, 2015** **Expiry Date: August 3, 2016** **Continuing Review Level: 1**

We are writing to advise you that the Health Sciences Research Ethics Board (REB) has granted approval to the above-named research protocol under the REB's delegated review process. Your protocol has been approved for a period of **one year** and ongoing research under this protocol must be renewed prior to the expiry date.

Any changes to the approved protocol or consent materials must be reviewed and approved through the amendment process prior to its implementation. Any adverse or unanticipated events in the research should be reported to the Office of Research Ethics as soon as possible.

Please ensure that you submit an Annual Renewal Form or a Study Completion Report 15 to 30 days prior to the expiry date of your current ethics approval. Note that annual renewals for studies cannot be accepted more than 30 days prior to the date of expiry.

If your research is funded by a third party, please contact the assigned Research Funding Officer in Research Services to ensure that your funds are released.

Best wishes for the successful completion of your research.

Yours sincerely,

PA Administrative Tracking

Event	Date
Receive from PI/FA	Jul-09-2015
Forward to PL	Jul-09-2015
Receive from PL	Jul-10-2015

Privacy Impact Assessment
ICES Project

About this Form: *This ICES Project PIA Form is used to request and document approval for the collection and use of ICES Data for ICES Projects. It is current and complete as of the date of Privacy approval below. Amendments, if any, must be documented and approved, and will be reflected in the ICES Projects Log. Failure to provide all required information will delay approval. Do not use this form to request permission to disclose ICES Data; contact the Privacy Office.*

A. PROJECT

Title	Functional Dependence in Ontario Long-Term Care Residents
TRIM	2016 0900 753 000

B. PROJECT SUMMARY & OBJECTIVES

Summary (Attach proposal and describe in 50 words or fewer)	Proposal attached Yes ☒	
	This study examines the long-term care home and resident characteristics associated with functional (activities of daily living) dependence and decline in residents of Ontario long-term care homes.	
Project Objectives (Use the "EPM" tick-box to highlight any objective that will evaluate or enable planning or management of the health system or health services in Ontario)	1. Assess the association between long-term care home and resident characteristics with functional dependence measured at one point in time.	EPM ☒
	2. Examine the proportion of variance in residents' functional (activities of daily living) dependence accounted for by resident characteristics versus long-term care home characteristics.	EPM ☒
	3. Determine which chronic conditions, geriatric syndromes and acute health events are most strongly associated with functional losses over time in long-term care residents.	EPM ☒
Anticipated public or scientific benefit (Maximum 50 words)	Outputs from Objectives 1 and 2 will guide long-term care home accountability policies in Ontario and abroad. Findings from Objective 2 will also inform future longitudinal studies of determinants of changes in functional dependence in long-term care residents over time. Outputs from Objective 3 will identify health impairments most strongly associated with functional decline and inform residents' care plan development to minimize functional losses.	
Contextual sensitivities or foreseeable harms (Potential to identify, stigmatize or harm any person or institution)	None identified ☒	Yes ☐ *(Identify and suggest mitigation below)*

Estimated Project completion date	August 30, 2017.	**Rapid Response** (Only available for Knowledge User requests that require approval in 1 - 3 business days. Research Practice is responsible for obtaining approvals.)	Yes ☐	No ☒

C. SPECIAL HANDLING *(Use this Section to declare any requirement to deviate from ICES policies and procedures or IT specifications in the collection or handling of data for the Project. An example would be a request to use a third party application for primary data collection. Any deviation is subject to a separate Privacy Impact Assessment and approval by ICES' Privacy Office.)*

D. AFFILIATION & RESPONSIBILITY

ICES research program	Cancer ☐	CV ☐	CDP ☐	HSPE ☒	KDT ☐	MHA ☐	PCPH ☐
ICES site	Central ☒	U Ottawa ☐	Queen's ☐	U of T ☐	Western ☐		
Principal Investigator	**Natasha E. Lane**						
PI type	Full Status ICES Scientist ☐		Probationary ICES Scientist ☐				
	ICES Collaborating Researcher ☐		ICES Student/Fellow/Post-Doctoral Trainee ☒				
Responsible ICES Scientist (Required if the PI is not a Full Status ICES	N/A ☐	**Dr. Walter P. Wodchis**					

Scientist)		

E. RESEARCH ETHICS BOARD REVIEW & APPROVALS *Use this Section to identify all Research Ethics Board applications and approvals associated with the Project and attachments. Attach copies of approvals and applications, including any accompanying protocols and applicable amendments. Failure to obtain or supply evidence of Research Ethics Board approvals, where required to authorize collection of new data or linking with ICES Data, will delay approval of the Project. ICES is not responsible for renewal of, or compliance with, Research Ethics Board approvals obtained by the Principal Investigator or other members of the Project Team.)*

Research Ethics Board name	Application	Approval	
1. University of Toronto Research Ethics Board	Attached ☒	Attached ☐	Pending ☒
2.	Attached ☐	Attached ☐	Pending ☐
3.	Attached ☐	Attached ☐	Pending ☐
4.	Attached ☐	Attached ☐	Pending ☐
5.	Attached ☐	Attached ☐	Pending ☐

F. ACKNOWLEDGEMENTS & APPROVALS *(This Section should be completed, in the order shown, after review of Sections A through E and Schedules 1 and 2. Completion of this Section must not be delegated. Names and dates must be recorded by the individuals identified, and will signify their confirmation or approval, as applicable. This Form is ready for review and approval only when accompanied by all attachments, including signed NDAs for any ICES Collaborating Researchers. Any scientific reservations must be resolved, and the Form updated, before forwarding to ICES' Privacy Office by the Program Administrator.)*

Principal Investigator Confirmation

Name	Natasha E. Lane	Date	6/19/2015

I request approval to conduct the Project as described on this Form and its Schedules. I warrant that all of the ICES Data identified Schedule 1, including any Project-Specific Data, is reasonably relevant and required to achieve the Project Objectives, and that these cannot be accomplished with other information. I acknowledge that conduct of the Project will be subject to ICES policies and procedures and the conditions identified on this Form and its Schedules, and ICES compliance monitoring.

Responsible ICES Scientist Confirmation *(Only applicable where the Principal Investigator is not a Full Status ICES Scientist.)*

Name	Walter Wodchis	Date	7/6/2015

I accept responsibility for overseeing conduct of the Project.

Program Approval *(Where the PI is a Program Leader, the Chief Science Officer approves)*

ICES Program Leader	Susan Bronskill	Date	9-Jul-2015

I have reviewed the contents of this Form and its Schedules. I confirm that I approve the Project, as described, and am satisfied the data in Schedule 1 is relevant and required to meet the Project Objectives.

Data Partnerships & Development Confirmation *(As applicable)*

Name		Date	

I have reviewed and confirm the completeness of any Requests to Collect Project-Specific Data in Schedule 1.

ICES Privacy Office Review & Approval

Privacy Reviewer	Don DeBoer	Date	July 21, 2015
Privacy Approver	Don DeBoer	Date	July 21, 2015

I have reviewed the contents of this Form and the confirmations and approvals in this Section, and approve conduct of the Project, subject to ICES policies and procedures and the terms and conditions identified on this Form.

Schedule 1: Application for Data

About this Schedule: *This Schedule is used to identify, and determine the availability of, data for the Project. Submission of this ICES Project PIA represents the Principal Investigator's scientific judgment the data listed is relevant and required to accomplish the Project Objectives. Requests to collect Project-Specific Data may include personal health information or other personally identifiable information only where the Project Objectives cannot be met with other information. Only data identified on this Schedule and approved on this ICES Project PIA may be collected, linked or used for the Project, subject to a more detailed Dataset Creation Plan, which must be established in consultation with ICES Research Practice. All data collected, linked, analyzed or otherwise handled or prepared by ICES will be considered ICES Data, subject to ICES' policies and procedures. This specifically includes ICES' policies and procedures governing levels of access and retention and destruction of ICES Data and protection against re-identification.*

A. REQUEST TO USE EXISTING ICES DATA

Two categories of ICES Data are generally available for ICES Projects. ICES General Use Data is available based on scientific need. ICES Controlled Use Data is subject to additional approvals or conditions. Both types of ICES Data are listed at the ICES Data Holding Obligations tab of the ICES Data Dictionary.

ICES General Use Data

ICES Data Holding	Rationale for use		Other rationale
Health Services			
☒ CCRS	Outcome or outcome definition	Predictor/cofactor/covariate	
☒ CIHI DAD	Exposure or exposure definition	Predictor/cofactor/covariate	
☐ CIHI SDS	See list	See list	
☐ CONTACT	See list	See list	
☐ CPRO	See list	See list	
☐ ERCLAIM	See list	See list	
☐ HCD	See list	See list	
☐ HCDMOH	See list	See list	
☒ NACRS	Predictor/cofactor/covariate	See list	
☐ NRS	See list	See list	
☐ ODB	See list	See list	
☐ OHCAS	See list	See list	
☐ CCRS	See list	See list	
☒ OHIP	Exposure or exposure definition	Predictor/cofactor/covariate	
☐ OMHRS	See list	See list	
☐ RAIHC	See list	See list	
☐ RAIHCMOH	See list	See list	
Care Providers			
☐ CPDB	See list	See list	
☐ IPDB	See list	See list	
Population	See list	See list	
☐ CENSUS	See list	See list	
☐ POP	See list	See list	
☒ RPDB	Predictor/cofactor/covariate	See list	
Coding/Geography			
☐ DIN	See list	See list	
☐ REF	See list	See list	
☐ LHIN	See list	See list	
☐ PCCF	See list	See list	
Facilities			
☐ INST	See list	See list	
ICES General Use Data (additional)			

ICES Data Holding	Rationale for use		Other rationale
See list	See list	See list	
See list	See list	See list	
See list	See list	See list	
See list	See list	See list	
See list	See list	See list	
See list	See list	See list	

ICES Controlled Use Data

ICES Data Holding	Rationale for use	Permission		ICES Privacy Office Use	
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:
See list	See list	Attached ☐	N/A ☐	Conditions satisfied ☐	Instructions:

Other Requests (Use this Section to make any request to negotiate permission to use ICES Data)

B. REQUEST FOR ICES TO COLLECT PROJECT-SPECIFIC DATA

All collection must be in accordance with ICES Collection of Personally IdentifiableInformation policy and procedures.

PROJECT-SPECIFIC DATA REQUEST 1 (Append supplementary request forms as needed)

Data name		
Data custodian(s)		
Technical contact(s) (where known)		
Estimated # records		
Collection method	Transfer to ICES ☐	ICES Primary Data Collection ☐
	For requests to scan What:	Applicable Yes ☐ No ☐ Why:
	Request for special handling?	Yes ☐ (Complete Section C on page 1) No ☐
Type	Clinical data ☐	Other personally identifiable information ☐
	Other information ☐	Biological materials ☐
Current use	Clinical/other primary use ☐	Research ☐

Statement of Purpose (Required content for Appendix A of the ICES data sharing agreement.)

Data Custodian

Purpose

Project Name		
Principal Investigator		
Information		
Data Set Name		
Why the Information is Necessary		
Data Timeframe		
Transfer Frequency	One-time ☐	Other:
Estimated Project End Date		
Variables	Collection Rationale	Other Collection Rationale

	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	
	See list	

Assessment & Instructions *(ICES Privacy Office Use Only)*				
Relevant authority	PHIPA ☐	Other statute:		Research ethics ☐
Specific authority	45(1) ☐	O. Reg 17 ☐	Other:	REB approval ☐
REB approval	Not required ☐	In place ☐	Action required:	
Special measures	Not applicable ☐	Describe: *(e.g. Biological materials)*		
DSA type	HIC ☐	Researcher ☐	Other authority ☐	Custom ☐
Recommendation	Approved ☐	Conditional approval ☐	Conditions:	

C. REQUEST TO LINK DATA IDENTIFIED IN SECTIONS A & B	
Yes ☒	No ☐

Schedule 2: Project Team

About this Schedule: *Use this Schedule to identify, and address questions related to, the Project Team. Only individuals listed in this Schedule may access and use ICES Data for the Project, subject to compliance with ICES' Privacy Awareness Requirements and ICES policies and procedures.*

A. CORE PROJECT TEAM

Role	Name(s)
Principal Investigator	Natasha E. Lane
Responsible ICES Scientist	Dr. Walter P. Wodchis
ICES Scientists	Dr. Therese A. Stukel
ICES Analytic Staff	Alice Newman
ICES Research Co-ordinator	
Other	

B. ICES COLLABORATING RESEARCHERS

Name	Affiliation	Relevant expertise	Email	Signed NDA
Dr. Cynthia M. Boyd	Johns Hopkins School of Public Health	Pacticing Geriatric Medicine physician	cyboyd@jhmi.edu	Attached ☒
				Attached ☐
				Attached ☐
				Attached ☐

ICES Collaborating Researchers are permitted to access and use Summary Data only, and must sign an ICES Collaborating Researcher NDA.

C. RISK OF RE-IDENTIFICATION

Access to ICES Data will be subject to an agreement not to attempt to use ICES Data to re-identify any individual. Failure to comply will result in suspension of access and potential termination of your relationship with ICES. Only Research Outputs and Reports with a signed-off Re-identification Risk Clearance may be published or shared outside the Project Team.

D. CONFLICT OF INTEREST

All ICES Employees and ICES Scientists have a duty to report conflicts of interest under, and are subject to, ICES' Conflict of Interest Policy.

Appendix 3.7: All Variable Coefficient Estimates from Models 1 and 2

	Unadjusted Bivariate Regressions Estimate (95% CI)	**Model 1**[§] Estimate (95% CI)	**Model 2**[‖] Estimate (95% CI)
Constant		4.07 (3.71, 4.44)[‡]	2.70 (2.18, 3.22)[‡]
Resident Characteristics			
Age			
65 – 74	Reference	Reference	Reference
75 – 84	0.76 (0.55, 0.98)[‡]	0.04 (-0.08, 0.17)	0.04 (-0.08, 0.16)
85 – 94	1.02 (0.81, 1.22)[‡]	0.18 (0.04, 0.31)[*]	0.18 (0.04, 0.31)[*]
95+	2.43 (2.16, 2.70)[‡]	0.61 (0.42, 0.80)[‡]	0.61 (0.42, 0.79)[‡]
Sex			
Female	Reference	Reference	Reference
Male	-1.03 (-1.16, -0.90)[‡]	-0.37 (-0.46, -0.28) [‡]	-0.36 (-0.46, -0.27)[‡]
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.92 (-1.06, -0.78)[‡]	-0.41 (-0.50, -0.31)[‡]	-0.41 (-0.50, -0.31)[‡]
Never married, separated or divorced	-2.21 (-2.40, -2.01)[‡]	-0.60 (-0.73, -0.48)[‡]	-0.60 (-0.73, -0.48)[‡]
Missing data on marital status	-1.23 (-1.73, -0.73)[‡]	-0.64 (-0.96, -0.32)[‡]	-0.64 (-0.97, -0.32)[‡]
Pre-LTCH Neighborhood Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.56 (0.37, 0.75)[‡]	0.13 (0.01, 0.26)[*]	0.12 (0.002, 0.25)[*]
3	0.52 (0.33, 0.71)[‡]	0.19 (0.07, 0.31)[†]	0.18 (0.06, 0.30)[†]
4	0.96 (0.76, 1.15)[‡]	0.29 (0.17, 0.41)[‡]	0.27 (0.15, 0.39)[‡]
5 (high)	0.95 (0.74, 1.15)[‡]	0.23 (0.10, 0.37)[†]	0.23 (0.09, 0.36)[†]
Missing data	1.54 (1.34, 1.75)[‡]	0.29 (0.14, 0.44)[‡]	0.28 (0.13, 0.43)[‡]
Days in LTCH Prior to Index Date		-	-
0 - 4 months	Reference	Reference	Reference

	Unadjusted Bivariate Regressions Estimate (95% CI)	**Model 1**[§] Estimate (95% CI)	**Model 2**[‖] Estimate (95% CI)
> 4 months - 12 months	-0.29 (-0.48, -0.11)[†]	-0.65 (-0.78, -0.52)[‡]	-0.65 (-0.78, -0.52)[‡]
> 1 year - 2 years	-0.01 (-0.19, 0.17)	-0.75 (-0.89, -0.62)[‡]	-0.76 (-0.89, -0.62)[‡]
> 2 years - 3 years	0.81 (0.59, 1.02)[‡]	-0.65 (-0.78, -0.51)[‡]	-0.65 (-0.78, -0.51)[‡]
> 3 years	2.66 (2.50, 2.82)[‡]	-0.31 (-0.44, -0.17)[‡]	-0.30 (-0.44, -0.17)[‡]
Prevalent Geriatric Syndromes			
Balance impairment	10.48 (10.34, 10.60)[‡]	5.69 (5.51, 5.87)[‡]	5.66 (5.48, 5.84)[‡]
Bowel incontinence	10.46 (10.37, 10.55)[‡]	4.53 (4.38, 4.68)[‡]	4.52 (4.37, 4.67)[‡]
Cognition			
Intact/borderline	Reference	Reference	Reference
Mild/moderate impairment	3.89 (3.76, 4.01)[‡]	1.67 (1.55, 1.79)[‡]	1.66 (1.54, 1.78)[‡]
Moderate-severe/severe impairment	11.73 (11.58, 11.87)[‡]	5.27 (5.10, 5.44)[‡]	5.26 (5.09, 5.43)[‡]
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	1.73 (1.55, 1.90)[‡]	0.03 (-0.08, 0.14)	0.03 (-0.08, 0.13)
Missing data	-0.56 (-1.80, 0.67)	0.66 (-0.15, 1.46)	0.67 (-0.11, 1.46)
Body mass index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-2.02 (-2.24, -1.80)[‡]	-0.54 (-0.68, -0.40)[‡]	-0.54 (-0.68, -0.40)[‡]
25 < BMI <30	-3.49 (-3.72, -3.26)[‡]	-0.87 (-1.03, -0.72)[‡]	-0.88 (-1.03, -0.72)[‡]
BMI ≥ 30	-3.74 (-3.98, -3.50)[‡]	-0.59 (-0.75, -0.43)[‡]	-0.60 (-0.76, -0.44)[‡]
Pain			
None	Reference	Reference	Reference
Less than daily pain	-0.70 (-0.85, -0.56)[‡]	0.29 (0.19, 0.39)[‡]	0.29 (0.19, 0.39)[‡]
Daily or severe daily pain	-0.12 (-0.29, 0.04)	0.82 (0.70, 0.94)[‡]	0.83 (0.70, 0.95)[‡]
Pressure ulcer	6.47 (6.23, 6.72)[‡]	2.67 (2.52, 2.82)[‡]	2.67 (2.52, 2.82)[‡]

	Unadjusted Bivariate Regressions Estimate (95% CI)	**Model 1**[§] Estimate (95% CI)	**Model 2**[‖] Estimate (95% CI)
Urinary incontinence	10.50 (10.40, 10.61)[‡]	4.19 (4.04, 4.35)[‡]	4.20 (4.04, 4.35)[‡]
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	3.09 (2.97, 3.22)[‡]	0.68 (0.59, 0.77)[‡]	0.68 (0.59, 0.76)[‡]
Severe impairment	7.62 (7.40, 7.84)[‡]	2.49 (2.33, 2.65)[‡]	2.49 (2.33, 2.65)[‡]
Prevalent Chronic Conditions			
Arthritis	-0.66 (-0.78, -0.54)[‡]	0.08 (-.0003, 0.15)	0.08 (0.0003, 0.15)[*]
Asthma	-0.71 (-0.94, -0.48)[‡]	0.10 (-0.04, 0.24)	0.10 (-0.04, 0.24)
Cancer	-1.23 (-1.36, -1.11)[‡]	-0.12 (-0.19, -0.04)[†]	-0.12 (-0.19, -0.04)[†]
Chronic kidney disease	0.06 (0.08, 0.20)[‡]	0.31 (0.22, 0.40)[‡]	0.31 (0.22, 0.40)[‡]
Coronary artery disease	-0.86 (-0.98, -0.74)[‡]	-0.13 (-0.21, -0.05)[†]	-0.13 (-0.21, -0.05)[†]
Chronic obstructive pulmonary disease	-1.39 (-1.54, -1.25)[‡]	-0.07 (-0.17, 0.02)	-0.07 (-0.17, 0.02)
Dementia	3.39 (3.22, 3.55)[‡]	-0.22 (-0.35, -0.10)[†]	-0.23 (-0.36, -0.11)[‡]
Diabetes	-0.09 (-0.21, 0.04)	-0.06 (-0.14, 0.02)	-0.06 (-0.14, 0.02)
Epilepsy	2.17 (1.94, 2.41)[‡]	0.47 (0.32, 0.61)[‡]	0.47 (0.33, 0.62)[‡]
Heart failure	-0.24 (-0.38, -0.11)[‡]	0.36 (0.27, 0.46)[‡]	0.36 (0.27, 0.45)[‡]
Limb paralysis or amputation	4.49 (4.29, 4.70)[‡]	1.78 (1.63, 1.93)[‡]	1.77 (1.62, 1.92)[‡]
Mood disorder	0.53 (0.41, 0.65)[‡]	0.30 (0.22, 0.38)[‡]	0.30 (0.22, 0.38)[‡]
Parkinson's disease	2.87 (2.66, 3.07)[‡]	1.75 (1.63, 1.87)[‡]	1.75 (1.63, 1.87)[‡]
Peripheral vascular disease	-0.14 (-0.34, 0.07)	0.03 (-0.10, 0.16)	0.03 (-0.10, 0.16)
Psychiatric conditions other than depression and dementia	-1.35 (-1.48, -1.22)[‡]	-0.42 (-0.50, -0.33)[‡]	-0.42 (-0.50, -0.33)[‡]
Stroke	1.85 (1.73, 1.98)[‡]	0.46 (0.38, 0.55)[‡]	0.46 (0.38, 0.55)[‡]
Fixed Long-Term Care Home Effects[¶]			
LTCH Size			
Small (≤64)	Reference	N/A	Reference
Medium (65 – 128)	0.10 (-0.38, 0.58)	N/A	-0.05 (-0.32, 0.21)

	Unadjusted Bivariate Regressions Estimate (95% CI)	**Model 1**[§] Estimate (95% CI)	**Model 2**[‖] Estimate (95% CI)
Large (129 – 192)	0.37 (-0.16, 0.89)	N/A	0.08 (-0.24, 0.40)
Extra-large (≥193)	0.79 (0.19, 1.39)	N/A	0.25 (-0.13, 0.63)
Ownership status			
Not-for-profit	Reference	N/A	Reference
For-profit	0.28 (-0.12, 0.68)	N/A	0.23 (0.006, 0.46)[*]
Missing data	-3.64 (-5.26, -2.02)[‡]	N/A	0.44 (-0.47, 1.35)
Location			
Rural	Reference	N/A	Reference
Sub-urban	0.28 (-0.25, 0.82)	N/A	0.14 (-0.22, 0.49)
Urban	1.47 (1.02, 1.92)[‡]	N/A	-0.12 (-0.41, 0.15)
Mean % residents received physio- or occupational therapy (Quartiles)			
Lowest quartile	Reference	N/A	Reference
2nd quartile	0.004 (-0.57, 0.57)	N/A	0.17 (-0.13, 0.47)
3rd quartile	0.78 (0.21, 1.35)[†]	N/A	0.14 (-0.17, 0.45)
Highest quartile	0.53 (-0.01, 1.07)	N/A	-0.05 (-0.35, 0.24)
Mean % residents restrained (Quartiles)			
Lowest quartile	Reference	N/A	Reference
2nd quartile	-0.32 (-0.89, 0.25)	N/A	0.007 (-0.30, 0.32)
3rd quartile	-0.19 (-0.79, 0.41)	N/A	-0.23 (-0.54, 0.07)
Highest quartile	0.50 (-0.06, 1.05)	N/A	-0.14 (-0.45, 0.16)
Median Resident ADL in each home (Quartiles)			
Lowest quartile	Reference	N/A	Reference
2nd quartile	1.87 (1.58, 2.17) [‡]	N/A	1.16 (0.87, 1.46) [‡]
3rd quartile	2.75 (2.45, 3.06) [‡]	N/A	1.62 (1.30, 1.94) [‡]
Highest quartile	4.76 (4.43, 5.10) [‡]	N/A	2.81 (2.50, 3.11) [‡]
Random Effects			
$\sqrt{\psi}$	-	1.58 (1.50, 1.68)	1.21 (1.13, 1.28)
$\sqrt{\theta}$	-	4.90 (4.84, 4.96)	4.90 (4.84, 4.96)

	Unadjusted Bivariate Regressions	Model 1[§]	Model 2[‖]
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Derived Estimates			
R^2	-	0.627	0.642
ρ	-	0.095	0.057

Reference: Variable category is the reference group for all other categories within that variable.
[*]p-value <0.05
[†]p-value <0.01
[‡]p-value <0.0001
[§]**Model 1:** Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes
[‖]**Model 2:** Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home, as well as the following long-term care home variables: size, ownership type, location, proportion of residents who recently received physiotherapy or occupation therapy, proportion of residents restrained, and median resident disability. Also a random intercept for long-term care homes.
[¶]LTCH coefficient estimates have standard errors adjusted for clustering of residents within long-term care homes.

$\sqrt{\psi}$: Square root of between-long-term care home variance
$\sqrt{\theta}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
R^2: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$
N/A: Not applicable because variable not included in model.

Appendix 3.8: Model 1 Excluding Chronic Conditions, Geriatric Syndromes

Variables	Model 1	Model 1 excluding chronic conditions	Model 1 excluding geriatric syndromes	Model 1, with only adjustment variables and select geriatric syndromes
Resident Characteristics				
Age				
65 – 74	Reference	Reference	Reference	
75 – 84	0.04 (-0.08, 0.17)	-0.08 (-0.21, 0.04)	0.60 (0.39, 0.82)‡	N/A
85 – 94	0.18 (0.04, 0.31)*	-0.10 (-0.24, 0.03)	1.16 (0.93, 1.39)‡	N/A
95+	0.61 (0.42, 0.80)‡	0.20 (0.02, 0.39)*	2.61 (2.31, 2.91)‡	N/A
Sex				
Female	Reference	Reference	Reference	
Male	-0.37 (-0.46, -0.28) ‡	-0.18 (-0.27, -0.09)‡	-1.38 (-1.53, -1.24)‡	N/A
Marital Status				
Married	Reference	Reference	Reference	
Widowed	-0.41 (-0.50, -0.31)‡	-0.47 (-0.56, -0.37)‡	-1.58 (-1.74, -1.43)‡	N/A
Never married, separated or divorced	-0.60 (-0.73, -0.48)‡	-0.75 (-0.87, -0.62)‡	-2.22 (-2.42, -2.02)‡	N/A
Missing data on marital status	-0.64 (-0.96, -0.32)‡	-0.76 (-1.10, -0.43)‡	-1.45 (-1.94, -0.96)‡	N/A
Pre-LTCH Neighborhood Income Quintile				
1 (low)	Reference	Reference	Reference	
2	0.13 (0.01, 0.26)*	0.16 (0.03, 0.28)*	0.29 (0.10, 0.48)†	N/A
3	0.19 (0.07, 0.31)†	0.22 (0.10, 0.34)‡	0.37 (0.17, 0.57)‡	N/A
4	0.29 (0.17, 0.41)‡	0.32 (0.19, 0.44)‡	0.61 (0.41, 0.80)‡	N/A
5 (high)	0.23 (0.10, 0.37)†	0.27 (0.13, 0.41)‡	0.59 (0.39, 0.79)‡	N/A
Missing data	0.29 (0.14, 0.44)‡	0.34 (0.18, 0.49)‡	1.07 (0.81, 1.32)‡	N/A
Days in LTC Prior to Index Date	-			
0 - 4 months	Reference	Reference	Reference	
> 4 months - 12 months	-0.65 (-0.78, -0.52)‡	-0.62 (-0.75, -0.48)‡	-0.48 (-0.66, -0.30)‡	N/A
> 1 year - 2 years	-0.75 (-0.89, -0.62)‡	0.73 (-0.87, -0.60)‡	-0.38 (-0.58, -0.17)‡	N/A
> 2 years - 3 years	-0.65 (-0.78, -0.51)‡	-0.64 (-0.78, -0.50)‡	0.32 (0.08, 0.57)‡	N/A
> 3 years	-0.31 (-0.44, -0.17)‡	-0.28 (-0.41, -0.14)‡	2.10 (1.88, 2.33)*	N/A
Prevalent Geriatric Syndromes				
Balance impairment	5.69 (5.51, 5.87)‡	6.04 (5.86, 6.22)‡	N/A	6.38 (6.19, 6.56) ‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.61 (4.46, 4.77)‡	N/A	4.91 (4.75, 5.07)‡
Cognition				
Intact/borderline	Reference	Reference		

Variables	Model 1	Model 1 excluding chronic conditions	Model 1 excluding geriatric syndromes	Model 1, with only adjustment variables and select geriatric syndromes
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.51 (1.39, 1.63)‡	N/A	1.46 (1.34, 1.59)‡
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	4.97 (4.80, 5.13)‡	N/A	5.27 (5.11, 5.44)‡
Hearing impairment				
None	Reference	Reference		
Hearing impaired	0.03 (-0.08, 0.14)	-0.01 (-0.12, 0.10)	N/A	N/A
Missing data	0.66 (-0.15, 1.46)	0.62 (-0.18, 1.42)	N/A	N/A
Body mass index (BMI)				
BMI < 18.5	Reference	Reference		
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.53 (-0.67, -0.39)‡	N/A	N/A
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.86 (-1.01, -0.70)‡	N/A	N/A
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.56 (-0.72, -0.41)‡	N/A	N/A
Pain				
None	Reference	Reference		
Less than daily pain	0.29 (0.19, 0.39)‡	0.35 (0.25, 0.45)‡	N/A	N/A
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.86 (0.74, 0.98)‡	N/A	N/A
Pressure ulcer	2.67 (2.52, 2.82)‡	2.79 (2.64, 2.94)‡	N/A	N/A
Urinary incontinence	4.19 (4.04, 4.35)‡	4.32 (4.16, 4.48)‡	N/A	4.26 (4.09, 4.42)‡
Visual impairment				
None	Reference	Reference		
Moderate impairment	0.68 (0.59, 0.77)‡	0.72 (0.63, 0.81)‡	N/A	N/A
Severe impairment	2.49 (2.33, 2.65)‡	2.47 (2.31, 2.63)‡	N/A	N/A
Prevalent Chronic Conditions				
Arthritis	0.08 (-.0003, 0.15)	N/A	-0.26 (-0.37, -0.14)‡	N/A
Asthma	0.10 (-0.04, 0.24)	N/A	-0.16 (-0.38, 0.06)	N/A
Cancer	-0.12 (-0.19, -0.04)†	N/A	-0.80 (-0.92, -0.68)‡	N/A
Chronic kidney disease	0 .31 (0.22, 0.40)‡	N/A	0.52 (0.39, 0.65)‡	N/A
Coronary artery disease	-0.13 (-0.21, -0.05)†	N/A	-0.61 (-0.74, -0.48)‡	N/A
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	N/A	-0.61 (-0.76, -0.45)‡	N/A
Dementia	-0.22 (-0.35, -0.10)†	N/A	3.29 (3.07, 3.50)‡	N/A
Diabetes	-0.06 (-0.14, 0.02)	N/A	-0.03 (-0.15, 0.10)	N/A
Epilepsy	0.47 (0.32, 0.61)‡	N/A	1.71 (1.48, 1.94)‡	N/A
Heart failure	0.36 (0.27, 0.46)‡	N/A	0.45 (0.32, 0.58)‡	N/A
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	N/A	4.02 (3.79, 4.24)‡	N/A
Mood disorder	0.30 (0.22, 0.38)‡	N/A	0.38 (0.26, 0.51)‡	N/A
Parkinson's disease	1.75 (1.63, 1.87)‡	N/A	3.11 (2.94, 3.29)‡	N/A
Peripheral vascular disease	0.03 (-0.10, 0.16)	N/A	0.09 (-0.11, 0.29)	N/A

Variables	Model 1	Model 1 excluding chronic conditions	Model 1 excluding geriatric syndromes	Model 1, with only adjustment variables and select geriatric syndromes
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	N/A	-1.09 (-1.23, -0.95)‡	N/A
Stroke	0.46 (0.38, 0.55)‡	N/A	1.21 (1.07, 1.34)‡	N/A
Random Effects				
√ψ	1.58	1.62	1.85	1.61
√θ	4.90	4.97	7.73	5.09
Derived Estimates				
R^2	0.627	0.616	0.112	0.599
ρ	0.095	0.096	0.054	0.091

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes
Reference: Variable category is the reference group for all other categories within that variable.
*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi}$: Square root of between-long-term care home variance
$\sqrt{\theta}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
R^2: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$
N/A: Not applicable because variable not included in model.

Appendix 3.9: All Variable Coefficient Estimates from Stratified Versions of Model 1

Table 3.9 (below) shows that while the significance of coefficients predictably varies across models due to smaller sample sizes among strata, the magnitude of geriatric syndrome and chronic condition effects on disability is fairly consistent.

Effects of geriatric syndromes and chronic conditions did not differ at all between females or males, residents aged 75 to 94 and the whole sample

Statistically significant differences in effect sizes of the following variables were noted across strata:

Age 65 – 74 stratum

- Mild to moderate cognitive impairment has smaller effect on disability (1.14, 95% CI: 0.85, 1.43) than in whole sample (1.67, 95% CI: 1.55, 1.79)
- Moderate severe to severe cognitive impairment has smaller effect on disability (4.21, 95% CI: 3.81, 4.61) than in whole sample (5.27, 95% CI: 5.10, 5.21, 5.59)

Age 95 – 105 stratum

- Diabetes has larger effect on disability (0.32, 95% CI: 0.04, 0.60) than in whole sample (-0.06, 95% CI: -0.14, 0.02)
- Bowel incontinence has a smaller effect on disability (3.98, 95% CI: 3.65, 4.32) than in whole sample (4.53, 95% CI: 4.38, 4.68)

No Cognitive Impairment

- Limb paralysis or amputation has a larger effect on disability (2.54, 95% CI: 2.24, 2.83) than in whole sample (1.78, 95% CI: 1.63, 1.93)
- Parkinson's disease has a larger effect on disability (2.18, 95% CI: 1.89, 2.47) than in whole sample (1.75, 95% CI: 1.63, 1.87)
- Pressure ulcer has a larger effect on disability (3.34, 95% CI: 2.98, 3.71) than in whole sample (2.67, 95% CI: 2.52, 2.82)

Cognitive Impairment

- Negative association dementia has with disability in whole sample (-0.22, -0.35, -0.10) is reversed in cognitively impaired individuals (0.23, 0.06, 0.40)
- Limb paralysis or amputation has smaller effect on disability (1.44, 95% CI: 1.27, 1.60) than in whole sample (1.78, 95% CI: 1.63, 1.93)

- Bowel incontinence has a larger effect on disability (5.43, 95% CI: 5.26, 5.60) than in whole sample (4.53, 95% CI: 4.38, 4.68)
- Moderate visual impairment has a larger effect on disability (0.99, 95% CI: 0.88, 1.09) than in whole sample (0.68, 95% CI: 0.59, 0.77)
- Severe visual impairment has a larger effect on disability (3.50, 95% CI: 3.32, 3.67) than in whole sample (2.49, 95% CI: 2.33, 2.65)

Table 3.9: All Variable Coefficient Estimates from Stratified Versions of Model 1

	Model 1	**Sex Stratified Models**		**Age Stratified Models**				**Cognitive Impairment-Stratified Models**	
		Females (n=54,953)	**Males (n=22,212)**	**Age 65-74 (n=7,859)**	**Age 75-84 (n=25,703)**	**Age 85-94 (n=36,676)**	**Age 95-105 (n=6,927)**	**No cognitive impairment (n=18,426)**	**Cognitive impairment present (n = 58,739)**
Age									
65 – 74	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
75 – 84	0.04 (-0.08, 0.17)	0.08 (-0.009, 0.25)	-0.04 (-0.25, 0.16)	N/A	N/A	N/A	N/A	-0.15 (-0.40, 0.10)	0.04 (-0.12, 0.20)
85 – 94	0.18 (0.04, 0.31)*	0.23 (0.05, 0.41)*	0.04 (-0.18, 0.26)	N/A	N/A	N/A	N/A	-0.10 (-0.39, 0.18)	-0.01 (-0.18, 0.16)
95+	0.61 (0.42, 0.80)‡	0.69 (0.46, 0.91)‡	0.36 (-0.02, 0.74)	N/A	N/A	N/A	N/A	0.62 (0.21, 1.02)†	0.16 (-0.06, 0.38)
Sex									
Female	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Male	-0.37 (-0.46, -0.28) ‡	N/A	N/A	-0.50 (-0.75, -0.26)‡	-0.40 (-0.54, -0.26)‡	-0.28 (-0.43, -0.13)‡	-0.44 (-0.79, -0.09)*	-0.29 (-0.48, -0.10)†	-0.47 (-0.58, -0.36)‡
Marital Status									
Married	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Widowed	-0.41 (-0.50, -0.31)‡	-0.45 (-0.57, -0.34)‡	-0.28 (-0.44, -0.12)†	-0.61 (-0.93, -0.28)‡	-0.46 (-0.61, -0.31)‡	-0.25 (-0.40, -0.11)†	-0.26 (-0.77, 0.24)	-0.23 (-0.43, -0.02)*	-0.71 (-0.82, -0.60)‡
Never married, separated or divorced	-0.60 (-0.73, -0.48)‡	-0.59 (-0.76, -0.43)‡	-0.60 (-0.79, -0.41)‡	-0.81 (-1.09, -0.52)‡	-0.75 (-0.95, -0.55)‡	-0.30 (-0.51, -0.08)†	-0.15 (-0.80, 0.50)	-0.33 (-0.59, -0.07)*	-1.09 (-1.23, -0.94)‡
Missing data on marital status	-0.64 (-0.96, -0.32)‡	-0.63 (-1.06, -0.20)†	-0.64 (-1.13, -0.15)*	-0.82 (-1.70, 0.06)	-0.72 (-1.30, -0.13)*	-0.47 (-1.01, 0.06)	-0.67 (-1.84, 0.51)	-0.08 (-0.85, 0.68)	-0.97 (-1.36, -0.57)‡
Pre-LTCH Neighborhood Income Quintile									
1 (low)	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
2	0.13 (0.01, 0.26)*	0.13 (-0.01, 0.28)	0.16 (-0.06, 0.38)	0.15 (-0.20, 0.51)	-0.01 (-0.21, 0.19)	0.24 (0.08, 0.41)†	0.18 (-0.19, 0.56)	0.14 (-0.13, 0.41)	0.15 (0.006, 0.29)*
3	0.19 (0.07, 0.31)†	0.21 (0.07, 0.35)†	0.12 (-0.08, 0.31)	0.08 (-0.26, 0.42)	0.08 (-0.13, 0.29)	0.27 (0.11, 0.43)†	0.17 (-0.20, 0.54)	0.17 (-0.11, 0.45)	0.19 (0.05, 0.32)†
4	0.29 (0.17, 0.41)‡	0.32 (0.17, 0.47)‡	0.23 (0.03, 0.44)*	0.36 (-0.03, 0.76)	0.20 (-0.007, 0.40)	0.36 (0.19, 0.54)‡	0.27 (-0.12, 0.66)	0.34 (0.06, 0.61)*	0.30 (0.16, 0.44)‡
5 (high)	0.23	0.27	0.18	0.34	0.25	0.24	0.05	0.14	0.32

	Model 1	Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
		Females (n=54,953)	Males (n=22,212)	Age 65-74 (n=7,859)	Age 75-84 (n=25,703)	Age 85-94 (n=36,676)	Age 95-105 (n=6,927)	No cognitive impairment (n=18,426)	Cognitive impairment present (n = 58,739)
	(0.10, 0.37)†	(0.11, 0.42)†	(-0.05, 0.40)	(-0.07, 0.76)	(0.03, 0.46)*	(0.05, 0.43)†	(-0.35, 0.46)	(-0.16, 0.45)	(0.17, 0.47)‡
Missing data	0.29 (0.14, 0.44)‡	0.27 (0.09, 0.45)†	0.40 (0.15, 0.65)†	0.009 (-0.43, 0.45)	0.17 (-0.05, 0.40)	0.46 (0.25, 0.67)‡	0.21 (-0.22, 0.64)	-0.07 (-0.40, 0.27)	0.44 (0.27, 0.61)‡
Days in LTC Prior to Index Date									
0 - 4 months	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
> 4 months - 12 months	-0.65 (-0.78, -0.52)‡	-0.64 (-0.79, -0.48)‡	-0.66 (-0.86, -0.45)‡	-0.36 (-0.70, -0.02)*	-0.61 (-0.81, -0.41)‡	-0.70 (-0.86, -0.53)‡	-0.91 (-1.35, -0.48)‡	-1.17 (-1.42, -0.93)‡	-0.44 (-0.58, -0.29)‡
> 1 year - 2 years	-0.75 (-0.89, -0.62)‡	-0.77 (-0.93, -0.61)‡	-0.68 (-0.89, -0.48)‡	-0.30 (-0.67, 0.06)	-0.64 (-0.86, -0.43)‡	-0.86 (-1.04, -0.69)‡	-1.10 (-1.53, -0.68)‡	-1.59 (-1.85, -1.32)‡	-0.36 (-0.51, -0.21)‡
> 2 years - 3 years	-0.65 (-0.78, -0.51)‡	-0.63 (-0.80, -0.46)‡	-0.63 (-0.88, -0.38)‡	-0.41 (-0.85, 0.02)	-0.42 (-0.65, -0.19)‡	-0.83 (-1.02, -0.64)‡	-0.61 (-1.06, -0.17)†	-1.76 (-2.05, -1.47)‡	-0.09 (-0.25, 0.07)
> 3 years	-0.31 (-0.44, -0.17)‡	-0.21 (-0.36, -0.05)‡	-0.61 (-0.81, -0.41)‡	-0.40 (-0.75, -0.05)*	-0.15 (-0.36, 0.06)	-0.37 (-0.53, -0.21)‡	-0.56 (-0.92, -0.20)†	-1.96 (-2.20, -1.71)‡	0.64 (0.48, 0.79)‡
Prevalent Geriatric Syndromes									
Balance impairment	5.69 (5.51, 5.87)‡	5.73 (5.52, 5.93)‡	5.51 (5.28, 5.74)‡	5.94 (5.57, 6.31)‡	5.71 (5.49, 5.93)‡	5.46 (5.25, 5.68)‡	5.42 (5.00, 5.85)‡	5.55 (5.31, 5.80)‡	5.95 (5.75, 6.16)‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.43 (4.26, 4.60)‡	4.77 (4.57, 4.97)‡	5.00 (4.66, 5.33)‡	4.61 (4.41, 4.82)‡	4.46 (4.28, 4.65)‡	3.98 (3.65, 4.32)‡	4.60 (4.35, 4.86)‡	5.43 (5.26, 5.60)‡
Cognition									
Intact/borderline	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.69 (1.55, 1.83)‡	1.67 (1.46, 1.88)‡	1.14 (0.85, 1.43)‡	1.51 (1.31, 1.70)‡	1.88 (1.71, 2.04)‡	1.86 (1.50, 2.22)‡	N/A	N/A
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	5.40 (5.21, 5.59)‡	4.94 (4.67, 5.21)‡	4.21 (3.81, 4.61)‡	5.16 (4.91, 5.41)‡	5.57 (5.34, 5.79)‡	5.35 (4.88, 5.81)‡	N/A	N/A
Hearing impairment									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.14)	0.02 (-0.12 0.15)	0.07 (-0.12, 0.26)	-0.13 (-0.71, 0.45)	-0.04 (-0.26, 0.18)	-0.04 (-0.18, 0.11)	0.26 (0.002, 0.51)*	0.43 (0.14, 0.72)†	0.08 (-0.04, 0.20)

	Model 1	Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
		Females (n=54,953)	**Males (n=22,212)**	**Age 65-74 (n=7,859)**	**Age 75-84 (n=25,703)**	**Age 85-94 (n=36,676)**	**Age 95-105 (n=6,927)**	**No cognitive impairment (n=18,426)**	**Cognitive impairment present (n = 58,739)**
Missing data	0.66 (-0.15, 1.46)	0.33 (-0.67, 1.34)	1.21 (-0.09, 2.52)	1.85 (-0.79, 4.49)	0.005 (-1.21, 1.22)	1.18 (-0.21, 2.57)	0.007 (-3.06, 3.08)	0.32 (-1.27, 1.90)	0.74 (-0.16, 1.64)
Body mass index (BMI)									
BMI < 18.5	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.56 (-0.71, -0.41)‡	-0.52 (-0.84, -0.21)†	-0.03 (-0.57, 0.52)	-0.46 (-0.72, -0.19)†	-0.67 (-0.86, -0.49)‡	-0.55 (-0.89, -0.20)†	-0.80 (-1.16, -0.43)‡	-0.51 (-0.66, -0.36)‡
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.83 (-0.99, -0.66)‡	-1.04 (-1.36, -0.71)‡	-0.69 (-1.24, -0.14)*	-0.82 (-1.09, -0.54)‡	-0.96 (-1.17, -0.76)‡	-0.83 (-1.23, -0.44)‡	-1.04 (-1.42, -0.67)‡	-0.97 (-1.14, -0.80)‡
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.52 (-0.69, -0.34)‡	-0.89 (-1.24, -0.53)‡	-0.68 (-1.23, -0.12)*	-0.55 (-0.84, -0.26)‡	-0.62 (-0.84, -0.41)‡	-0.31 (-0.80, 0.18)	-0.50 (-0.89,-0.10)†	-0.98 (-1.16, -0.81)‡
Pain									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)‡	0.25 (0.13, 0.36)‡	0.39 (0.22, 0.57)‡	0.26 (-0.03, 0.54)	0.18 (0.03, 0.34)*	0.34 (0.20, 0.48)‡	0.19 (-0.09, 0.48)	0.50 (0.30, 0.69)‡	-0.007 (-0.12, 0.11)
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.78 (0.64, 0.92)‡	0.90 (0.68, 1.13)‡	0.70 (0.35, 1.05)‡	0.76 (0.57, 0.95)‡	0.86 (0.69, 1.02)‡	0.67 (0.28, 1.05)†	0.81 (0.59, 1.04)‡	0.62 (0.47, 0.76)‡
Pressure ulcer	2.67 (2.52, 2.82)‡	2.70 (2.52, 2.87)‡	2.59 (2.32, 2.86)‡	3.03 (2.57, 3.48)‡	2.70 (2.45, 2.95)‡	2.63 (2.42, 2.84)‡	2.39 (1.98, 2.81)‡	3.34 (2.98, 3.71)‡	2.78 (2.62, 2.94)‡
Urinary incontinence	4.19 (4.04, 4.35)‡	4.30 (4.12, 4.49)‡	3.97 (3.76, 4.19)‡	4.00 (3.66, 4.34)‡	4.19 (3.98, 4.40)‡	4.28 (4.08, 4.49)‡	4.06 (3.66, 4.45)‡	4.48 (4.25, 4.71)‡	4.28 (4.10, 4.46)‡
Visual impairment									
None	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Moderate impairment	0.68 (0.59, 0.77)‡	0.68 (0.57, 0.78)‡	0.70 (0.55, 0.85)‡	0.73 (0.48, 0.98)‡	0.64 (0.50, 0.79)‡	0.67 (0.55, 0.79)‡	0.80 (0.53, 1.07)‡	0.53 (0.33, 0.73)‡	0.99 (0.88, 1.09)‡
Severe impairment	2.49 (2.33, 2.65)‡	2.45 (2.27, 2.63)‡	2.58 (2.30, 2.86)‡	2.82 (2.38, 3.26)‡	2.72 (2.45, 3.00)‡	2.39 (2.18, 2.60)‡	2.21 (1.83, 2.59)‡	1.98 (1.49, 2.48)‡	3.50 (3.32, 3.67)‡
Prevalent Chronic Conditions									
Arthritis	0.08 (-.0003, 0.15)	0.09 (-0.007, 0.18)	0.04 (-0.09, 0.16)	-0.16 (-0.40, 0.08)	0.10 (-0.03, 0.23)	0.12 (0.006, 0.23)*	0.13 (-0.11, 0.38)	0.13 (-0.05, 0.32)	-0.10 (-0.18, -0.008)*
Asthma	0.10 (-0.04, 0.24)	0.09 (-0.06, 0.24)	0.17 (-0.11, 0.45)	0.03 (-0.42, 0.48)	0.10 (-0.14, 0.34)	0.20 (-0.001, 0.40)	-0.11 (-0.62, 0.39)	0.07 (-0.22, 0.35)	0.08 (-0.07, 0.24)

	Model 1	Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
		Females (n=54,953)	**Males (n=22,212)**	**Age 65-74 (n=7,859)**	**Age 75-84 (n=25,703)**	**Age 85-94 (n=36,676)**	**Age 95-105 (n=6,927)**	**No cognitive impairment (n=18,426)**	**Cognitive impairment present (n = 58,739)**
Cancer	-0.12 (-0.19, -0.04)†	-0.15 (-0.25, -0.06)†	-0.06 (-0.20, 0.06)	-0.09 (-0.36, 0.18)	-0.16 (-0.29, -0.03)*	-0.08 (-0.20, 0.02)	-0.17 (-0.43, 0.08)	-0.20 (-0.38, -0.03)*	-0.21 (-0.30, -0.12)‡
Chronic kidney disease	0 31 (0.22, 0.40)‡	0.26 (0.15, 0.37)‡	0.40 (0.24, 0.55)‡	0.39 (0.09, 0.68)*	0.32 (0.17, 0.48)‡	0.31 (0.18, 0.44)‡	0.32 (0.02, 0.62)*	0.22 (0.03, 0.41)*	0.26, (0.15, 0.36)‡
Coronary artery disease	-0.13 (-0.21, -0.05)†	-0.11 (-0.20, -0.02)*	-0.18 (-0.32, -0.04)*	-0.29 (-0.56, -0.02)*	-0.04 (-0.17, 0.10)	-0.15 (-0.26, -0.04)*	-0.19 (-0.44, 0.05)	-0.25 (-0.43, -0.08)†	-0.17 (-0.26, -0.07)‡
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	-0.09 (-0.21, 0.02)	-0.04 (-0.20, 0.12)	-0.09 (-0.38, 0.21)	-0.30 (-0.47, -0.14)‡	0.08 (-0.05, 0.21)	0.11 (-0.21, 0.44)	-0.16 (-0.35, 0.03)	-0.23 (-0.34, -0.12)‡
Dementia	-0.22 (-0.35, -0.10)†	-0.32 (-0.47, -0.17)‡	0.02 (-0.20, 0.23)	-0.41 (-0.72, -0.10)*	-0.39 (-0.61, -0.17)‡	-0.10 (-0.29, 0.08)	0.21 (-0.16, 0.59)	-0.25 (-0.43, -0.06)†	0.23 (0.06, 0.40)†
Diabetes	-0.06 (-0.14, 0.02)	-0.03 (-0.13, 0.07)	-0.12 (-0.25, 0.01)	-0.24 (-0.49, 0.009)	-0.10 (-0.23, 0.03)	-0.004 (-0.12, 0.12)	0.32 (0.04, 0.60)*	-0.34 (-0.52, -0.16)‡	-0.12 (-0.21, -0.03)*
Epilepsy	0.47 (0.32, 0.61)‡	0.61 (0.44, 0.78)‡	0.20 (-0.03, 0.44)	0.47 (0.16, 0.77)†	0.36 (0.14, 0.58)†	0.60 (0.37, 0.84)‡	-0.05 (-0.77, 0.67)	0.13 (-0.23, 0.49)	0.62 (0.46, 0.79)‡
Heart failure	0.36 (0.27, 0.46)‡	0.36 (0.25, 0.47)‡	0.37 (0.20, 0.53)‡	0.31 (-0.009, 0.63)	0.41 (0.24, 0.58)‡	0.35 (0.22, 0.48)‡	0.34 (0.06, 0.61)*	0.47 (0.29, 0.65)‡	0.20 (0.09, 0.31)‡
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	1.81 (1.63, 2.00)‡	1.79 (1.55, 2.02)‡	1.59 (1.27, 1.91)‡	1.93 (1.70, 2.17)‡	1.77 (1.55, 1.99)‡	1.57 (1.11, 2.04)‡	2.54 (2.24, 2.83)‡	1.44 (1.27, 1.60)‡
Mood disorder	0.30 (0.22, 0.38)‡	0.32 (0.23, 0.42)‡	0.26 (0.12, 0.41)‡	-0.10 (-0.33, 0.14)	0.20 (0.08, 0.33)†	0.44 (0.33, 0.55)‡	0.38 (0.12, 0.64)†	0.42 (0.23, 0.60)‡	0.15 (0.06, 0.24)†
Parkinson's disease	1.75 (1.63, 1.87)‡	1.79 (1.63, 1.95)‡	1.72 (1.53, 1.91)‡	1.61 (1.25, 1.97)‡	1.87 (1.69, 2.06)‡	1.66 (1.46, 1.86)‡	1.66 (1.09, 2.23)‡	2.18 (1.89, 2.47)‡	1.54 (1.41, 1.67)‡
Peripheral vascular disease	0.03 (-0.10, 0.16)	0.11 (-0.05, 0.27)	-0.10 (-0.31, 0.11)	-0.24 (-0.65, 0.17)	0.01 (-0.21, 0.23)	0.13 (-0.06, 0.31)	0.001 (-0.44, 0.45)	-0.18 (-0.43, 0.06)	-0.03 (-0.18, 0.13)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	-0.39 (-0.49, -0.29)‡	-0.46 (-0.62, -0.31)‡	-0.61 (-0.84, -0.39)‡	-0.38 (-0.52, -0.24)‡	-0.35 (-0.48, -0.23)‡	-0.20 (-0.49, 0.09)	-0.65 (-0.83, -0.46)‡	-0.39 (-0.48, -0.30)‡
Stroke	0.46	0.48	0.45	0.39	0.48	0.45	0.56	0.68	0.35

Model 1	Sex Stratified Models		Age Stratified Models				Cognitive Impairment-Stratified Models	
	Females (n=54,953)	**Males (n=22,212)**	**Age 65-74 (n=7,859)**	**Age 75-84 (n=25,703)**	**Age 85-94 (n=36,676)**	**Age 95-105 (n=6,927)**	**No cognitive impairment (n=18,426)**	**Cognitive impairment present (n = 58,739)**
(0.38, 0.55)‡	(0.37, 0.58)‡	(0.29, 0.60)‡	(0.13, 0.66)†	(0.34, 0.63)‡	(0.32, 0.58)‡	(0.28, 0.83)‡	(0.49, 0.86)‡	(0.25, 0.44)‡

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes

Reference: Variable category is the reference group for all other categories within that variable.

*p-value <0.05

†p-value <0.01

‡p-value <0.0001

N/A – Not applicable; variable not included in indicated model.

Appendix 3.10: Sensitivity of Model 1 Findings to Unmeasured LTCH Variables and Lack of adjustment for Long-Term Care Homes

Variables	Model 1	Model 1 with fixed effect for LTCHs	Model 1 with no Random Effects for LTCHs
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Resident Characteristics			
Age			
65 – 74	Reference	Reference	Reference
75 – 84	0.04 (-0.08, 0.17)	0.04 (-0.09, 0.17)	0.12 (-0.01, 0.25)
85 – 94	0.18 (0.04, 0.31)*	0.17 (0.04, 0.31)*	0.27 (0.12, 0.42)‡
95+	0.61 (0.42, 0.80)‡	0.60 (0.42, 0.78)‡	0.76 (0.55, 0.97)‡
Sex			
Female	Reference	Reference	Reference
Male	-0.37 (-0.46, -0.28)‡	-0.36 (-0.45, -0.28)‡	-0.40 (-0.50, -0.30)‡
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.41 (-0.50, -0.31)‡	-0.41 (-0.50, -0.31)‡	-0.38 (-0.49, -0.27)‡
Never married, separated or divorced	-0.60 (-0.73, -0.48)‡	-0.61 (-0.73, -0.49)‡	-0.55 (-0.70, -0.41)‡
Missing data on marital status	-0.64 (-0.96, -0.32)‡	-0.64 (-0.96, -0.32)‡	-0.64 (-1.08, -0.19)†
Pre-LTCH Neighborhood Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.13 (0.01, 0.26)*	0.13 (0.02, 0.25)*	0.14 (-0.02, 0.30)
3	0.19 (0.07, 0.31)†	0.20 (0.08, 0.31)†	0.10 (-0.07, 0.28)
4	0.29 (0.17, 0.41)‡	0.28 (0.16, 0.40)‡	0.30 (0.13, 0.48)†
5 (high)	0.23 (0.10, 0.37)†	0.23 (0.11, 0.35)‡	0.25 (0.05, 0.45)*
Missing data	0.29 (0.14, 0.44)‡	0.29 (0.14, 0.43)‡	0.23 (-0.02, 0.48)
Days in LTC Prior to Index Date	-		
0 - 4 months	Reference	Reference	Reference
> 4 months - 12 months	-0.65 (-0.78, -0.52)‡	-0.65 (-0.76, -0.54)‡	-0.65 (-0.80, -0.49)‡
> 1 year - 2 years	-0.75 (-0.89, -0.62)‡	-0.75 (-0.86, -0.64)‡	-0.71 (-0.87, -0.54)‡
> 2 years - 3 years	-0.65 (-0.78, -0.51)‡	-0.65 (-0.78, -0.52)‡	-0.61 (-0.78, -0.44)‡
> 3 years	-0.31 (-0.44, -0.17)‡	-0.31 (-0.41, -0.20)‡	-0.29 (-0.46, -0.13)‡
Prevalent Geriatric Syndromes			
Balance impairment	5.69 (5.51, 5.87)‡	5.72 (5.62, 5.81)‡	5.35 (5.12, 5.59)‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.52 (4.43, 4.61)‡	4.61 (4.43, 4.78)‡
Cognition			
Intact/borderline	Reference	Reference	Reference
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.67 (1.57, 1.77)‡	1.68 (1.53, 1.83)‡

Variables	Model 1	Model 1 with fixed effect for LTCHs	Model 1 with no Random Effects for LTCHs
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	5.26 (5.14, 5.39)‡	5.33 (5.13, 5.53)‡
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.14)	0.03 (-0.07, 0.14)	-0.02 (-0.14, 0.10)
Missing data	0.66 (-0.15, 1.46)	0.66 (-0.14, 1.46)	0.75 (-0.18, 1.68)
Body mass index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.54 (-0.67, -0.41)‡	-0.57 (-0.71, -0.42)‡
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.87 (-1.01, -0.73)‡	-0.97 (-1.14, -0.81)‡
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.58 (-0.73, -0.44)‡	-0.72 (-0.91, -0.53)‡
Pain			
None	Reference	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)‡	0.30 (0.21, 0.39)‡	0.12 (-0.02, 0.26)
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.84 (0.73, 0.94)‡	0.56 (0.38, 0.75)‡
Pressure ulcer	2.67 (2.52, 2.82)‡	2.67 (2.52, 2.82)‡	2.72 (2.56, 2.88)‡
Urinary incontinence	4.19 (4.04, 4.35)‡	4.19 (4.10, 4.28)‡	4.22 (4.05, 4.40)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.68 (0.59, 0.77)‡	0.68 (0.60, 0.76)‡	0.73 (0.62, 0.85)‡
Severe impairment	2.49 (2.33, 2.65)‡	2.50 (2.36, 2.64)‡	2.40 (2.22, 2.57)‡
Prevalent Chronic Conditions			
Arthritis	0.08 (-.0003, 0.15)	0.08 (0.0003, 0.15)*	0.08 (-0.01, 0.17)
Asthma	0.10 (-0.04, 0.24)	0.09 (-0.04, 0.23)	0.20 (0.04, 0.35)*
Cancer	-0.12 (-0.19, -0.04)†	-0.11 (-0.19, -0.03)†	-0.18 (-0.27, -0.10)‡
Chronic kidney disease	0.31 (0.22, 0.40)‡	0.31 (0.22, 0.39)‡	0.35 (0.24, 0.45)‡
Coronary artery disease	-0.13 (-0.21, -0.05)†	-0.13 (-0.20, -0.05)†	-0.17 (-0.28, -0.07)†
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	-0.07 (-0.16, 0.02)	-0.09 (-0.20, 0.01)
Dementia	-0.22 (-0.35, -0.10)†	-0.23 (-0.34, -0.12)‡	-0.21 (-0.39, -0.03)*
Diabetes	-0.06 (-0.14, 0.02)	-0.06 (-0.14, 0.01)	0.06 (-0.04, 0.16)
Epilepsy	0.47 (0.32, 0.61)‡	0.47 (0.33, 0.61)‡	0.47 (0.32, 0.62)‡
Heart failure	0.36 (0.27, 0.46)‡	0.36 (0.27, 0.45)‡	0.38 (0.28, 0.49)‡
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	1.77 (1.63, 1.90)‡	2.00 (1.84, 2.16)‡
Mood disorder	0.30 (0.22, 0.38)‡	0.30 (0.22, 0.37)‡	0.35 (0.26, 0.45)‡
Parkinson's disease	1.75 (1.63, 1.87)‡	1.74 (1.62, 1.87)‡	1.82 (1.69, 1.94)‡

Variables	Model 1	Model 1 with fixed effect for LTCHs	Model 1 with no Random Effects for LTCHs
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Peripheral vascular disease	0.03 (-0.10, 0.16)	0.04 (-0.09, 0.16)	-0.03 (-0.18, 0.12)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	-0.42 (-0.50, -0.33)‡	-0.39 (-0.49, -0.29)‡
Stroke	0.46 (0.38, 0.55)‡	0.47 (0.39, 0.55)‡	0.46 (0.36, 0.55)‡
Random Effects			
$\sqrt{\psi}$	1.58	1.66	N/A
$\sqrt{\theta}$	4.90	4.90	N/A
Residual Variance	N/A	N/A	5.16
Derived Estimates			
R^2	0.627	0.624	0.626
ρ	0.095	0.103	N/A

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes
Reference: Variable category is the reference group for all other categories within that variable.
*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\boldsymbol{\psi}}$: Square root of between-long-term care home variance
$\sqrt{\boldsymbol{\theta}}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
$\boldsymbol{R^2}$: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$

Appendix 3.11: Sensitivity of Model 1 Findings to Coding of Chronic Conditions

Variables	Model 1	Model 1 with Chronic Conditions Coded Using Health Administrative Claims Only	Model 1 with Chronic Conditions Coded Using RAI-MDS Data Only
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Resident Characteristics			
Age			
65 – 74	Reference	Reference	Reference
75 – 84	0.04 (-0.08, 0.17)	-0.07 (-0.19, 0.05)	0.08 (-0.04, 0.21)
85 – 94	0.18 (0.04, 0.31)*	-0.01 (-0.15, 0.12)	0.23 (0.09, 0.36)†
95+	0.61 (0.42, 0.80)‡	0.36 (0.17, 0.54)‡	0.64 (0.46, 0.83)‡
Sex			
Female	Reference	Reference	Reference
Male	-0.37 (-0.46, -0.28)‡	-0.32 (-0.41, -0.23)‡	-0.37 (-0.46, -0.28)‡
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.41 (-0.50, -0.31)‡	-0.42 (-0.51, -0.32)‡	-0.41 (-0.51, -0.32)‡
Never married, separated or divorced	-0.60 (-0.73, -0.48)‡	-0.63 (-0.75, -0.50)‡	-0.63 (-0.76, -0.51)‡
Missing data on marital status	-0.64 (-0.96, -0.32)‡	-0.67 (-1.00, -0.35)‡	-0.67 (-0.99, -0.34)‡
Pre-LTCH Neighborhood Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.13 (0.01, 0.26)*	0.14 (0.01, 0.26)*	0.15 (0.02, 0.27)*
3	0.19 (0.07, 0.31)†	0.20 (0.08, 0.32)†	0.20 (0.09, 0.32)†
4	0.29 (0.17, 0.41)‡	0.30 (0.17, 0.42)‡	0.30 (0.18, 0.42)‡
5 (high)	0.23 (0.10, 0.37)†	0.25 (0.11, 0.38)‡	0.24 (0.11, 0.38)‡
Missing data	0.29 (0.14, 0.44)‡	0.32 (0.17, 0.47)‡	0.30 (0.15, 0.46)‡
Days in LTC Prior to Index Date	-		
0 - 4 months	Reference	Reference	Reference
> 4 months - 12 months	-0.65 (-0.78, -0.52)‡	-0.60 (-0.73, -0.47)‡	-0.65 (-0.78, -0.52)‡
> 1 year - 2 years	-0.75 (-0.89, -0.62)‡	-0.69 (-0.82, -0.55)‡	-0.78 (-0.91, -0.64)‡
> 2 years - 3 years	-0.65 (-0.78, -0.51)‡	-0.57 (-0.71, -0.43)‡	-0.68 (-0.82, -0.54)‡
> 3 years	-0.31 (-0.44, -0.17)‡	-0.13 (-0.27, 0.005)	-0.36 (-0.50, -0.23)‡
Prevalent Geriatric Syndromes			
Balance impairment	5.69 (5.51, 5.87)‡	5.83 (5.65, 6.01)‡	5.70 (5.51, 5.88)‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.60 (4.44, 4.75)‡	4.55 (4.40, 4.71)‡
Cognition			
Intact/borderline	Reference	Reference	Reference
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.64 (1.52, 1.76)‡	1.77 (1.64, 1.89)‡

Variables	Model 1	Model 1 with Chronic Conditions Coded Using Health Administrative Claims Only	Model 1 with Chronic Conditions Coded Using RAI-MDS Data Only
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	5.20 (5.03, 5.37)‡	5.41 (5.23, 5.58)‡
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.14)	0.007 (-0.10, 0.12)	0.02 (-0.08, 0.13)
Missing data	0.66 (-0.15, 1.46)	0.60 (-0.20, 1.40)	0.70 (-0.12, 1.51)
Body mass index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.53 (-0.67, -0.39)‡	-0.53 (-0.67, -0.39)‡
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.84 (-0.99, -0.69)‡	-0.86 (-1.01, -0.71)‡
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.56 (-0.72, -0.40)‡	-0.58 (-0.74, -0.42)‡
Pain			
None	Reference	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)‡	0.31 (0.21, 0.41)‡	0.28 (0.18, 0.37)‡
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.84 (0.72, 0.97)‡	0.79 (0.67, 0.91)‡
Pressure ulcer	2.67 (2.52, 2.82)‡	2.75 (2.60, 2.90)‡	2.67 (2.52, 2.82)‡
Urinary incontinence	4.19 (4.04, 4.35)‡	4.23 (4.07, 4.39)‡	4.21 (4.05, 4.37)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.68 (0.59, 0.77)‡	0.70 (0.61, 0.78)‡	0.68 (0.59, 0.77)‡
Severe impairment	2.49 (2.33, 2.65)‡	2.48 (2.32, 2.64)‡	2.49 (2.32, 2.64)‡
Prevalent Chronic Conditions			
Arthritis	0.08 (-.0003, 0.15)	0.05 (-0.03, 0.12)	0.10 (0.02, 0.17)*
Asthma	0.10 (-0.04, 0.24)	0.06 (-0.12, 0.24)	0.10 (-0.07, 0.28)
Cancer	-0.12 (-0.19, -0.04)†	-0.14 (-0.22, -0.05)†	-0.02 (-0.13, 0.09)
Chronic kidney disease	0.31 (0.22, 0.40)‡	0.36 (0.26, 0.46)‡	0.23 (0.11, 0.35)‡
Coronary artery disease	-0.13 (-0.21, -0.05)†	-0.08 (-0.17, 0.0008)	-0.11 (-0.21, -0.01)*
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	0.02 (-0.09, 0.13)	-0.07 (-0.17, 0.03)
Dementia	-0.22 (-0.35, -0.10)†	-0.21 (-0.33, -0.10)‡	-0.40 (-0.50, -0.30)‡
Diabetes	-0.06 (-0.14, 0.02)	-0.01 (-0.10, 0.07)	-0.02 (-0.10, 0.06)
Epilepsy	0.47 (0.32, 0.61)‡	0.38 (0.19, 0.57)‡	0.55 (0.38, 0.71)‡
Heart failure	0.36 (0.27, 0.46)‡	0.36 (0.27, 0.46)‡	0.29 (0.17, 0.40)‡
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	-0.07 (-0.21, 0.06)	1.75 (1.60, 1.91)‡
Mood disorder	0.30 (0.22, 0.38)‡	-0.02 (-0.12, 0.09)	0.31 (0.23, 0.39)‡

Variables	Model 1	Model 1 with Chronic Conditions Coded Using Health Administrative Claims Only	Model 1 with Chronic Conditions Coded Using RAI-MDS Data Only
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Parkinson's disease	1.75 (1.63, 1.87)‡	1.75 (1.61, 1.88)‡	1.82 (1.69, 1.95)‡
Peripheral vascular disease	0.03 (-0.10, 0.16)	-0.11 (-0.33, 0.11)	0.08 (-0.06, 0.23)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	-0.39 (-0.49, -0.29)‡	-0.45 (-0.57, -0.33)‡
Stroke	0.46 (0.38, 0.55)‡	0.98 (0.88, 1.07)‡	0.40 (0.31, 0.49)‡
Random Effects			
$\sqrt{\psi}$	1.58	1.61	1.59
$\sqrt{\theta}$	4.90	4.93	4.90
Derived Estimates			
R^2	0.627	0.622	0.626
ρ	0.095	0.096	0.095

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes

Reference: Variable category is the reference group for all other categories within that variable.

*p-value <0.05

†p-value <0.01

‡p-value <0.0001

$\sqrt{\boldsymbol{\psi}}$: Square root of between-long-term care home variance

$\sqrt{\boldsymbol{\theta}}$: Square root of within-long-term care home variance

The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).

$\boldsymbol{R^2}$: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)

ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$

Appendix 3.12: Sensitivity of Model 2 Findings to Exclusion of Admission Assessments

Of the 77,165 residents included in the Study 2 sample, data for 9,302 of them came from assessments done at their admission to long-term care. Because such residents had not been exposed to the conditions of the long-term care home, it is possible that their inclusion weakened the association between resident disability and long-term care home characteristics. This sensitivity test examined whether this was the case. The table below illustrates that the exclusion of data from admission assessments has no effect on the findings from Study 2. Coefficient estimate sizes are unchanged in the version of Model 2 re-run in the sample of residents (n = 67,863) whose assessment data were not from admission assessments.

	Model 2[‖] (n = 77, 165)	**Model 2 in Sample Excluding Admission Assessments** (n = 67,863)
	Estimate (95% CI)	Estimate (95% CI)
Constant	2.70 (2.18, 3.22)[‡]	2.65 (2.10, 3.20)
Resident Characteristics		
Age		
65 – 74	Reference	Reference
75 – 84	0.04 (-0.08, 0.16)	0.03 (-0.10, 0.16)
85 – 94	0.18 (0.04, 0.31)[*]	0.15 (0.01, 0.29)[*]
95+	0.61 (0.42, 0.79)[‡]	0.60 (0.41, 0.80)[‡]
Sex		
Female	Reference	Reference
Male	-0.36 (-0.46, -0.27)[‡]	-0.36 (-0.46, -0.27)[‡]
Marital Status		
Married	Reference	Reference
Widowed	-0.41 (-0.50, -0.31)[‡]	-0.43 (-0.53, -0.33)[‡]
Never married, separated or divorced	-0.60 (-0.73, -0.48)[‡]	-0.60 (-0.73, -0.47)[‡]
Missing data on marital status	-0.64 (-0.97, -0.32)[‡]	-0.60 (-0.94, -0.25)[†]
Pre-LTCH Neighborhood Income Quintile		
1 (low)	Reference	Reference
2	0.12 (0.002, 0.25)[*]	0.08 (-0.04, 0.21)
3	0.18 (0.06, 0.30)[†]	0.17 (0.05, 0.29)[†]
4	0.27 (0.15, 0.39)[‡]	0.29 (0.16, 0.41)[‡]
5 (high)	0.23 (0.09, 0.36)[†]	0.19 (0.05, 0.34)[†]
Missing data	0.28 (0.13, 0.43)[‡]	0.25 (0.10, 0.40)[†]
Days in LTCH Prior to Index Date	-	
0 - 4 months	Reference	Reference
> 4 months - 12 months	-0.65 (-0.78, -0.52)[‡]	-0.69 (-0.84, -0.55)[‡]
> 1 year - 2 years	-0.76 (-0.89, -0.62)[‡]	-0.82 (-0.97, -0.67)[‡]
> 2 years - 3 years	-0.65 (-0.78, -0.51)[‡]	-0.72 (-0.88, -0.57)[‡]
> 3 years	-0.30 (-0.44, -0.17)[‡]	-0.41 (-0.55, -0.27)[‡]
Prevalent Geriatric Syndromes		
Balance impairment	5.66 (5.48, 5.84)[‡]	5.67 (5.48, 5.86)[‡]

	Model 2[‖] (n = 77, 165)	**Model 2 in Sample Excluding Admission Assessments** (n = 67,863)
	Estimate (95% CI)	Estimate (95% CI)
Bowel incontinence	4.52 (4.37, 4.67)[‡]	4.57 (4.41, 4.73)[‡]
Cognition		
Intact/borderline	Reference	Reference
Mild/moderate impairment	1.66 (1.54, 1.78)[‡]	1.80 (1.66, 1.93)[‡]
Moderate-severe/severe impairment	5.26 (5.09, 5.43)[‡]	5.42 (5.24, 5.60)[‡]
Hearing impairment		
None	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.13)	-0.02 (-0.13, 0.10)
Missing data	0.67 (-0.11, 1.46)	0.61 (-0.19, 1.41)
Body mass index (BMI)		
BMI < 18.5	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)[‡]	-0.59 (-0.74, -0.45)[‡]
25 < BMI <30	-0.88 (-1.03, -0.72)[‡]	-0.88 (-1.04, -0.72)[‡]
BMI ≥ 30	-0.60 (-0.76, -0.44)[‡]	-0.62 (-0.79, -0.45)[‡]
Pain		
None	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)[‡]	0.26 (0.16, 0.37)[‡]
Daily or severe daily pain	0.83 (0.70, 0.95)[‡]	0.75 (0.62, 0.88)[‡]
Pressure ulcer	2.67 (2.52, 2.82)[‡]	2.59 (2.44, 2.75)[‡]
Urinary incontinence	4.20 (4.04, 4.35)[‡]	4.39 (4.22, 4.55)[‡]
Visual impairment		
None	Reference	Reference
Moderate impairment	0.68 (0.59, 0.76)[‡]	0.64 (0.52, 0.73)[‡]
Severe impairment	2.49 (2.33, 2.65)[‡]	2.47 (2.31, 2.63)[‡]
Prevalent Chronic Conditions		
Arthritis	0.08 (0.0003, 0.15)[*]	0.07 (-0.01, 0.15)
Asthma	0.10 (-0.04, 0.24)	0.12 (-0.03, 0.26)
Cancer	-0.12 (-0.19, -0.04)[†]	-0.12 (-0.20, -0.03)[†]
Coronary artery disease	-0.13 (-0.21, -0.05)[†]	-0.14 (-0.23, -0.06)[†]
Chronic obstructive pulmonary disease	-0.07 (-0.17, 0.02)	-0.09 (-0.19, 0.01)
Dementia	-0.23 (-0.36, -0.11)[‡]	-0.17 (-0.31, -0.04)[†]
Diabetes	-0.06 (-0.14, 0.02)	-0.06 (-0.14, 0.02)
Epilepsy	0.47 (0.33, 0.62)[‡]	0.48 (0.33, 0.63)[‡]
Heart failure	0.36 (0.27, 0.45)[‡]	0.35 (0.25, 0.44)[‡]
Kidney disease	0.31 (0.22, 0.40)[‡]	0.25 (0.15, 0.35)[‡]
Limb paralysis or amputation	1.77 (1.62, 1.92)[‡]	1.75 (1.60, 1.91)[‡]
Mood disorder	0.30 (0.22, 0.38)[‡]	0.27 (0.19, 0.35)[‡]
Parkinson's disease	1.75 (1.63, 1.87)[‡]	1.71 (1.58, 1.84)[‡]
Peripheral vascular disease	0.03 (-0.10, 0.16)	0.05 (-0.09, 0.19)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)[‡]	-0.42 (-0.51, -0.33)[‡]
Stroke	0.46 (0.38, 0.55)[‡]	0.43 (0.34, 0.52)[‡]
LTCH Size		
Small (≤64)	Reference	Reference
Medium (65 – 128)	-0.05 (-0.32, 0.21)	-0.04 (-0.31, 0.23)
Large (129 – 192)	0.08 (-0.24, 0.40)	0.10 (-0.22, 0.42)
Extra-large (≥193)	0.25 (-0.13, 0.63)	0.25 (-0.13, 0.64)
Ownership Status		
Not-for-profit	Reference	Reference
For-profit	0.23 (0.006, 0.46)[*]	0.16 (-0.06, 0.39)
Missing data	0.44 (-0.47, 1.35)	0.22 (-0.81, 1.26)

	Model 2‖ (n = 77, 165)	**Model 2 in Sample Excluding Admission Assessments** (n = 67,863)
	Estimate (95% CI)	Estimate (95% CI)
LTCH Location		
Rural	Reference	Reference
Sub-urban	0.14 (-0.22, 0.49)	0.21 (-0.16, 0.57)
Urban	-0.12 (-0.41, 0.15)	-0.11 (-0.39, 0.18)
Mean % residents received physio- or occupational therapy (Quartiles)		
Lowest quartile	Reference	Reference
2nd quartile	0.17 (-0.13, 0.47)	0.01 (-0.30, 0.33)
3rd quartile	0.14 (-0.17, 0.45)	-0.22 (-0.53, 0.10)
Highest quartile	-0.05 (-0.35, 0.24)	-0.12 (-0.42, 0.19)
Mean % residents restrained (Quartiles)		
Lowest quartile	Reference	Reference
2nd quartile	0.007 (-0.30, 0.32)	0.21 (-0.10, 0.51)
3rd quartile	-0.23 (-0.54, 0.07)	0.17 (-0.14, 0.48)
Highest quartile	-0.14 (-0.45, 0.16)	-0.04 (-0.34, 0.25)
Median Resident ADL in each home (Quartiles)		
Lowest quartile	Reference	Reference
2nd quartile	1.16 (0.87, 1.46)‡	1.07 (0.78, 1.37)‡
3rd quartile	1.62 (1.30, 1.94)‡	1.54 (1.22, 1.86)‡
Highest quartile	2.81 (2.50, 3.11)‡	2.72 (2.41, 3.03)‡
Random Effects		
$\sqrt{\psi}$	1.21 (1.13, 1.28)	1.21 (1.13, 1.29)
$\sqrt{\theta}$	4.90 (4.84, 4.96)	4.86 (4.80, 4.92)
Derived Estimates		
R^2	0.642	0.647
ρ	0.057	0.058

Model 2: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home, as well as the following long-term care home variables: size, ownership type, location, proportion of residents who recently received physiotherapy or occupation therapy, proportion of residents restrained, and median resident disability. Also a random intercept for long-term care homes.
Reference: Variable category is the reference group for all other categories within that variable.
*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi}$: Square root of between-long-term care home variance
$\sqrt{\theta}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
R^2: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$

Appendix 3.13: Correlation between LTCH Variables

Table 3.13a below examines the correlation between continuous LTCH variables and the associations between categorical LTCH variables. The highest level of correlation between LTCH variables in their continuous form is +0.22 ($p<0.0001$), between the median ADL LFS for all residents in a home and the percent of residents restrained in that home.

Table 3.13b shows that a larger proportion of extra-small, small and medium-sized long-term care homes are for-profit, whereas a majority (54.8%) of extra-large homes are not-for-profit. Table 3.13c shows that extra-small and small long-term care homes tended to exist more in rural areas, whereas medium and large long-term care homes were predominantly in urban areas.

Table 3.13a: Pearson Correlation Coefficients for Continuous LTCH Variables

	Median Resident ADL in each home (Quartiles)	Mean % residents restrained	Mean % residents received physio- or occupational therapy (Quartiles)
Median Resident ADL in each home (Quartiles)	1.00	0.22182 <.0001	0.15350 0.001
Mean % residents restrained	0.22182 <0.0001	1.00	-0.00236 0.9534
Mean % residents received physio- or occupational therapy (Quartiles)	0.15350 <0.0001	-0.00236 0.9534	1.00

Table 3.13b: Frequency of Different LTCH Size Categories by Different LTCH Ownership Categories

		Ownership status			Total
		Not for profit	For profit	Missing Data	
LTCH Size					
Small	Frequency	35	89	4	128
	Percent	5.7	14.5	0.6	20.8
	Row %	27.3	69.5	3.1	
	Column %	15.4	23.5	50.0	
Medium	Frequency	83	162	3	248
	Percent	13.5	26.4	0.5	40.4
	Row %	33.5	65.3	1.2	
	Column %	36.4	42.9	37.5	
Large	Frequency	64	90	0	154
	Percent	10.4	14.7	0.00	25.1
	Row %	41.6	58.4	0.00	
	Column %	28.1	23.8	0.00	
Extra Large	Frequency	46	37	1	84
	Percent	7.5	6.0	0.2	13.7
	Row %	54.8	44.0	1.2	
	Column %	20.2	9.8	12.5	
Total	Frequency				
	Percent	37.1	61.6	1.3	100.0

Table 3.13c: Frequency of Different LTCH Size Categories by Different LTCH Location Categories

LTCH Size		LTCH Location			Total
		Rural	Sub-urban	Urban	
Small	Frequency	61	25	42	128
	Percent	9.9	4.1	6.8	20.8
	Row %	47.7	19.5	32.8	
	Column %	44.8	25.8	11.0	
Medium	Frequency	65	43	140	248
	Percent	10.6	7.0	22.8	40.4
	Row %	26.2	17.3	56.4	
	Column %	47.8	44.3	36.8	
Large	Frequency	10	22	122	154
	Percent	1.6	3.6	19.9	25.1
	Row %	6.5	14.3	79.2	
	Column %	7.4	22.7	32.0	
Extra Large	Frequency	0	7	77	84
	Percent	0.00	1.1	12.5	13.7
	Row %	0.00	8.3	91.7	
	Column %	0.00	7.2	20.2	
Total	Frequency	136	97	381	614
	Percent	22.2	15.8	62.0	100.0

Appendix 3.14: Sensitivity of Model 1 to Varying Levels of Adjustment for LTCH Effects

The models in this table tested the sensitivity of Study 2 Model 1 to varying degrees of adjustment for LTCH effects on disability.

"Model 1 with fixed effects for LTCHs" shows that adjustment for effects of unmeasured features of LTCHs on disability does not significantly increase the amount of variance explained by LTCHs, nor does it change the effects of geriatric syndromes or chronic conditions on disability.

"Model 1 without random or fixed effects for LTCHs" reports the findings from a simple linear regression of Model 1, with no adjustment for clustering of residents within LTCHs. Other than yielding statistically (but not clinically) smaller effects of balance impairment and daily or severe pain on disability, the findings from Model 1 were unchanged by the absence of adjustment for clustering of residents in LTCHs.

Variables	**Model 1**	**Model 1 with fixed effect for LTCHs**	**Model 1 without random or fixed effect for LTCHs**
Resident Characteristics			
Age			
65 – 74	Reference	Reference	Reference
75 – 84	0.04 (-0.08, 0.17)	0.04 (-0.09, 0.17)	0.12 (-0.03, 0.25)
85 – 94	0.18 (0.04, 0.31)*	0.17 (0.04, 0.31)*	0.27 (0.13, 0.41)‡
95+	0.61 (0.42, 0.80)‡	0.60 (0.42, 0.78)‡	0.76 (0.58, 0.95)‡
Sex			
Female	Reference	Reference	Reference
Male	-0.37 (-0.46, -0.28) ‡	-0.36 (-0.45, -0.28)‡	-0.40 (-0.49, -0.31)‡
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.41 (-0.50, -0.31)‡	-0.41 (-0.50, -0.31)‡	-0.38 (-0.48, -0.28)‡
Never married, separated or divorced	-0.60 (-0.73, -0.48)‡	-0.61 (-0.73, -0.49)‡	-0.55 (-0.68, -0.43)‡
Missing data on marital status	-0.64 (-0.96, -0.32)‡	-0.64 (-0.96, -0.32)‡	-0.64 (-0.97, -0.31)‡
Pre-LTC Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.13 (0.01, 0.26)*	0.13 (0.02, 0.25)*	0.14 (0.02, 0.26)*
3	0.19 (0.07, 0.31)†	0.20 (0.08, 0.31)†	0.10 (-0.01, 0.22)
4	0.29 (0.17, 0.41)‡	0.28 (0.16, 0.40)‡	0.30 (0.18, 0.42)‡
5 (high)	0.23 (0.10, 0.37)†	0.23 (0.11, 0.35)‡	0.25 (0.13, 0.38)‡
Missing data	0.29 (0.14, 0.44)‡	0.29 (0.14, 0.43)‡	0.23 (0.10, 0.36)‡
Days in LTC Prior to Index Date	-		

Variables	Model 1	Model 1 with fixed effect for LTCHs	Model 1 without random or fixed effect for LTCHs
0 - 4 months	Reference	Reference	Reference
> 4 months - 12 months	-0.65 (-0.78, -0.52)‡	-0.65 (-0.76, -0.54)‡	-0.65 (-0.76, -0.53)‡
> 1 year - 2 years	-0.75 (-0.89, -0.62)‡	-0.75 (-0.86, -0.64)‡	-0.71 (-0.82, -0.59)‡
> 2 years - 3 years	-0.65 (-0.78, -0.51)‡	-0.65 (-0.78, -0.52)‡	-0.61 (-0.74, -0.47)‡
> 3 years	-0.31 (-0.44, -0.17)‡	-0.31 (-0.41, -0.20)‡	-0.29 (-0.40, -0.19)‡
Prevalent Geriatric Syndromes			
Balance impairment	5.69 (5.51, 5.87)‡	5.72 (5.62, 5.81)‡	5.35 (5.26, 5.45)‡
Bowel incontinence	4.53 (4.38, 4.68)‡	4.52 (4.43, 4.61)‡	4.61 (4.51, 4.70)‡
Cognition			
Intact/borderline	Reference	Reference	Reference
Mild/moderate impairment	1.67 (1.55, 1.79)‡	1.67 (1.57, 1.77)‡	1.68 (1.58, 1.78)‡
Moderate-severe/severe impairment	5.27 (5.10, 5.44)‡	5.26 (5.14, 5.39)‡	5.33 (5.20, 5.46)‡
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	0.03 (-0.08, 0.14)	0.03 (-0.07, 0.14)	-0.02 (-0.13, 0.09)
Missing data	0.66 (-0.15, 1.46)	0.66 (-0.14, 1.46)	0.75 (-0.07, 1.57)
BMI			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.54 (-0.68, -0.40)‡	-0.54 (-0.67, -0.41)‡	-0.57 (-0.70, -0.43)‡
25 < BMI <30	-0.87 (-1.03, -0.72)‡	-0.87 (-1.01, -0.73)‡	-0.97 (-1.12, -0.83)‡
BMI ≥ 30	-0.59 (-0.75, -0.43)‡	-0.58 (-0.73, -0.44)‡	-0.72 (-0.87, -0.57)‡
Pain			
None	Reference	Reference	Reference
Less than daily pain	0.29 (0.19, 0.39)‡	0.30 (0.21, 0.39)‡	0.12 (0.03, 0.21)*
Daily or severe daily pain	0.82 (0.70, 0.94)‡	0.84 (0.73, 0.94)‡	0.56 (0.46, 0.67)‡
Pressure ulcer	2.67 (2.52, 2.82)‡	2.67 (2.52, 2.82)‡	2.72 (2.56, 2.87)‡
Urinary incontinence	4.19 (4.04, 4.35)‡	4.19 (4.10, 4.28)‡	4.22 (4.13, 4.32)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.68 (0.59, 0.77)‡	0.68 (0.60, 0.76)‡	0.73 (0.65, 0.81)‡
Severe impairment	2.49 (2.33, 2.65)‡	2.50 (2.36, 2.64)‡	2.40 (2.25, 2.54)‡
Prevalent Chronic Conditions			
Arthritis	0.08 (-.0003, 0.15)	N/A	0.08 (0.002, 0.16)
Asthma	0.10 (-0.04, 0.24)	N/A	0.20 (0.06, 0.34)†
Cancer	-0.12 (-0.19, -0.04)†	N/A	-0.18 (-0.26, -0.10)†
Chronic kidney disease	0 .31 (0.22, 0.40)‡	N/A	0.35 (0.25, 0.44)†
Coronary artery disease	-0.13 (-0.21, -0.05)†	N/A	-0.17 (-0.25, -0.09)†
COPD	-0.07 (-0.17, 0.02)	N/A	-0.09 (-0.19, 0.0005)
Dementia	-0.22 (-0.35, -0.10)†	N/A	-0.21 (-0.32, -0.10)†
Diabetes	-0.06 (-0.14, 0.02)	N/A	0.06 (-0.02, 0.14)
Epilepsy	0.47 (0.32, 0.61)‡	N/A	0.47 (0.32, 0.62)†
Heart failure	0.36 (0.27, 0.46)‡	N/A	0.38 (0.29, 0.47)†

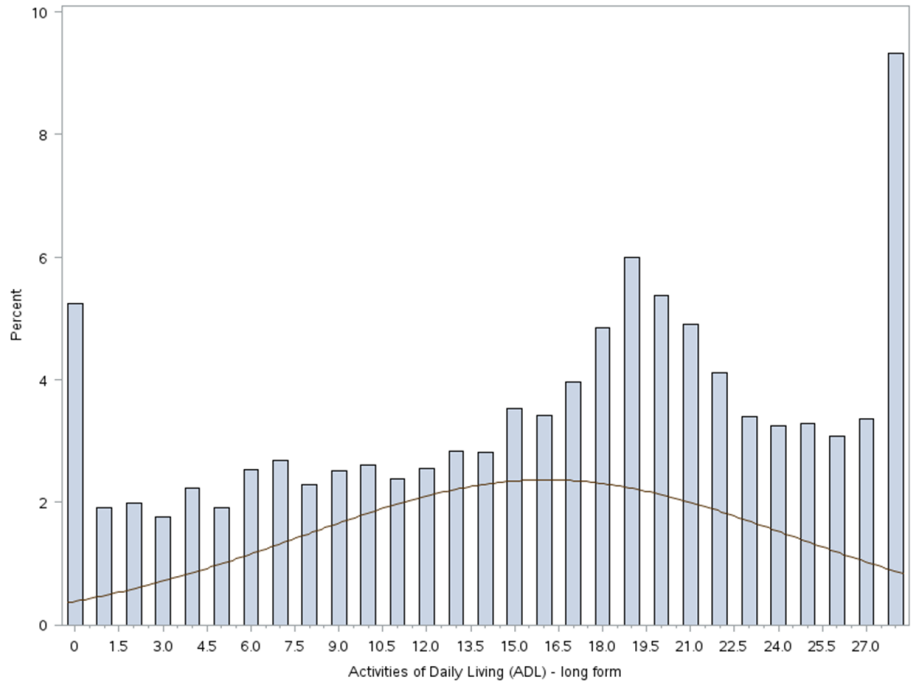
Variables	Model 1	Model 1 with fixed effect for LTCHs	Model 1 without random or fixed effect for LTCHs
Limb paralysis or amputation	1.78 (1.63, 1.93)‡	N/A	2.00 (1.86, 2.14)†
Mood disorder	0.30 (0.22, 0.38)‡	N/A	0.35 (0.28, 0.43)†
Parkinson's disease	1.75 (1.63, 1.87)‡	N/A	1.81 (1.69, 1.94)†
Peripheral vascular disease	0.03 (-0.10, 0.16)	N/A	-0.03 (-0.16, 0.10)
Psychiatric conditions other than depression and dementia	-0.42 (-0.50, -0.33)‡	N/A	-0.39 (-0.48, -0.31)†
Stroke	0.46 (0.38, 0.55)‡	N/A	0.46 (0.37, 0.54)†
Random Effects			
$\sqrt{\psi}$	1.58	1.66	N/A
$\sqrt{\theta}$	4.90	4.90	N/A
Derived Estimates			
R^2	0.627	0.624	0.626
ρ	0.095	0.103	N/A

Model 1: Adjusted for resident age, sex, marital status, pre-admission neighborhood income quintile, number of days since admission to long-term care home; includes random intercept for long-term care homes
Reference: Variable category is the reference group for all other categories within that variable.
*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\boldsymbol{\psi}}$: Square root of between-long-term care home variance
$\sqrt{\boldsymbol{\theta}}$: Square root of within-long-term care home variance
The **null model** of disability containing only random LTCH intercepts and no explanatory resident or LTCH variables had a within-LTCH variance of 66.91 and a between-LTCH variance of 4.16; variances from all multivariable models were compared to these values to estimate proportion of variance explained (R^2).
$\boldsymbol{R^2}$: The proportional reduction in the estimated total residual variance compared to the null model (Model 1)
ρ: Proportion of variance that is explained by LTCH characteristics = $\psi/(\psi+\theta)$
N/A: Not applicable within this model.

Appendix 3.15: Expanded Descriptive Statistics for Select Continuous Variables in Study 2

Some of the continuous variables in this study were categorized for analysis. This was done either to reflect a non-continuous relationship between the variable and disability (e.g. age) or because continuous variables were skewed (e.g. percent of residents who received therapy). Descriptive statistics for these categorized continuous variables are in the table below.

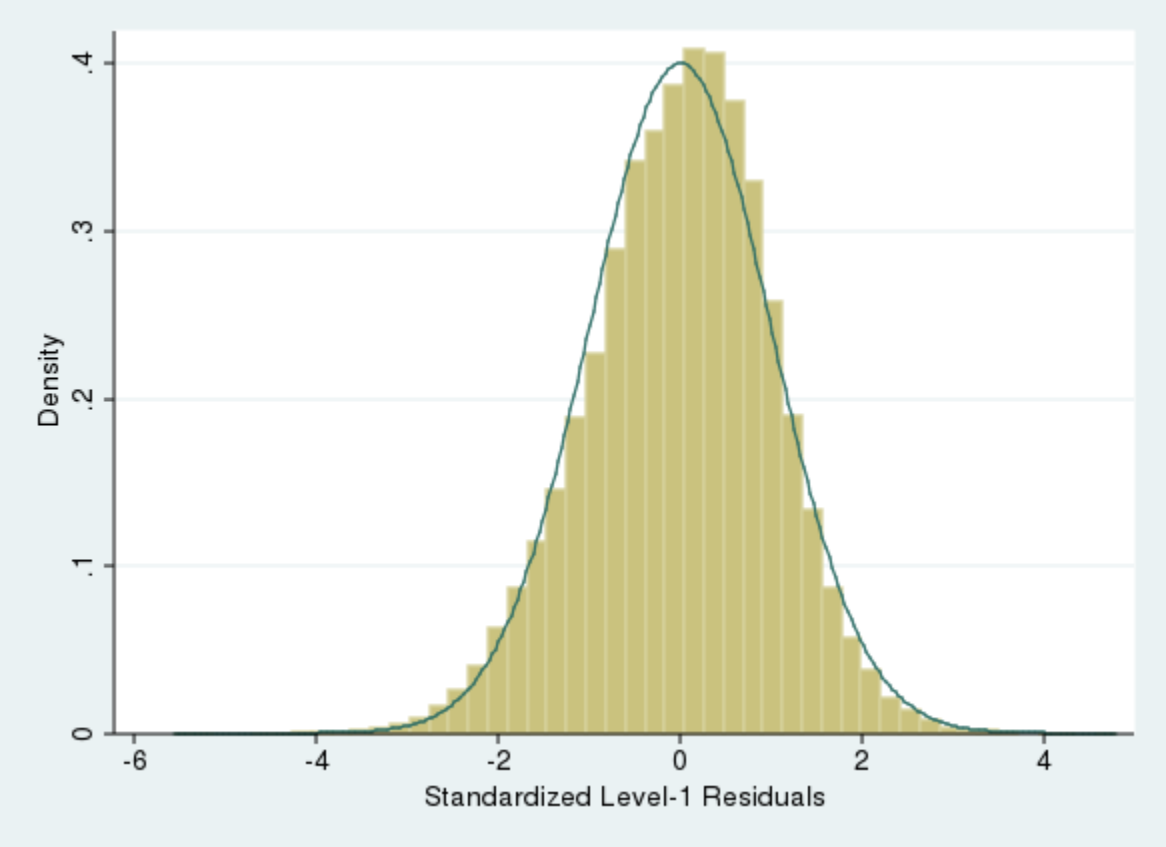
Continuous Variable	Mean (SD)	Median (IQR)
Measured in Residents (n = 77,165)		
Disability (ADL Long-Form Score, Range: 0 – 28)	16.1 (8.43)	18 (9, 23)
Days sine admission to LTCH	864.8 (1116.7)	462 (127, 1223)
Age (years)	84.9 (7.5)	86 (80, 90)
Measured in LTCHs (n = 614)		
Percent of residents restained in past 7 days.	14.1 (9.7)	13.3 (6.0, 20.6)
Percent of residents who received occupational or physiotherapy in past 7 days.	81.3 (17.4)	86.4 (74.5, 94.1)



Appendix Figure 3.15: Distribution of Disability (ADL Long-Form Score) in Study Sample

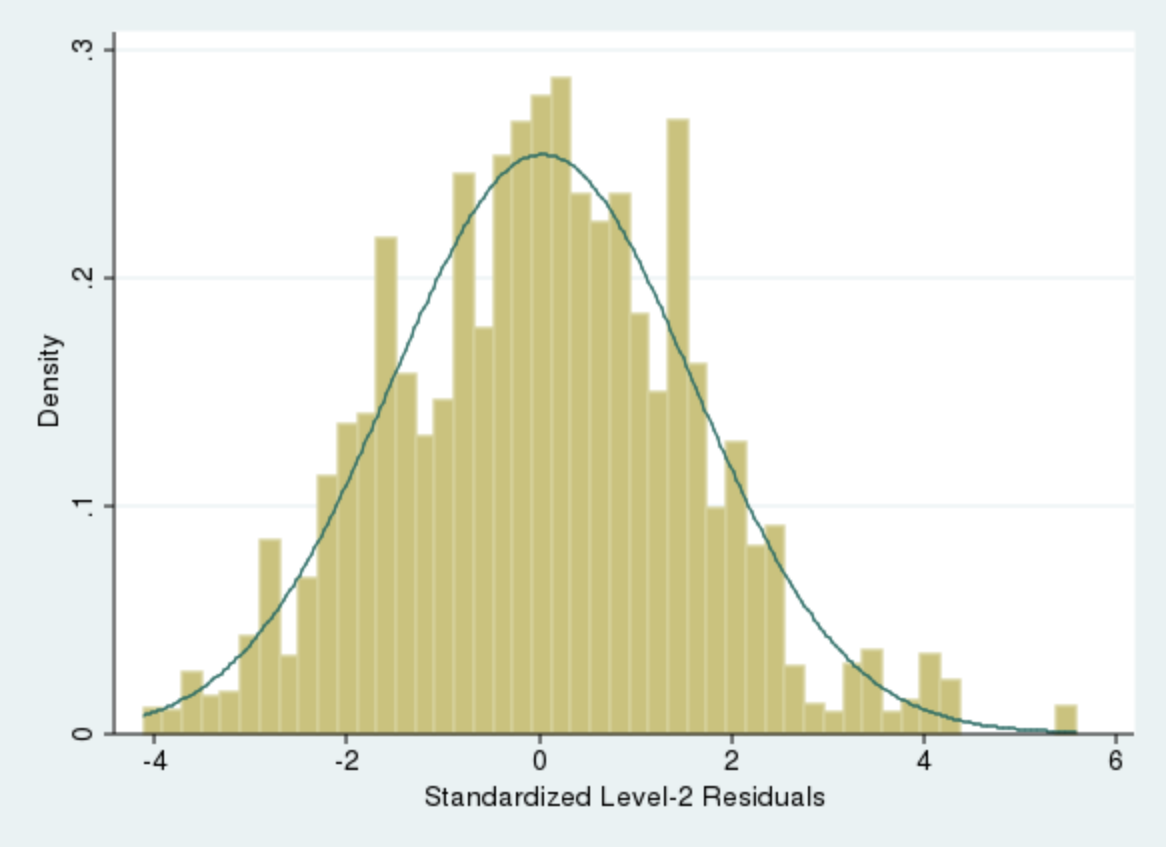
Although the ADL LFS is an ordinal measure of disability, it was treated as a continuous variable in this study. The graph above shows this treatment was appropriate, as the ADL LFS are fairly evenly distributed within the sample.

Appendix 3.16: Distribution of Random Effects and Residuals for Study 2 Model 1



Appendix Figure 3.16a: Distribution of Level 1 Residuals for Study 2 Model 1

One of the assumptions of hierarchical multivariable models is that level-1 residuals are normally distributed. The above figure illustrates that this assumption was met in Model 1 of Study 2.



Appendix Figure 3.16b: Distribution of Level 2 Residuals for Study 2 Model 1

One of the assumptions of hierarchical multivariable models is that random intercepts are normally distributed. The above figure illustrates that this assumption was fairly well met in Model 1 of Study 2.

Appendix 3.17: Staged Addition of Sociodemographic Variables to Simple Linear Regression of Model 1

To examine for possible confounding of variables' relationship with disability by other variables in the model, simple linear regressions unadjusted for clustering of residents within long-term care homes were run. Sociodemographic variables were entered one by one, followed by geriatric syndromes, chronic conditions and number of days since entry to long-term care, as follows:

Model 1: Disability = age

Model 2: Disability = age + sex

Model 3: Disability = age + sex + marital status

Model 4: Disability = age + sex + marital status + pre-admission neighbourhood income quintile

Model 5: Disability = age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes

Model 6: Disability = age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + chronic conditions

Model 7: Disability = age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + chronic conditions + days since admission to long-term care

The effect of age on disability is greatly diminished by adjustment for sex and geriatric syndromes. The protective effect of male sex is significantly decreased by adjustment for coexisting geriatric syndromes but significantly increased by adjustment for coexisting chronic conditions. The protective effect of marital status other than married is significantly decreased by adjustment for geriatric syndromes.

Model 4 showed that higher pre-admission neighborhood income quintile was associated with more disability, adjusting for marital status, sex and age, but this association was nullified in Model 5 with adjustment for geriatric syndromes. This may reflect differences in state of health

at entry to long-term care: people from high income neighborhoods might have the resources to delay entry to long-term care with higher levels of disability, independent of their age, sex and marital status. But prevalent geriatric syndromes may necessitate entry to long-term care, regardless of neighborhood differences in resources available in the community.

Model 7 shows that residents who are recently admitted to long-term care have the highest disability, likely because these individuals do not survive in long-term care for very long. Although adjustment for days in long-term care did not significantly change the effects of any chronic conditions or geriatric syndromes, it did account for an additional 1% of variance in disability, which is the same incremental change in R^2 caused by adjustment for all co-existing chronic conditions (Model 6).

Appendix Table 3.17: Staged Addition of Sociodemographic Variables to Simple Linear Regression of Model 1

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Constant	15.13‡ (14.95, 15.32)	15.53‡ (15.33, 15.72)	17.12‡ (16.89, 17.35)	16.55‡ (16.29, 16.80)	4.31‡ (4.08, 4.54)	3.93‡ (3.68, 4.18)	4.26‡ (4.01, 4.51)
Age							
65 – 74	Reference	Reference	Reference	Reference	Reference	Reference	Reference
75 – 84	0.76‡ (0.55, 0.98)	0.67‡ (0.46, 0.89)	0.48‡ (0.26, 0.69)	0.47‡ (0.26, 0.69)	-0.05‡ (-0.18, 0.09)	0.10 (-0.03, 0.24)	0.12 (-0.02, 0.25)
85 – 94	1.02‡ (0.81, 1.22)	0.83‡ (0.62, 1.03)	0.77‡ (0.55, 0.98)	0.75‡ (0.53, 0.96)	-0.09‡ (-0.22, 0.05)	0.24† (0.10, 0.38)	0.27‡ (0.13, 0.41)
95+	2.43‡ (2.16, 2.70)	2.17‡ (1.90, 2.44)	2.29‡ (2.00, 2.57)	2.24‡ (1.96, 2.52)	0.26† (0.07, 0.44)	0.73‡ (0.54, 0.91)	0.76‡ (0.58, 0.95)
Sex							
Female		Reference	Reference	Reference	Reference	Reference	Reference
Male		-0.87‡ (-1.01, -0.74)	-1.31‡ (-1.44, -1.17)	-1.31‡ (-1.45, -1.16)	-0.19‡ (-0.28, -0.11)	-0.39‡ (-0.49, -0.30)	-0.40‡ (-0.49, -0.31)
Marital Status							
Married			Reference	Reference	Reference	Reference	Reference
Widowed			-1.71‡ (-1.86, -1.55)	-1.70‡ (-1.86, -1.55)	-0.43‡ (-0.53, -0.33)	-0.38‡ (-0.48, -0.28)	-0.38‡ (-0.48, -0.28)
Never married,			-2.32‡ (-2.52, -2.12)	-2.32‡ (-2.52, -2.12)	-0.69‡ (-0.81, -0.56)	-0.55‡ (-0.68, -0.43)	-0.55‡ (-0.68, -0.43)

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
separated or divorced							
Missing data on marital status			-1.57‡ (-2.07, -1.08)	-1.57‡ (-2.07, -1.08)	-0.72‡ (-1.05, -0.38)	-0.60‡ (-0.93, -0.27)	-0.64‡ (-0.97, -0.31)
Pre-LTC Income Quintile							
1 (low)				Reference	Reference	Reference	Reference
2				0.48‡ (0.29, 0.67)	0.17† (0.05, 0.29)	0.14* (0.02, 0.26)	0.14* (0.02, 0.26)
3				0.40‡ (0.21, 0.59)	0.12* (0.007, 0.24)	0.10 (-0.01, 0.22)	0.10 (-0.01, 0.22)
4				0.83‡ (0.63, 1.03)	0.33‡ (0.20, 0.45)	0.31‡ (0.19, 0.43)	0.30‡ (0.18, 0.42)
5 (high)				0.79‡ (0.59, 0.99)	0.28‡ (0.16, 0.41)	0.25‡ (0.13, 0.38)	0.25‡ (0.13, 0.38)
Missing data				1.52‡ (1.31, 1.73)	0.27‡ (0.14, 0.40)	0.24‡ (0.11, 0.37)	0.23‡ (0.10, 0.36)
Prevalent Geriatric Syndromes							
Balance impairment					5.71‡ (5.62, 5.81)	5.35‡ (5.25, 5.45)	5.35‡ (5.26, 5.45)
Bowel incontinence					4.71‡ (4.61, 4.80)	4.61‡ (4.52, 4.70)	4.61‡ (4.51, 4.70)
Cognition							

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Intact/borderline					Reference	Reference	Reference
Mild/moderate impairment					1.52‡ (1.43, 1.62)	1.69‡ (1.59, 1.79)	1.68‡ (1.58, 1.78)
Moderate-severe/severe impairment					5.03‡ (4.91, 5.15)	5.34‡ (5.21, 5.46)	5.33‡ (5.20, 5.46)
Hearing impairment							
None					Reference	Reference	Reference
Hearing impaired					-0.05 (-0.16, 0.07)	-0.009 (-0.12, 0.10)	-0.02 (-0.13, 0.09)
Missing data					0.65 (-0.18, 1.49)	0.69 (-0.13, 1.51)	0.75 (-0.07, 1.57)
BMI							
BMI < 18.5					Reference	Reference	Reference
18.5 ≤ BMI ≤ 25					-0.58‡ (-0.72, -0.44)	-0.59‡ (-0.73, -0.46)	-0.57‡ (-0.70, -0.43)
25 < BMI <30					-0.99‡ (-1.13, -0.84)	-1.02‡ (-1.17, -0.88)	-0.97‡ (-1.12, -0.83)
BMI ≥ 30					-0.71‡ (-0.87, -0.56)	-0.078‡ (-0.93, -0.62)	-0.72‡ (-0.87, -0.57)

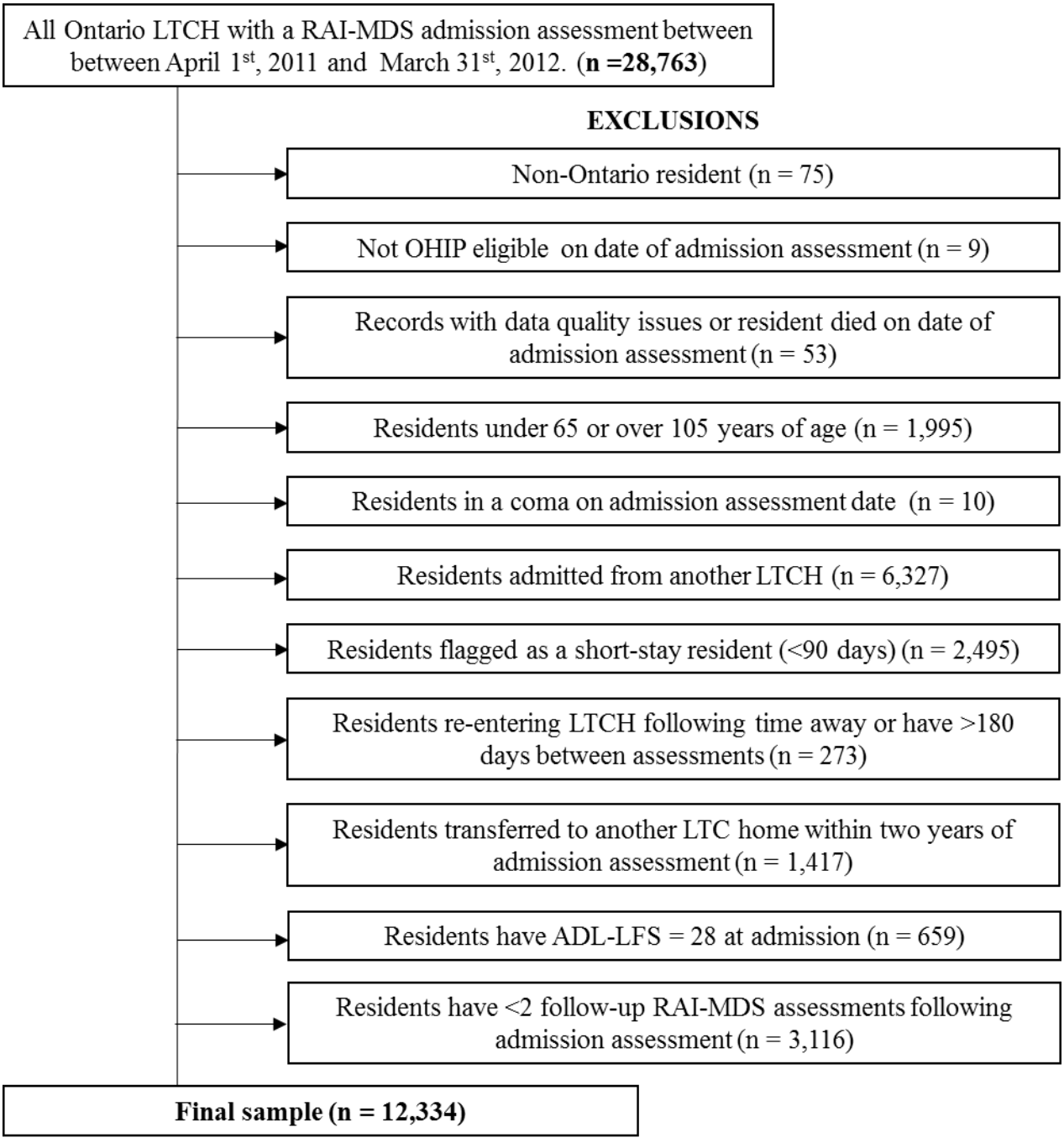
Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Pain							
None					Reference	Reference	Reference
Less than daily pain					0.18‡ (0.09, 0.27)	0.13† (0.04, 0.22)	0.12† (0.03, 0.21)
Daily or severe daily pain					0.62‡ (0.51, 0.72)	0.59‡ (0.49, 0.69)	0.56‡ (0.46, 0.67)
Pressure ulcer					2.91‡ (2.75, 3.06)	2.78‡ (2.63, 2.93)	2.72‡ (2.56, 2.87)
Urinary incontinence					4.34‡ (4.24, 4.44)	4.20‡ (4.10, 4.30)	4.22‡ (4.13, 4.32)
Visual impairment							
None					Reference	Reference	Reference
Moderate impairment					0.79‡ (0.71, 0.87)	0.74‡ (0.66, 0.82)	0.73‡ (0.65, 0.81)
Severe impairment					2.39‡ (2.24, 2.54)	2.42‡ (2.27, 2.56)	2.40‡ (2.25, 2.54)
Prevalent Chronic Conditions							
Arthritis						0.07 (-0.004, 0.15)	0.08* (0.002, 0.16)
Asthma						0.21† (0.06, 0.35)	0.20† (0.06, 0.34)
Cancer						-0.18‡	-0.18‡

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
						(-0.26, -0.10)	(-0.26, -0.10)
Chronic kidney disease						0.37‡ (0.27, 0.46)	0.35‡ (0.25, 0.44)
Coronary artery disease						-0.17‡ (-0.25, -0.09)	-0.17‡ (-0.25, -0.09)
COPD						-0.09 (-0.19, 0.0004)	-0.09 (-0.19, 0.0005)
Dementia						-0.23‡ (-0.34, -0.12)	-0.21‡ (-0.32, -0.10)
Diabetes						0.06 (-0.02, 0.14)	0.06 (-0.02, 0.14)
Epilepsy						0.47‡ (0.32, 0.62)	0.47‡ (0.32, 0.62)
Heart failure						0.40‡ (0.31, 0.49)	0.38‡ (0.29, 0.47)
Limb paralysis or amputation						1.99‡ (1.85, 2.13)	2.00‡ (1.86, 2.14)
Mood disorder						0.33‡ (0.26, 0.41)	0.35‡ (0.28, 0.43)
Parkinson’s disease						1.81‡ (1.68, 1.94)	1.82‡ (1.69, 1.94)

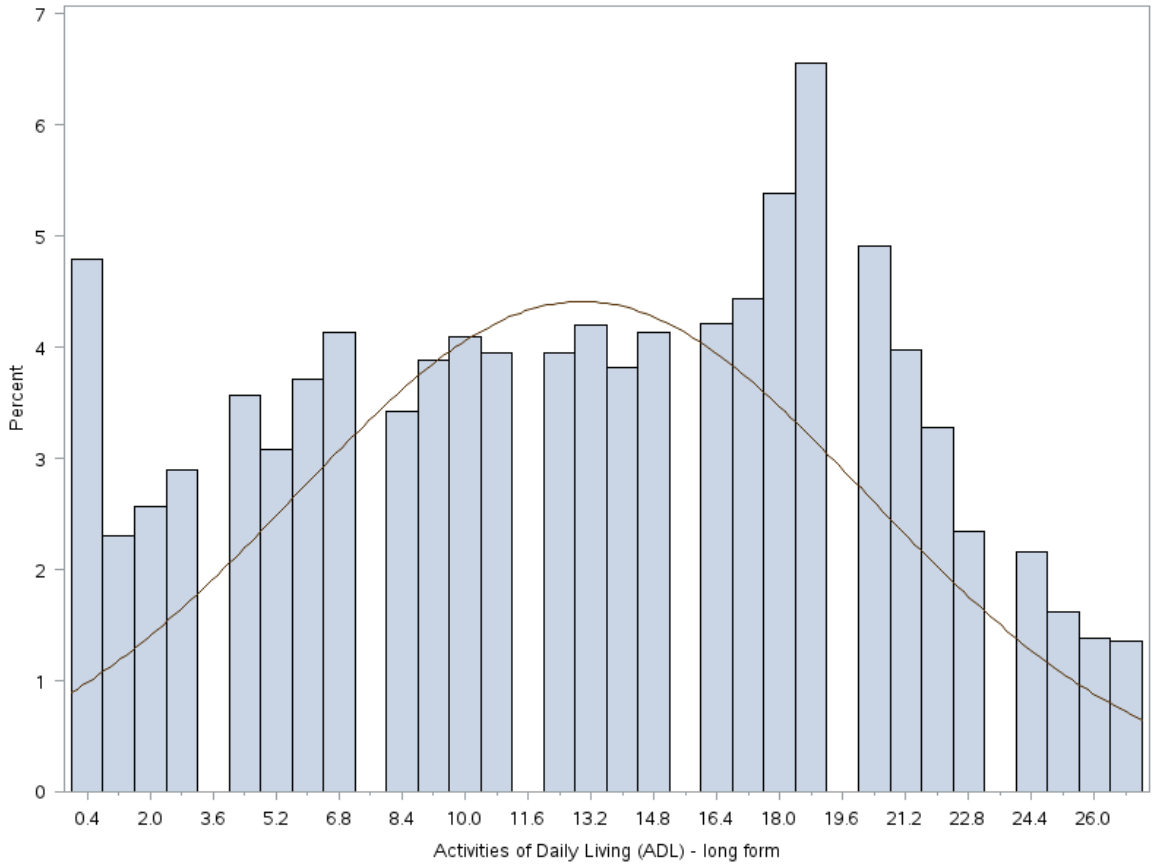
Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Peripheral vascular disease						-0.03 (-0.16, 0.10)	-0.03 (-0.16, 0.10)
Psychiatric conditions other than depression and dementia						-0.39‡ (-0.47, -0.31)	-0.39‡ (-0.48, -0.31)
Stroke						0.45‡ (0.37, 0.54)	0.46‡ (0.37, 0.54)
Days in LTC Prior to Index Date							
0 - 4 months							Reference
> 4 months - 12 months							-0.65‡ (-0.76, -0.53)
> 1 year - 2 years							-0.71‡ (-0.82, -0.59)
> 2 years - 3 years							-0.61‡ (-0.74, -0.47)
> 3 years							-0.29‡ (-0.40, -0.19)
R^2	0.004	0.006	0.01	0.02	0.61	0.62	0.63

***R*²**: The proportion of estimated total residual variance explained by variables in the model

Appendix 4.1: Study 3 Cohort Creation



Appendix 4.2: Distribution of Disability (ADL Long-Form Score) in Study Sample



Appendix Figure 4.2: Distribution of ADL Long-Form Score in Study 3 Sample at Admission

Although the ADL LFS is an ordinal measure of disability, it was treated as a continuous variable in this study. The graph above shows this treatment was appropriate, as the ADL LFS are fairly evenly distributed within the sample. Note that although the ADL LFS ranges from 0 – 28, the study sample only contained residents with ADL LFS scores of 0 – 27.

Median ADL LFS = 13;

75^{th} percentile = 19;

25^{th} percentile = 7.

Appendix 4.3: Protocol for Balance Test in Long-Term Care Residents

Test for Balance (7-day look back)

Intent: To record the resident's capacity of balance while standing (not walking) without an assistive device or assistance of a person.

Process

Preparation:

- Obtain a watch with a second hand to time the test.
- Pick a time to test the resident when he or she is likely to be at his or her best.
- Place a chair directly behind the resident in case the resident needs to sit down.
- Stand close to the resident while testing balance in order to catch or balance the resident, if necessary.
- If the resident is heavy or tall or seems frail, ask another staff person to stand by with you in case the resident needs assistance.
- Test balance without assistive devices (but with prostheses, if used). For residents who use walkers, make sure the walker is placed directly in front of the resident within easy reach in case it is needed for rebalancing.

Conducting the tests:

- **DO** each of the following tests (10 seconds each) on residents who are able to stand without physical help.
- **DO NOT** attempt to test residents who cannot stand by themselves. Code these residents as "3", Not able to attempt test without physical help.
- For persons with visual impairment who may not be able to see your demonstrations of feet placement, provide rich verbal descriptions

Position 1 -

"I would like you to stand with your feet together, side-by-side, like this (demonstrate as illustrated). [Note, in this and all tests, both feet should be firmly on the floor for support.]

"Do not move your feet until I say stop. Ready, OK, begin." If the resident is ABLE to maintain this position for 10 seconds, proceed to test resident in Position 2. **If the resident is NOT ABLE to maintain this position for 10 seconds, stop testing here.**

Position 2 -

"Now I would like you to stand with one foot halfway in front of the other like this" (demonstrate as illustrated).

"You may use either foot, whichever is more comfortable for you. Ready, OK, begin." If the resident is ABLE to maintain this position for 10 seconds, proceed to test resident in Position 3. **If the resident is NOT ABLE to do this, stop testing here.**

Position 3 -

"Now I would like you to stand with the heel of one foot in front of you touching the toes of the other foot like this (demonstrate as illustrated). You may use either

Coding:

0. **Maintained Position as Required in Test** - Resident was able to maintain all 3 standing positions for 10 seconds without moving feet out of position.

1. **Unsteady, but Able to Rebalance Self Without Physical Support** - Resident was unable to maintain one or more standing positions for 10 seconds each without moving feet out of position. Resident was unsteady but was able to rebalance self without physical support from others or from an assistive device in at least the first position.

2. **Partial Physical Support During Test, or Stands but Does Not Follow Directions for Test** - While the resident performed part of the activity, resident was unable to maintain one or more standing positions without physical support from other(s) or from an assistive device. This category also includes residents who can stand but are unable or refuse to follow your directions to perform a test of balance.

3. **Not Able to Attempt Test Without Physical Help** - Resident is not able to stand without physical help from another person or an assistive device.

Source:

http://www.aanac.org/docs/mds-3.0-rai-users-manual/11122_mds_3-0_chapter_3_-_section_g_v1-12.pdf?sfvrsn=10

Appendix 4.4: Likelihood Ratio Tests for Addition of Random Slopes, Intercepts to Models

The table below contains results from likelihood ratio tests comparing the maximized log likelihoods of models with a random intercept for long-term care homes, then a random coefficient for time added in a stepwise fashion to a model with a fixed coefficient for time and a random resident intercept. The findings from these test support the inclusion of random intercepts for long-term care homes and random coefficients for the effect of time on disablement.

Model Contents	**Random Effects**					**Likelihood Ratio Test**	
	$\sqrt{\psi_{11}^{(2)}}$	$\sqrt{\psi_{22}^{(2)}}$	$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\psi_{22}^{(2)})}$	$\sqrt{\psi_{11}^{(3)}}$	$\sqrt{\theta}$	**Likelihood test statistic (*L*)***	***p- value* of likelihood test**
Coefficient for time, random resident intercept.	6.69	N/A	N/A	N/A	4.10	-	-
Coefficient for time, random resident intercept, random long-term care home intercept.	6.40	N/A	N/A	1.93	4.10	459.1	0.0000
Random coefficient for time, random resident intercept, random long-term care home intercept.	6.64	0.34	-0.26	2.11	3.40	12813.0	0.0000

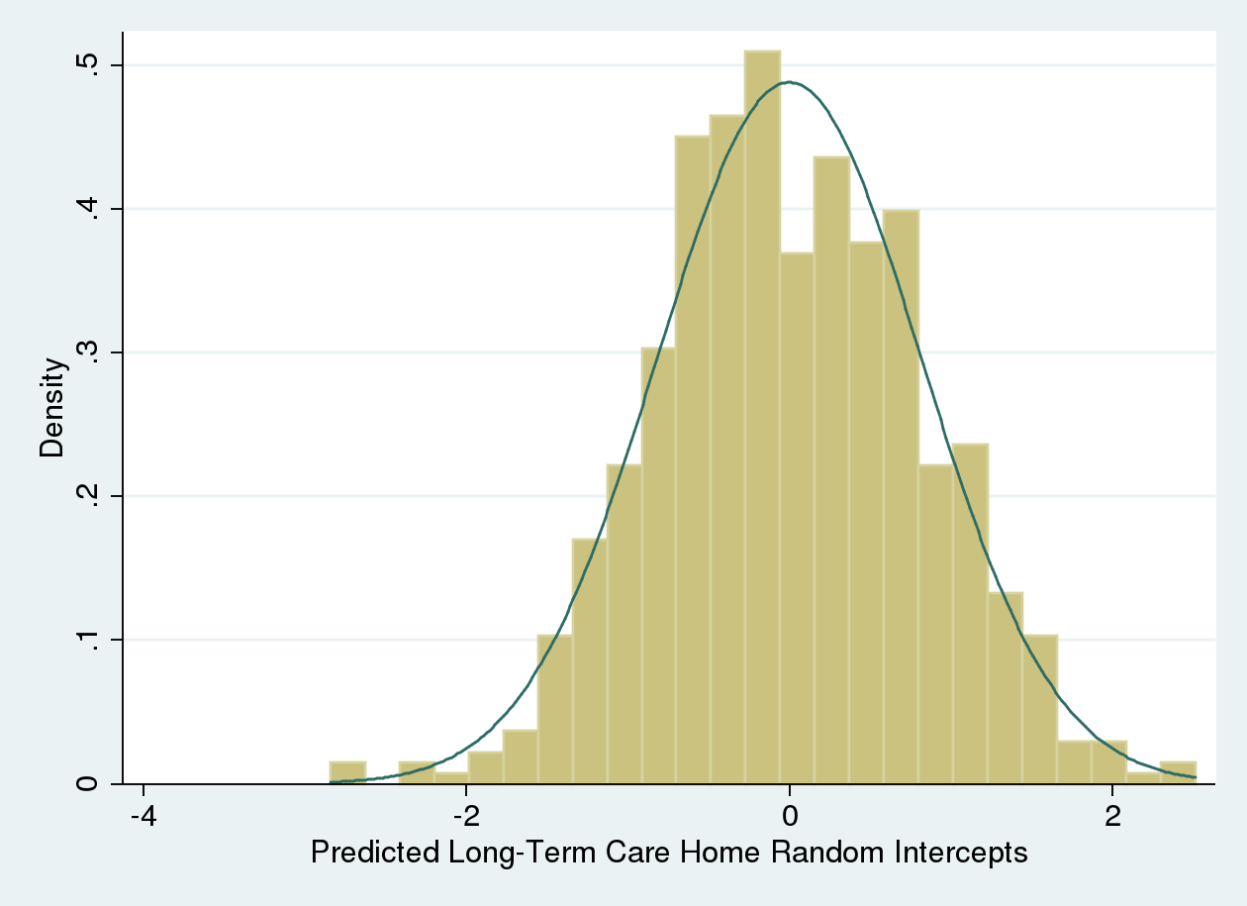
*Compared to model in row directly above.

Likelihood Ratio Test Statistic is:
$L = 2\ (l_1 - l_0)$

Where
l_1 = the maximized log likelihood for the model with the added random slope or coefficient
l_0 = the maximized log likelihood for the model without the added slope of coefficient

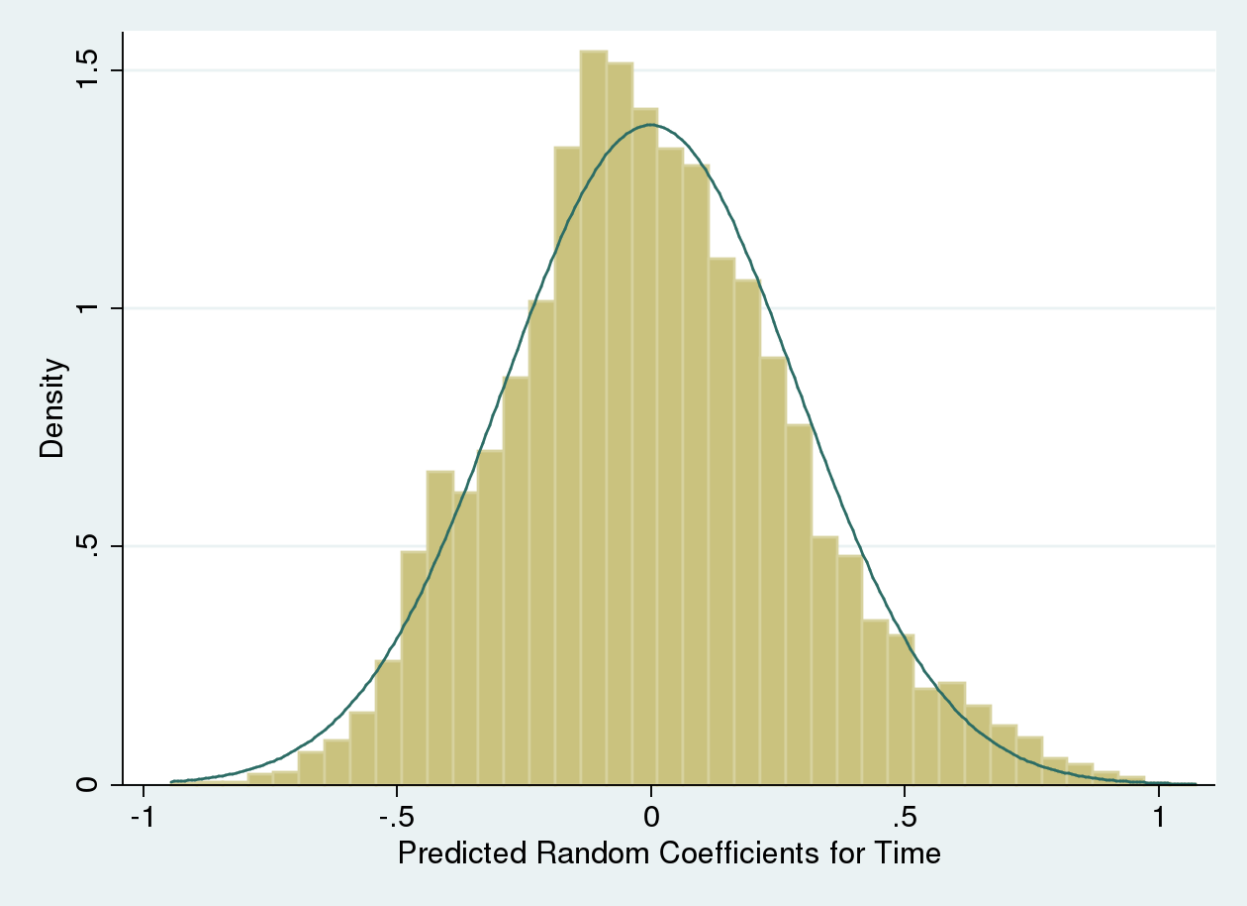
If *L* has a significant *p-value*, it is grounds for rejection of the null hypothesis that there is no between-resident variance in rate of disablement or between-home differences in disability at admission. Thus, the findings from this test indicate that inclusion of random coefficients for time and random intercepts for long-term care homes are justified in this sample.

Appendix 4.5: Distribution of Random Effects and Residuals for Study 3 Model 2



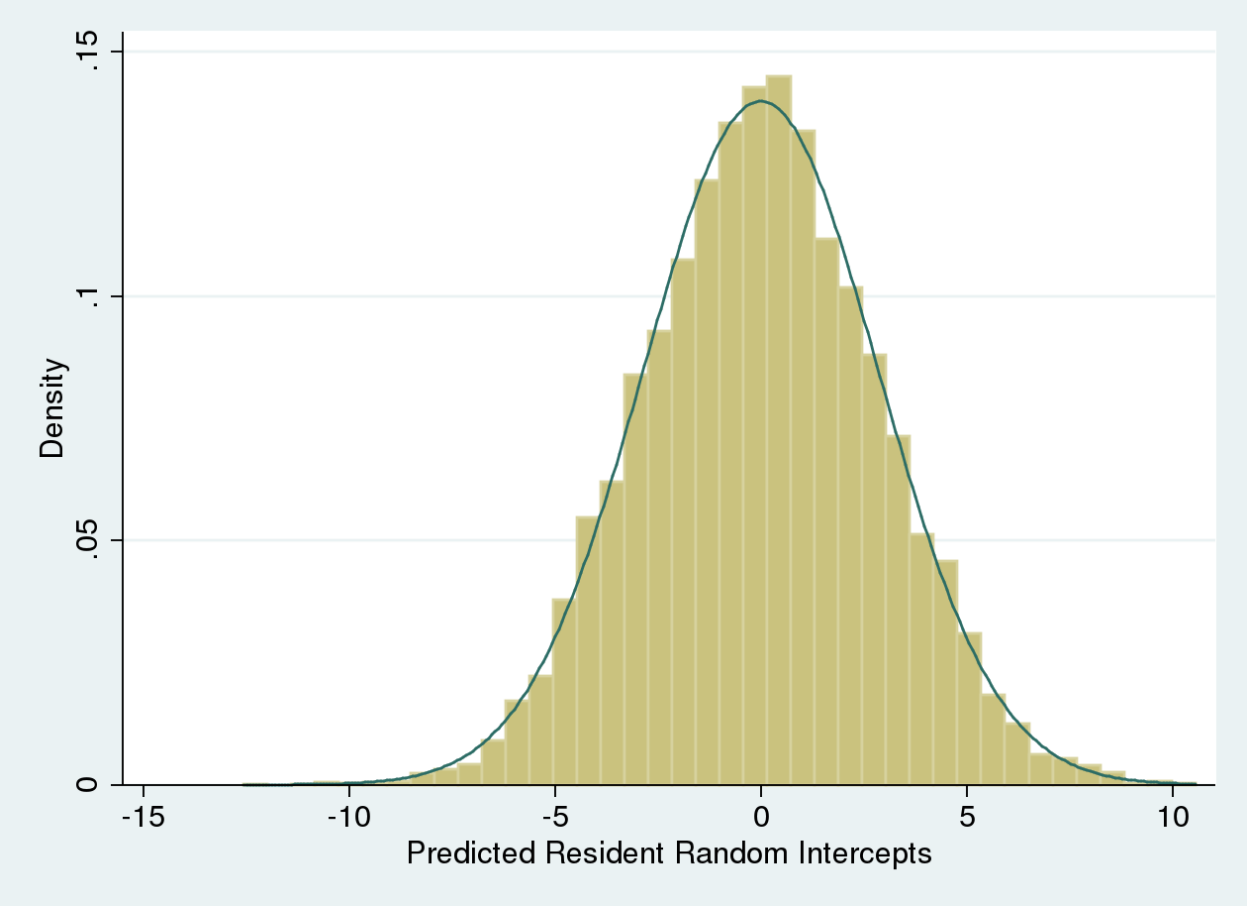
Appendix Figure 4.5a: Distribution of Long-Term Care Home Random Intercepts ($\zeta_k^{(3)}$) for Study 3 Model 2

One of the assumptions of hierarchical multivariable models is that random intercepts are normally distributed. The above figure illustrates that this assumption was met for the random long-term care home intercepts in Model 2 of Study 3.



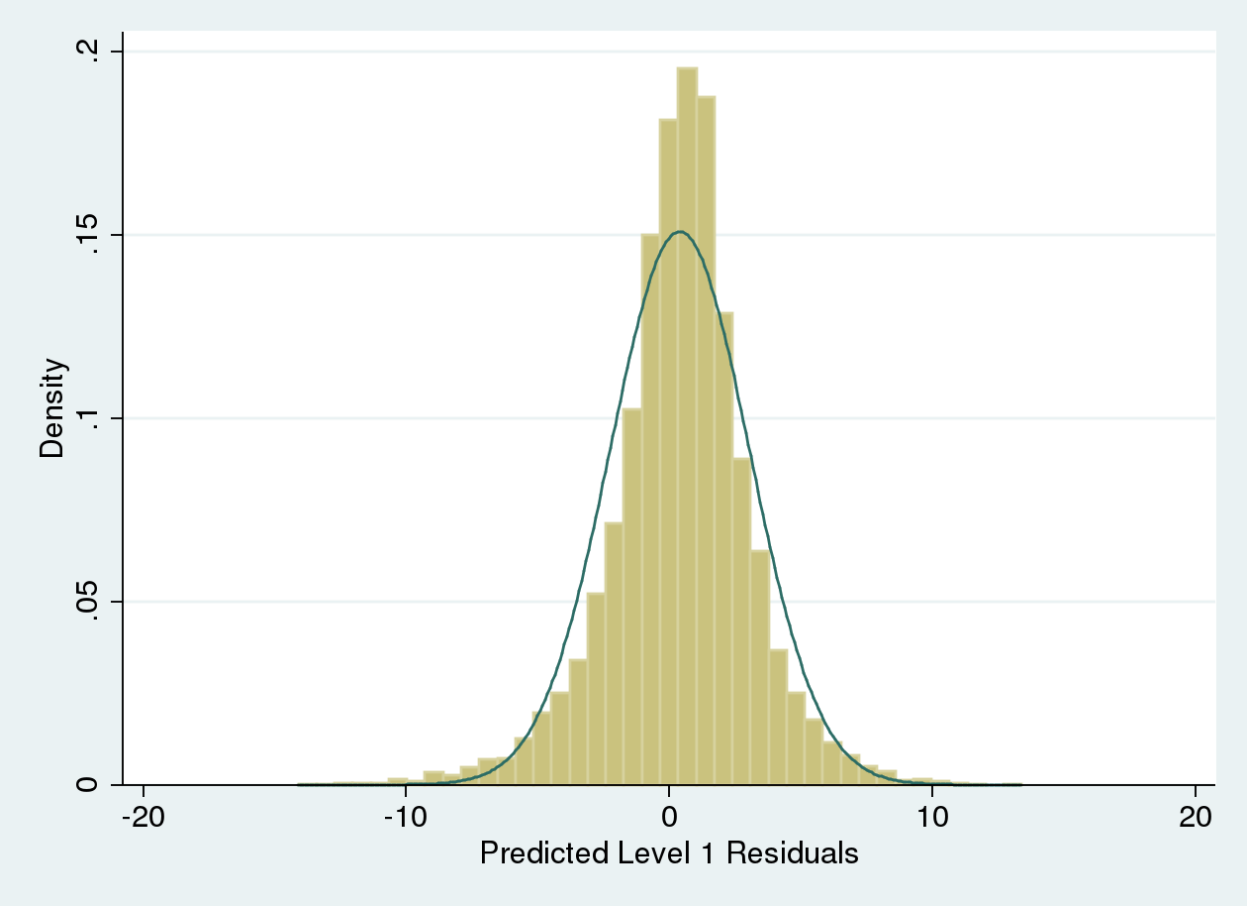
Appendix Figure 4.5b: Distribution of Resident Random Coefficients for Time ($\zeta_{2jk}^{(2)}$), Study 3 Model 2

One of the assumptions of hierarchical multivariable models is that random coefficients are normally distributed. In Model 2 of Study 3, this assumption was met.



Appendix Figure 4.5c: Distribution of Resident Random Intercepts ($\zeta_{1jk}^{(2)}$) for Study 3 Model 2

One of the assumptions of hierarchical multivariable models is that random intercepts are normally distributed. The above figure illustrates that this assumption was met for random resident intercepts in Model 2 of Study 3.



Appendix Figure 4.5d: Distribution of Level 1 Residuals (ε_{ijk}) for Study 3 Model 2

One of the assumptions of hierarchical multivariable models is that residuals are normally distributed. The above figure illustrates that this assumption was met for the between-assessment residuals in Model 2 of Study 3.

Appendix 4.6: No Value Added from Quadratic Time Term in Model 3 of Study 3

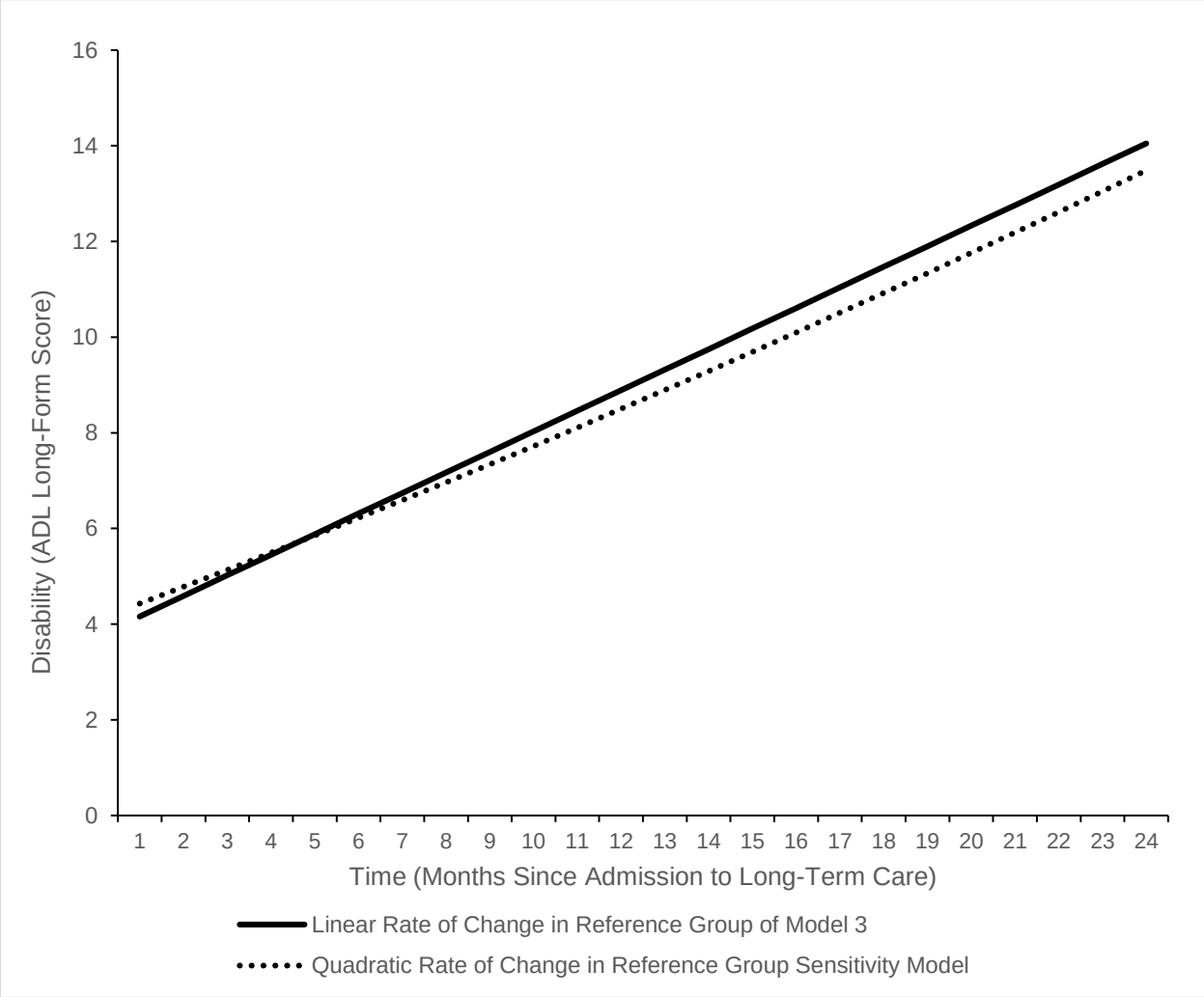


Figure 4.6: Comparison of linear versus quadratic rates of change in disability among residents in Study 3.

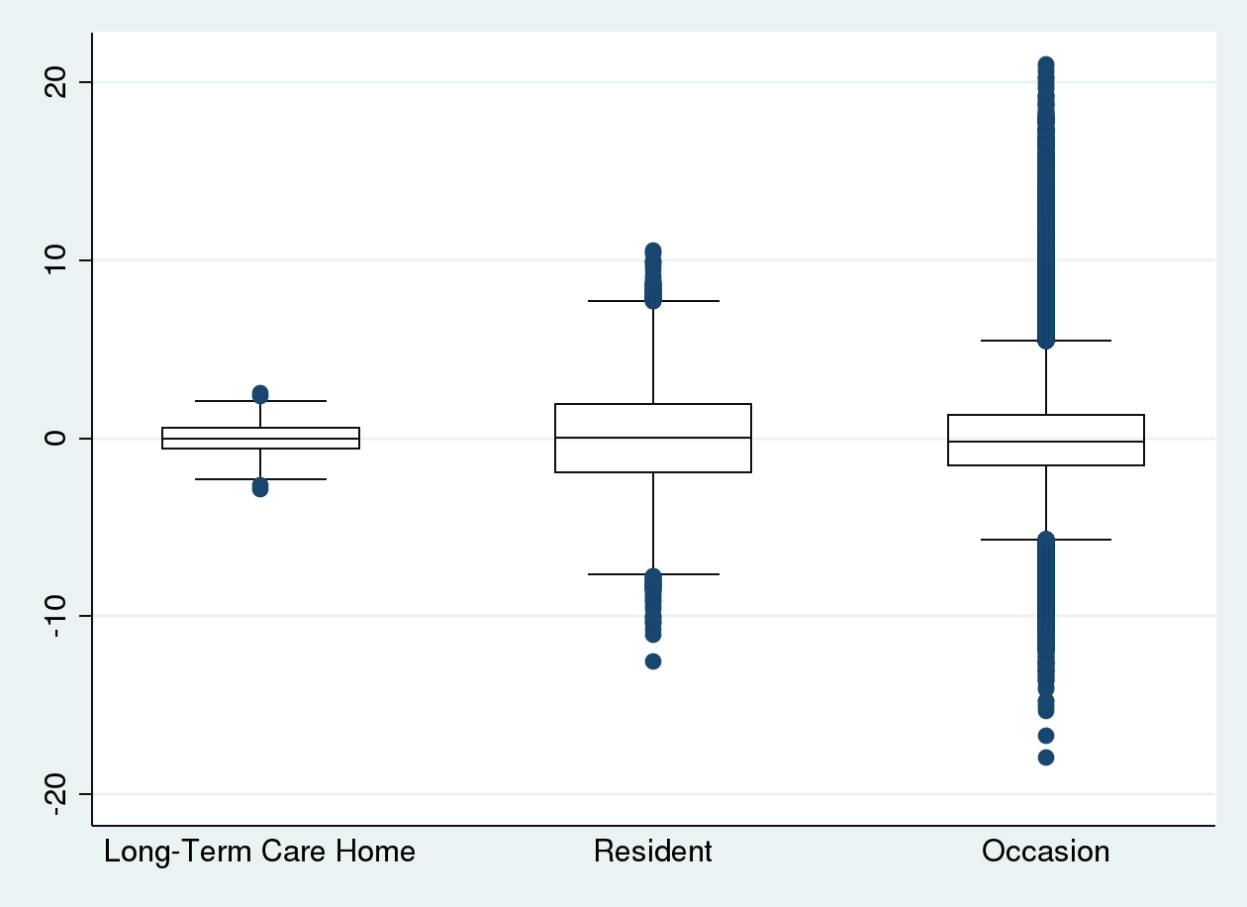
Figure 4.15 depicts the outputs from a version of Study 3 Model 3 that was re-run to include a fixed quadratic effect of time, without changing any other variables or model specifications. Although the quadratic term for time was statistically significant (0.004, 95%CI: 0.003, 0.005, p <0.0001), its addition to the model did not affect variance of any of the model components, nor did it significantly change coefficient estimates for interactions between exposures and time.

Appendix 4.7: Mean Disability Score at Admission for Residents Admitted from Different Locations

Given the important role of disability at admission in association with subsequent disablement, correlates of disability at admission are important to understand. The table below clearly illustrates that location of admission is strongly associated with disability at admission.

	N	**%**	**Mean ADL LFS (SD) at Admission**
Full Cohort	12,334	100	-
Admitted from:			
Private home (no home care)	3,664	29.7	10.68 (6.8)
Ambulatory health service or home care	1,526	12.4	11.63 (7.0)
Assisted living (residential care without 24 hour nursing care)	2,276	18.5	11.94 (6.8)
Complex continuing care, inpatient rehabilitation or psychiatry care	1,115	9.0	14.36 (7.3)
Inpatient acute care	3,753	30.4	15.93 (6.9)

Appendix 4.8: Boxplot of Random Long-Term Care Home Intercepts ($\zeta_k^{(3)}$), Random Resident Intercepts ($\zeta_{1jk}^{(2)}$) and Residuals for Assessments ε_{ijk}



Appendix Figure 4.8: Boxplot of Random Long-Term Care Home Intercepts ($\zeta k^{(3)}$), Random Resident Intercepts ($\zeta_{1jk}^{(2)}$) and Residuals for Assessments ε_{ijk} (from Model 3)

In Appendix Figure 4.8 above, "occasion" refers to RAI-MDS assessments. Only one resident per long-term care home was used to construct this figure. Outer bars indicate 95% confidence intervals and dots outside outer bars indicate outliers.

This figure shows that there is much more variability within LTCHs than between them, and variability in disability between residents is greater than variability within residents across assessments. There also appear to be numerous outlying residents with very high or very low

disability at admission. Note that random slopes ($\zeta_{2jk}^{(2)}$) are measured on a different scale than intercepts and were therefore not included in the above figure.

Appendix 4.9a: Prevalence of Balance Impairment, Moderate to Severe Cognitive Impairment and Daily or Severe Pain among Residents with Disability Above or Below the Median at Admission

The table below illustrates the distribution of residents with balance impairment, moderate severe to severe cognitive impairment and daily or severe daily pain, by disability score above or below the sample median at admission to long-term care. Compared with the distribution of these impairments in the whole sample, a larger proportion (21%) of residents with high disability at admission had balance impairment, whereas the proportion of residents with moderate to severe cognitive impairment and daily or severe pain are only slightly greater (7% and 3% respectively) among those with high disability at admission.

Geriatric Syndromes at Admission	**All Residents (%)**	**Residents with Disability Score 0 – 13 (%)**	**Residents with Disability Score 14 – 27 (%)**
	(n = 12,334)	**(n = 6, 229)**	**(n = 6,105)**
Balance Impairment			
Absent	4,544 (36.8)	3,593 (57.7)	951 (15.6)
Present	7,790 (63.2)	2,636 (42.3)	5,154 (84.4)
Moderate Severe to Severe Cognitive Impairment			
Absent	10,555 (85.6)	5,746 (92.2)	4809 (78.8)
Present	1,779 (14.4)	483 (7.8)	1,296 (21.2%)
Daily or Severe Daily Pain			
Absent	10,264 (83.2)	5,364 (86.1)	4,900 (80.3)
Present	2,070 (16.8)	865 (13.9)	1205 (19.7)

Appendix 4.9b: Fate of Residents in Sample between Admission and End of Two-Year Observation Period

Between admission and the end of two years observation, 4,213 (34%) of the 12,334 residents in the sample died. Most of them (70.3%) died in the long-term care home to which they were admitted, while 28.1% died in hospital. On the date of their deaths, a final ADL LFS score of 28 was imputed in their records. Of the 8,121 residents who remained alive for the two years of observation, only 4,109 had uninterrupted stays in their long-term care homes. Approximately 25% were hospitalized or admitted to inpatient services for a period of less than 180 days, while 2.5% were discharged home or to less intense services.

Departure from Long-Term Care Home	**Survived until the end of observation (n = 8,121)**		**Died during the observation period (n = 4,213)**	
	n	%	n	%
Acute hospitalization	2,011	24.7	1,183	28.1
Inpatient rehabilitation service, inpatient continuing care service, inpatient psychiatry service or other unclassified service.	85	1.0	22	0.5
Ambulatory health services, home care services, assisted living or private home	205	2.5	45	1.1
Total	2,301	28.3	1,250	29.7

Appendix 4.9c: Proportion of Residents with Prevalence of Balance Impairment, Moderate to Severe Cognitive Impairment and Daily or Severe Pain who Died During the Two-Year Follow-up, Compared with the Whole Sample

Of the 12,334 residents who were admitted to long-term care and survived long enough (approximately six months) to have two subsequent disability measures, 4,213 died during the study period. These individuals had a final ADL LFS value of 28 imputed on the date of death to reflect the precipitous drop in independence associated with death. Measures of disablement in these individuals were however based on fewer data points than among those residents who remained alive for the duration of the study period. The table below shows that a comparable proportion of residents with daily or severe daily pain died during follow-up to the whole sample, whereas a larger proportion of residents with balance impairment and moderate severe to severe cognitive impairment died. Based on this informative censoring, it is possible that relationships between balance impairment, moderate severe to severe cognitive impairment and disability are under-estimated.

Sample	Number at admission	Number (%) who died during 2-year follow-up
Whole sample	12,334	4,213 (34.2%)
Balance impairment	7,790	2,978 (38.2%)
Moderate Severe to Severe Cognitive Impairment	1,779	720 (40.5%)
Daily or Severe Daily Pain	2,070	713 (34.4%)

Appendix 4.10: Comparison of Residents in Sample to Those Excluded Due to Inadequate Follow-up Assessments

Appendix 4.1 shows that 3,116 residents who met all other inclusion criteria were excluded from the sample because they had fewer than two RAI-MDS assessments after their initial admission assessment. This means that all residents who died within six months of being admitted to a LTCH were excluded. The use of maximum likelihood estimation in hierarchical linear models assumes that the probability of missing outcome data is random, conditioning on the observed variables (Raudenbush & Bryk, 2002). But individuals most likely to experience rapid disablement are also at the highest risk of death within six months of admission (Gill, Hardy, & Williams, 2002; Warner & Brown, 2011). Thus, disability measures missing from residents who had fewer than two RAI-MDS assessments post-admission expected to be missing not at random (MNAR) (Enders, 2010). It is possible that this MNAR data resulted in underestimation of mean rate of disablement due to geriatric syndromes that are also associated with early mortality (Berry, Ngo, Samelson, & Kiel, 2010).

Residents who were omitted from the sample due to too few follow-up measures of disability had higher mean disability at admission (17.5, SD: 7.3) than those who were included in the sample (13.4, SD: 7.5). Table 4.10 compares the characteristics of the study sample with those excluded because they had fewer than two RAI-MDS assessments following their initial admission assessment. It shows that residents who were excluded due to inadequate follow-up were more likely to be male, be underweight, to have balance impairment, bowel and urinary incontinence, daily or severe daily pain, cancer, kidney disease, coronary artery disease, chronic obstructive pulmonary disease, diabetes and heart failure. Excluded residents had lower prevalence of dementia and Parkinson's disease than sample residents and comparable levels of moderate to severe cognitive impairment.

Appendix Table 4.10: Comparison of Sample Residents to Those Excluded Due to too Few Post-Admission RAI-MDS Assessments

Resident Characteristic	**Study Sample (n = 12,334) (%)**	**Residents Excluded with <2 Post-Admission Assessments (n = 3,116) (%)**
High versus low Disability at Admission		
Low (0 – 13)	50.5	29.9
High (14 – 27)	49.5	70.1
Age (years)		
65 – 74	10.7	9.8
75 – 84	37.1	33.0
85 – 94	46.2	49.5
95+	6.0	7.6
Sex		
Female	67.7	57.0
Male	32.3	43.0
Marital Status		
Married	30.1	33.6
Widowed	55.7	53.9
Never married/ Separated/Divorced	12.3	10.8
Missing	1.9	1.6
Pre-NH Neighborhood Income Quintile		
1 (low)	22.9	22.2
2	18.7	16.3
3	16.5	17.5
4	14.5	13.9
5 (high)	12.6	13.3
Missing	14.8	16.8
Prevalent Geriatric Syndromes		
Balance impairment	63.2	77.3
Bowel incontinence	30.4	44.2
Cognition		
Intact or borderline	26.8	28.5
Moderate impairment	58.8	53.5
Moderate-Severe/very severe impairment	14.4	18.0
Hearing impaired	14.3	16.5
BMI		

Resident Characteristic	Study Sample (n = 12,334) (%)	Residents Excluded with <2 Post-Admission Assessments (n = 3,116) (%)
BMI < 18.5	10.1	17.0
18.5 ≤ BMI ≤ 25	45.3	45.8
25 < BMI <30	27.2	45.8
BMI ≥ 30	17.4	15.0
Pain		
No pain	58.1	49.8
Less than daily pain	25.1	27.4
Daily or severe pain daily pain	16.8	22.8
Pressure ulcer	5.4	13.7
Urinary incontinence	55.8	62.0
Visual impairment		
Moderate impairment	33.5	36.6
Severe impairment	4.8	5.5
Prevalent Chronic Conditions		
Arthritis	47.8	47.8
Asthma	5.6	7.4
Cancer	34.9	43.6
Kidney disease	20.10	30.9
Coronary artery disease	34.9	44.5
COPD	16.0	26.5
Dementia	69.5	61.5
Diabetes	29.7	34.0
Epilepsy	3.5	3.3
Heart failure	21.9	37.3
Limb paralysis or amputation	14.6	15.9
Mood disorders	15.7	15.1
Parkinson’s disease	7.3	5.6
Peripheral vascular disease	3.6	4.2
Psychiatric conditions other than depression and dementia	21.6	20.5
Stroke	20.4	21.5

Appendix 4.11: All Model Coefficients from Study 3 Models

	Model 1	**Model 2**	**Model 3**
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Constant	4.38 (3.89, 4.87)‡	4.15 (3.66, 4.65)‡	4.16 (3.67, 4.65)‡
Time (months since admission)	0.32 (0.31, 0.33)‡	0.44 (0.42, 0.45)‡	0.43 (0.42, 0.45)‡
Activities of Daily Living Score at Admission			
0 – 13	Reference	Reference	Reference
14 – 27	7.76 (7.54, 7.97)‡	8.28 (8.06, 8.50)‡	8.29 (8.07, 8.52)‡
Age			
65 – 74	Reference	Reference	Reference
75 – 84	-0.05 (-0.30, 0.20)	-0.04 (-0.29, 0.21)	-0.04 (-0.29, 0.21)
85 – 94	0.08 (-0.19, 0.36)	0.10 (-0.18, 0.37)	0.10 (-0.18, 0.37)
95+	0.58 (0.20, 0.96)†	0.61 (0.22, 0.99)†	0.61 (0.22, 0.99)†
Sex			
Female	Reference	Reference	Reference
Male	-0.13 (-0.30, 0.04)	-0.12 (-0.29, 0.05)	-0.12 (-0.29, 0.05)
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.30 (-0.47, -0.13)†	-0.30 (-0.47, -0.13)†	-0.30 (-0.47, -0.13)†
Never married, separated or divorced	-0.42 (-0.65, -0.19)‡	-0.42 (-0.66, -0.19)‡	-0.42 (-0.66, -0.19) ‡
Missing data on marital status	-0.67 (-1.24, -0.09)*	-0.67 (-1.24, -0.09)*	-0.67 (-1.24, -0.09) *
Pre-Admission Neighborhood Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.23 (0.01, 0.44)*	0.23 (0.01, 0.44)*	0.23 (0.01, 0.44) *
3	0.20 (-0.03, 0.43)	0.20 (-0.03, 0.44)	0.20 (-0.03, 0.44)x
4	0.05 (-0.20, 0.30)	0.05 (-0.20, 0.30)	0.05 (-0.20, 0.30)x

	Model 1	Model 2	Model 3
	Est (95% CI)	Est (95% CI)	Est (95% CI)
5 (high)	0.35 (0.08, 0.62)*	0.35 (0.08, 0.62)*	0.35 (0.08, 0.62) *
Missing data on Pre-Admission Neighborhood Income Quintile	0.34 (0.08, 0.59)*	0.34 (0.08, 0.60)†	0.34 (0.09, 0.60) †
Prevalent Geriatric Syndromes			
Balance impairment	2.04 (1.86, 2.22)‡	2.04 (1.86, 2.22)‡	2.03 (1.84, 2.21)‡
Bowel incontinence	1.75 (1.57, 1.92)‡	1.74 (1.57, 1.92)‡	1.74 (1.57, 1.92)‡
Cognition			
Intact or borderline	Reference	Reference	Reference
Moderate impairment	1.04 (0.83, 1.24)‡	1.04 (0.84, 1.24)‡	1.04 (0.84, 1.24)‡
Moderate-Severe/very severe impairment	2.87 (2.58, 3.15)‡	2.88 (2.59, 3.16)‡	2.78 (2.49, 3.07)‡
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	-0.05 (-0.26, 0.16)	-0.05 (-0.26, 0.16)	-0.05 (-0.26, 0.16)
Body Mass Index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.13 (-0.38, 0.12)	-0.14 (-0.39, 0.12)	-0.14 (-0.39, 0.12)
25 < BMI <30	-0.23 (-0.49, 0.04)	-0.24 (-0.52, 0.03)	-0.24 (-0.50, 0.03)
BMI ≥ 30	0.03 (-0.26, 0.31)	0.01 (-0.27, 0.30)	0.01 (-0.27, 0.30)
Pain			
None	Reference	Reference	Reference
Less than daily pain	0.01 (-0.18, 0.19)	0.003 (-0.18, 0.19)	0.003 (-0.18, 0.19)
Daily or severe daily pain	0.33 (0.12, 0.54)†	0.33 (0.12, 0.53)†	0.39 (0.18, 0.60)†
Pressure ulcer	1.42 (1.12, 1.73)‡	1.44 (1.13, 1.74)‡	1.44 (1.13, 1.74)‡
Urinary incontinence	1.83 (1.65, 2.01)‡	1.83 (1.64, 2.01)‡	1.82 (1.64, 2.01)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.28 (0.12, 0.44)‡	0.28 (0.12, 0.43)‡	0.28 (0.12, 0.43)‡

	Model 1	Model 2	Model 3
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Severe impairment	1.13 (0.78, 1.48)‡	1.13 (0.78, 1.48)‡	1.13 (0.78, 1.48)‡
Prevalent Chronic Conditions			
Arthritis	0.02 (-0.12, 0.16)	0.02 (-0.12, 0.16)	0.02 (-0.13 0.16)
Asthma	-0.001 (-0.30, 0.30)	0.0003 (-0.30, 0.30)	-0.0001 (-0.30, 0.30)
Cancer	0.01 (-0.15, 0.16)	0.01 (-0.14, 0.17)	0.01 (-0.14, 0.17)
Coronary artery disease	-0.10 (-0.26, 0.06)	-0.10 (-0.26, 0.06)	-0.10 (-0.26, 0.06)
Chronic obstructive pulmonary disease	-0.25 (-0.45, -0.05)*	-0.24 (-0.45, -0.04)*	-0.24 (-0.45, -0.04)*
Dementia	0.08 (-0.08, 0.25)	0.08 (-0.08, 0.25)	0.08 (-0.08, 0.25)
Diabetes	0.10 (-0.05, 0.26)	0.11 (-0.05, 0.27)	0.11 (-0.05, 0.27)
Epilepsy	0.42 (0.03, 0.80)*	0.42 (0.04, 0.80)*	0.42 (0.03, 0.80)*
Heart failure	0.28 (0.09, 0.47)†	0.29 (0.10, 0.48)†	0.29 (0.10, 0.48)†
Kidney disease	0.26 (0.08, 0.43)†	0.26 (0.08, 0.44)†	0.26 (0.08, 0.44)†
Limb paralysis or amputation	-0.09 (-0.29, 0.10)	-0.10 (-0.30, 0.10)	-0.10 (-0.30, 0.10)
Mood disorder	-0.10 (-0.29, 0.08)	-0.10 (-0.29, 0.08)	-0.10 (-0.29, 0.08)
Parkinson's disease	1.11 (0.84, 1.37)‡	1.11 (0.84, 1.37)‡	1.11 (0.84, 1.37)‡
Peripheral vascular disease	-0.22 (-0.57, 0.14)	-0.22 (-0.57, 0.14)	-0.22 (-0.57, 0.14)
Psychiatric conditions other than depression and dementia	-0.11 (-0.28, 0.06)	-0.11 (-0.28, 0.06)	-0.11 (-0.28, 0.06)
Stroke	0.48 (0.31, 0.66)‡	0.48 (0.30, 0.66)‡	0.48 (0.30, 0.66) ‡
Interaction Terms			
Activities of Daily Living Score at Admission*time	N/A	-0.26 (-0.27, -0.24)‡	-0.26 (-0.28, -0.25) ‡
Balance impairment*time	N/A	N/A	0.01 (-0.01, 0.02)
Moderate-severe to severe cognitive impairment*time	N/A	N/A	0.04 (0.03, 0.06) ‡
Daily or severe daily pain*time	N/A	N/A	-0.03 (-0.05, -0.01)†

	Model 1	Model 2	Model 3
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Random Effects			
$\sqrt{\psi_{11}^{(2)}}$	3.36	3.35	3.35
$\sqrt{\psi_{22}^{(2)}}$	0.36	0.33	0.33
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$	-0.01	0.02	0.02
$\sqrt{\psi_{11}^{(3)}}$	1.10	1.10	1.10
$\sqrt{\theta}$	3.39	3.39	3.39

*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi_{11}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of random intercept $\zeta_{1jk}^{(2)}$
$\sqrt{\psi_{22}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance in random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$ = Covariance of random intercept $\zeta_{1jk}^{(2)}$ and random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{11}^{(3)}}$ = Between-home variance of random intercept $\zeta_{k}^{(3)}$
$\sqrt{\theta}$ = Between-assessment, within-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of level-1 residuals ε_{ijk}
Model 1: Contains random intercepts for residents and long-term care homes, random coefficient for time + resident demographic characteristics and morbidity burden at admission to LTC (t1). Coefficients represent adjusted relationship between variable and resident disability at admission to long-term care.
Model 2: Contains Model 1 + interaction term for Activities of Daily Living (ADL) score at admission and time. Main effects coefficients represent adjusted relationship between variable and resident disability at admission to long-term care. Interaction terms represent association between ADL score at admission and resident disablement over two years.
Model 3: Contains Model 2 + interaction terms for balance impairment, moderate to severe cognitive impairment and daily or severe daily pain and time. Main effects coefficients represent adjusted relationship between variable and resident disability at admission to long-term care. Interaction terms represent association between geriatric syndromes and resident disablement over two years.

Appendix 4.12: Sensitivity of Model 3 Estimates to Imputation for Death and Complete Case Analysis

For the 4,213 residents who died during the observation period, a final disability measure of 28 was imputed on the date of their death. The output in the table below indicates that this imputation had no effect on the main findings regarding the relationship between disability and geriatric syndromes at admission with disablement over time. Examination the random effects reveals that not imputing the highest disability score for death yields a sample with slightly more between-resident variance in admission disability score, less between-resident variance in disablement over time and less within-resident variance in disability across assessments.

Figure 4.12 illustrates that when Study 3 is conducted as a complete case analysis (excluding the 4,213 residents who died during follow-up), the adjusted rate of disablement in the reference group is significantly slower (0.29/month) and the difference in rate of disablement associated with having high disability is less. This finding suggests that the mortality selection in Study 3 because sample residents were required to have at least two post-admission assessments could have also led to under-estimation of exposure effects on disablement, and rate of disablement overall.

	Model 3 (n = 12, 334)	**Model 3 Excluding Residents Who Died Within Two Years of Admission** (n = 8, 171)	**Model 3 without Imputation for Death** (n = 12, 334)
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Constant	4.16 (3.67, 4.65)‡	4.12 (3.55, 4.69)‡	4.38 (3.90, 4.86)‡
Time (months since admission)	0.43 (0.42, 0.45)‡	0.25 (0.24, 0.26)‡	0.33 (0.31, 0.34)‡
Activities of Daily Living Score at Admission			
0 – 13	Reference	Reference	Reference
14 – 27	8.29 (8.07, 8.52)‡	8.20 (7.95, 8.46)‡	8.27 (8.05, 8.48)‡
Age			
65 – 74	Reference	Reference	Reference
75 – 84	-0.04 (-0.29, 0.21)	-0.10 (-0.38, 0.17)	-0.05 (-0.29, 0.19)
85 – 94	0.10 (-0.18, 0.37)	-0.04 (-0.33, 0.26)	0.08 (-0.19, 0.34)
95+	0.61 (0.22, 0.99)†	0.33 (-0.13, 0.79)	0.57 (0.20, 0.93)†

	Model 3 (n = 12, 334)	**Model 3 Excluding Residents Who Died Within Two Years of Admission** (n = 8, 171)	**Model 3 without Imputation for Death** (n = 12, 334)
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Sex			
Female	Reference	Reference	Reference
Male	-0.12 (-0.29, 0.05)	-0.28 (-0.49, -0.07)†	-0.15 (-0.32, 0.02)
Marital Status			
Married	Reference	Reference	Reference
Widowed	-0.30 (-0.47, -0.13)†	-0.28 (-0.49, -0.07)†	-0.29 (-0.45, -0.12)†
Never married, separated or divorced	-0.42 (-0.66, -0.19)‡	-0.31 (-0.59, -0.03)*	-0.41 (-0.64, -0.19)‡
Missing data on marital status	-0.67 (-1.24, -0.09)*	-0.65 (-1.28, -0.03)*	-0.71 (-1.27, -0.15)*
Pre-Admission Neighborhood Income Quintile			
1 (low)	Reference	Reference	Reference
2	0.23 (0.01, 0.44)*	0.15 (-0.11, 0.41)	0.19 (-0.02, 0.39)
3	0.20 (-0.03, 0.44)	0.23 (-0.05, 0.52)	0.17 (-0.05, 0.40)
4	0.05 (-0.20, 0.30)	-0.01 (-0.29, 0.26)	0.02 (-0.22, 0.25)
5 (high)	0.35 (0.08, 0.62)*	0.40 (0.11, 0.70)†	0.33 (0.07, 0.59)*
Missing data on Pre-Admission Neighborhood Income Quintile	0.34 (0.09, 0.60)†	0.14 (-0.16, 0.45)	0.31 (0.06, 0.56)*
Prevalent Geriatric Syndromes			
Balance impairment	2.03 (1.84, 2.21)‡	1.95 (1.73, 2.18)‡	2.04 (1.87, 2.22)‡
Bowel incontinence	1.74 (1.57, 1.92)‡	1.67 (1.45, 1.88)‡	1.73 (1.56, 1.90)‡
Cognition			
Intact or borderline	Reference	Reference	Reference
Moderate impairment	1.04 (0.84, 1.24)‡	1.12 (0.87, 1.36)‡	1.04 (0.85, 1.24)‡
Moderate-Severe or very severe impairment	2.78 (2.49, 3.07)‡	2.89 (2.53, 3.25)‡	2.73 (2.45, 3.01)‡
Hearing impairment			
None	Reference	Reference	Reference
Hearing impaired	-0.05 (-0.26, 0.16)	0.06 (-0.32, 0.20)	-0.07 (-0.27, 0.14)
Body Mass Index (BMI)			
BMI < 18.5	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.14 (-0.39, 0.12)	-0.04 (-0.36, 0.28)	-0.12 (-0.36, 0.13)
25 < BMI <30	-0.24 (-0.50, 0.03)	-0.07 (-0.41, 0.27)	-0.20 (-0.46, 0.06)
BMI ≥ 30	0.01 (-0.27, 0.30)	0.13 (-0.22, 0.50)	0.05 (-0.23, 0.33)
Pain			
None	Reference	Reference	Reference

	Model 3 (n = 12, 334)	**Model 3 Excluding Residents Who Died Within Two Years of Admission** (n = 8, 171)	**Model 3 without Imputation for Death** (n = 12, 334)
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Less than daily pain	0.003 (-0.18, 0.19)	0.04 (-0.18, 0.26)	0.02 (-0.16, 0.20)
Daily or severe daily pain	0.39 (0.18, 0.60)†	0.26 (0.01, 0.52)*	0.40 (0.19, 0.60)‡
Pressure ulcer	1.44 (1.13, 1.74)‡	1.41 (1.03, 1.80)‡	1.46 (1.16, 1.76)‡
Urinary incontinence	1.82 (1.64, 2.01)‡	1.95 (1.73, 2.17)‡	1.84 (1.66, 2.02)‡
Visual impairment			
None	Reference	Reference	Reference
Moderate impairment	0.28 (0.12, 0.43)‡	0.23 (0.05, 0.42)†	0.28 (0.12, 0.43)‡
Severe impairment	1.13 (0.78, 1.48)‡	1.06 (0.61, 1.52)‡	1.14 (0.80, 1.48)‡
Prevalent Chronic Conditions			
Arthritis	0.02 (-0.13 0.16)	0.06 (-0.11, 0.23)	0.01 (-0.12, 0.15)
Asthma	-0.0001 (-0.30, 0.30)	-0.16 (-0.55, 0.22)	-0.03 (-0.32, 0.26)
Cancer	0.01 (-0.14, 0.17)	-0.05 (-0.24, 0.14)	-0.01 (-0.16, 0.14)
Coronary artery disease	-0.10 (-0.26, 0.06)	-0.16 (-0.36, 0.03)	-0.10 (-0.26, 0.05)
Chronic obstructive pulmonary disease	-0.24 (-0.45, -0.04)*	-0.50 (-0.75, -0.25)‡	-0.22 (-0.42, -0.03)*
Dementia	0.08 (-0.08, 0.25)	0.20 (0.001, 0.40)*	0.08 (-0.08, 0.25)
Diabetes	0.11 (-0.05, 0.27)	0.03 (-0.15, 0.22)	0.08 (-0.07, 0.24)
Epilepsy	0.42 (0.03, 0.80)*	0.46 (0.002, 0.92)*	0.42 (0.04, 0.79)*
Heart failure	0.29 (0.10, 0.48)†	0.09 (-0.14, 0.32)	0.23 (0.05, 0.41)*
Kidney disease	0.26 (0.08, 0.44)†	0.39 (0.17, 0.62)‡	0.27 (0.10, 0.44)†
Limb paralysis or amputation	-0.10 (-0.30, 0.10)	0.01 (-0.22, 0.25)	-0.06 (-0.26, 0.13)
Mood disorder	-0.10 (-0.29, 0.08)	-0.02 (-0.25, 0.21)	-0.10 (-0.29, 0.09)
Parkinson's disease	1.11 (0.84, 1.37)‡	1.28 (0.94, 1.61)‡	1.15 (0.89, 1.41)‡
Peripheral vascular disease	-0.22 (-0.57, 0.14)	0.06 (-0.37, 0.50)	-0.20 (-0.54, 0.15)
Psychiatric conditions other than depression and dementia	-0.11 (-0.28, 0.06)	-0.18 (-0.38, 0.03)	-0.11 (-0.27, 0.06)
Stroke	0.48 (0.30, 0.66)‡	0.51 (0.29, 0.72)‡	0.49 (0.32, 0.67)‡
Interaction Terms			
Activities of Daily Living Score at Admission*time	-0.26 (-0.28, -0.25)‡	-0.19 (-0.20, -0.18)‡	-0.24 (-0.25, -0.23)‡
Balance impairment*time	0.01 (-0.01, 0.02)	-0.02 (-0.03, -0.003)*	-0.01 (-0.02, 0.01)

	Model 3 (n = 12, 334)	**Model 3 Excluding Residents Who Died Within Two Years of Admission** (n = 8, 171)	**Model 3 without Imputation for Death** (n = 12, 334)
	Est (95% CI)	Est (95% CI)	Est (95% CI)
Moderate-severe to severe cognitive impairment*time	0.04 (0.03, 0.06)‡	0.07 (0.05, 0.08)‡	0.06 (0.05, 0.08)‡
Daily or severe daily pain*time	-0.03 (-0.05, -0.01)†	-0.03 (-0.05, -0.02)‡	-0.04 (-0.05, -0.02)‡
Random Effects			
$\sqrt{\psi_{11}^{(2)}}$	3.35	3.46	3.39
$\sqrt{\psi_{22}^{(2)}}$	0.33	0.23	0.26
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$	0.02	-0.04	0.04
$\sqrt{\psi_{11}^{(3)}}$	1.10	1.17	1.10
$\sqrt{\theta}$	3.39	2.64	2.83

*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi_{11}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of random intercept $\zeta_{1jk}^{(2)}$
$\sqrt{\psi_{22}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance in random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$ = Covariance of random intercept $\zeta_{1jk}^{(2)}$ and random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{11}^{(3)}}$ = Between-home variance of random intercept $\zeta_{k}^{(3)}$
$\sqrt{\theta}$ = Between-assessment, within-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of level-1 residuals ε_{ijk}

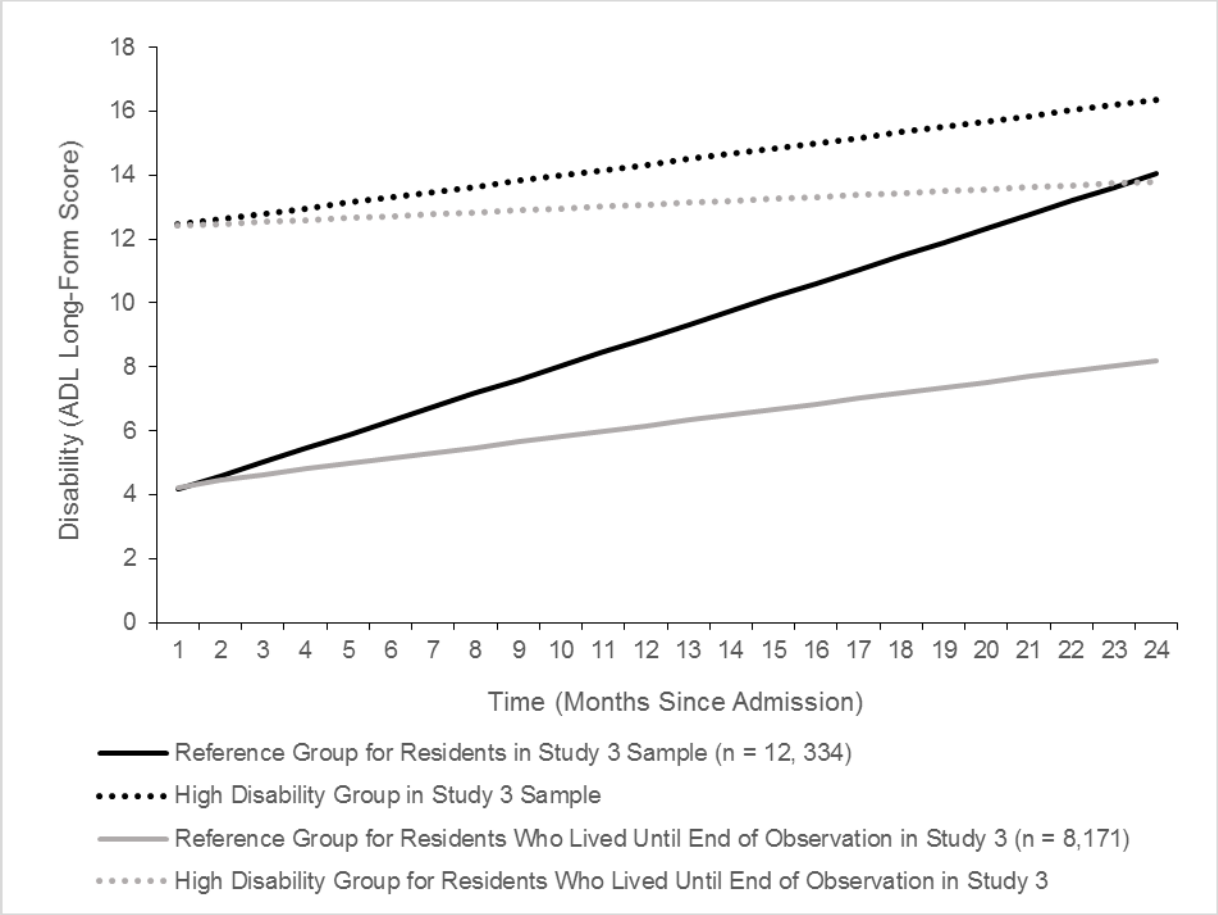


Figure 4.12: Effect of Complete Case Analyses on Rate of Disablement in Reference Group versus Residents with High Disability at Admission, based on contents of Table 4.12.

Appendix 4.13: Sensitivity of Model 3 Estimates to Coding of Chronic Conditions Using Only RAI-MDS Admission Assessment Data

In Study 3, chronic conditions present at admission were coded using exclusively claims data from OHIP or DAD from the five years prior to admission. The output in the model below confirms that coding of chronic conditions based on those indicated in the admission RAI-MDS assessment does not affect main findings.

	Model 3	**Model 3 with chronic conditions coded from RAI-MDS**
	Est (95% CI)	Est (95% CI)
Constant	4.16 (3.67, 4.65)‡	4.20 (3.71, 4.69)‡
Time (months since admission)	0.43 (0.42, 0.45)‡	0.43 (0.42, 0.45)‡
Activities of Daily Living Score at Admission		
0 – 13	Reference	Reference
14 – 27	8.29 (8.07, 8.52)‡	8.29 (8.07, 8.51)‡
Age		
65 – 74	Reference	Reference
75 – 84	-0.04 (-0.29, 0.21)	-0.02 (-0.26, 0.23)
85 – 94	0.10 (-0.18, 0.37)	0.13 (-0.14, 0.41)
95+	0.61 (0.22, 0.99)†	0.67 (0.29, 1.05)†
Sex		
Female	Reference	Reference
Male	-0.12 (-0.29, 0.05)	-0.18 (-0.35, -0.004)*
Marital Status		
Married	Reference	Reference
Widowed	-0.30 (-0.47, -0.13)†	-0.29 (-0.46, -0.11)†
Never married, separated or divorced	-0.42 (-0.66, -0.19)‡	-0.42 (-0.65, -0.19)‡
Missing data on marital status	-0.67 (-1.24, -0.09)*	-0.61 (-1.19, -0.04)*
Pre-Admission Neighborhood Income Quintile		
1 (low)	Reference	Reference
2	0.23 (0.01, 0.44)*	0.24 (0.02, 0.45)*
3	0.20 (-0.03, 0.44)	0.21 (-0.02, 0.44)
4	0.05 (-0.20, 0.30)	0.07 (-0.18, 0.31)
5 (high)	0.35 (0.08, 0.62)*	0.35 (0.08, 0.61)*

	Model 3	Model 3 with chronic conditions coded from RAI-MDS
	Est (95% CI)	Est (95% CI)
Missing data on Pre-Admission Neighborhood Income Quintile	0.34 (0.09, 0.60)†	0.36 (0.10, 0.62)†
Prevalent Geriatric Syndromes		
Balance impairment	2.03 (1.84, 2.21)‡	2.01 (1.83, 2.19)‡
Bowel incontinence	1.74 (1.57, 1.92)‡	1.73 (1.56, 1.91)‡
Cognition		
Intact or borderline	Reference	Reference
Moderate impairment	1.04 (0.84, 1.24)‡	1.03 (0.82, 1.25)‡
Moderate-Severe or very severe impairment	2.78 (2.49, 3.07)‡	2.76 (2.46, 3.06)‡
Hearing impairment		
None	Reference	Reference
Hearing impaired	-0.05 (-0.26, 0.16)	-0.06 (-0.27, 0.15)
Body Mass Index (BMI)		
BMI < 18.5	Reference	Reference
18.5 ≤ BMI ≤ 25	-0.14 (-0.39, 0.12)	-0.11 (-0.36, 0.14)
25 < BMI <30	-0.24 (-0.50, 0.03)	-0.21 (-0.48, 0.06)
BMI ≥ 30	0.01 (-0.27, 0.30)	0.06 (-0.23, 0.35)
Pain		
None	Reference	Reference
Less than daily pain	0.003 (-0.18, 0.19)	-0.01 (-0.19, 0.18)
Daily or severe daily pain	0.39 (0.18, 0.60)†	0.41 (0.20, 0.63)‡
Pressure ulcer	1.44 (1.13, 1.74)‡	1.46 (1.15, 1.76)‡
Urinary incontinence	1.82 (1.64, 2.01)‡	1.82 (1.64, 2.01)‡
Visual impairment		
None	Reference	Reference
Moderate impairment	0.28 (0.12, 0.43)‡	0.27 (0.11, 0.42)†
Severe impairment	1.13 (0.78, 1.48)‡	1.14 (0.79, 1.49)‡
Prevalent Chronic Conditions		
Arthritis	0.02 (-0.13 0.16)	0.0001 (-0.15, 0.15)
Asthma	-0.0001 (-0.30, 0.30)	-0.18 (-0.56, 0.19)
Cancer	0.01 (-0.14, 0.17)	-0.08 (-0.33, 0.16)
Coronary artery disease	-0.10 (-0.26, 0.06)	-0.02 (-0.26, 0.21)
Chronic obstructive pulmonary disease	-0.24 (-0.45, -0.04)*	-0.03 (-0.24, 0.17)

	Model 3	Model 3 with chronic conditions coded from RAI-MDS
	Est (95% CI)	Est (95% CI)
Dementia	0.08 (-0.08, 0.25)	0.04 -0.13, 0.21)
Diabetes	0.11 (-0.05, 0.27)	0.05 (-0.11, 0.21)
Epilepsy	0.42 (0.03, 0.80)*	0.44 (0.05, 0.84)*
Heart failure	0.29 (0.10, 0.48)†	0.02 (-0.20, 0.24)
Kidney disease	0.26 (0.08, 0.44)†	0.21 (-0.02, 0.45)
Limb paralysis or amputation	-0.10 (-0.30, 0.10)	1.17 (0.82, 1.52)‡
Mood disorder	-0.10 (-0.29, 0.08)	0.03 (-0.13, 0.21)
Parkinson's disease	1.11 (0.84, 1.37)‡	1.17 (0.90, 1.44)‡
Peripheral vascular disease	-0.22 (-0.57, 0.14)	-0.22 (-0.49, 0.06)
Psychiatric conditions other than depression and dementia	-0.11 (-0.28, 0.06)	-0.48 (-0.73, -0.22)‡
Stroke	0.48 (0.30, 0.66)‡	0.29 (0.10, 0.48)†
Interaction Terms		
Activities of Daily Living Score at Admission*time	-0.26 (-0.28, -0.25)‡	-0.26 (-0.28, -0.25)‡
Balance impairment*time	0.01 (-0.01, 0.02)	0.01 (-0.01, 0.02)
Moderate-severe to severe cognitive impairment*time	0.04 (0.03, 0.06)‡	0.04 (0.03, 0.06)‡
Daily or severe daily pain*time	-0.03 (-0.05, -0.01)†	-0.03 (-0.05, -0.01)†
Random Effects		
$\sqrt{\psi_{11}^{(2)}}$	3.35	3.35
$\sqrt{\psi_{22}^{(2)}}$	0.33	0.33
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$	0.02	0.02
$\sqrt{\psi_{11}^{(3)}}$	1.10	1.10
$\sqrt{\theta}$	3.39	3.39

*p-value <0.05
†p-value <0.01
‡p-value <0.0001
$\sqrt{\psi_{11}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of random intercept $\zeta_{1jk}^{(2)}$
$\sqrt{\psi_{22}^{(2)}}$ = Between-resident, within baseline ADL group (0-13 vs. 14-27), within home variance in random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{21}^{(2)}}/\sqrt{(\psi_{11}^{(2)}\ \psi_{22}^{(2)})}$ = Covariance of random intercept $\zeta_{1jk}^{(2)}$ and random slope $\zeta_{2jk}^{(2)}$
$\sqrt{\psi_{11}^{(3)}}$ = Between-home variance of random intercept $\zeta_{k}^{(3)}$
$\sqrt{\theta}$ = Between-assessment, within-resident, within baseline ADL group (0-13 vs. 14-27), within home variance of level-1 residuals ε_{ijk}

Appendix 4.14: Possible Mechanisms Behind Study 3 Findings

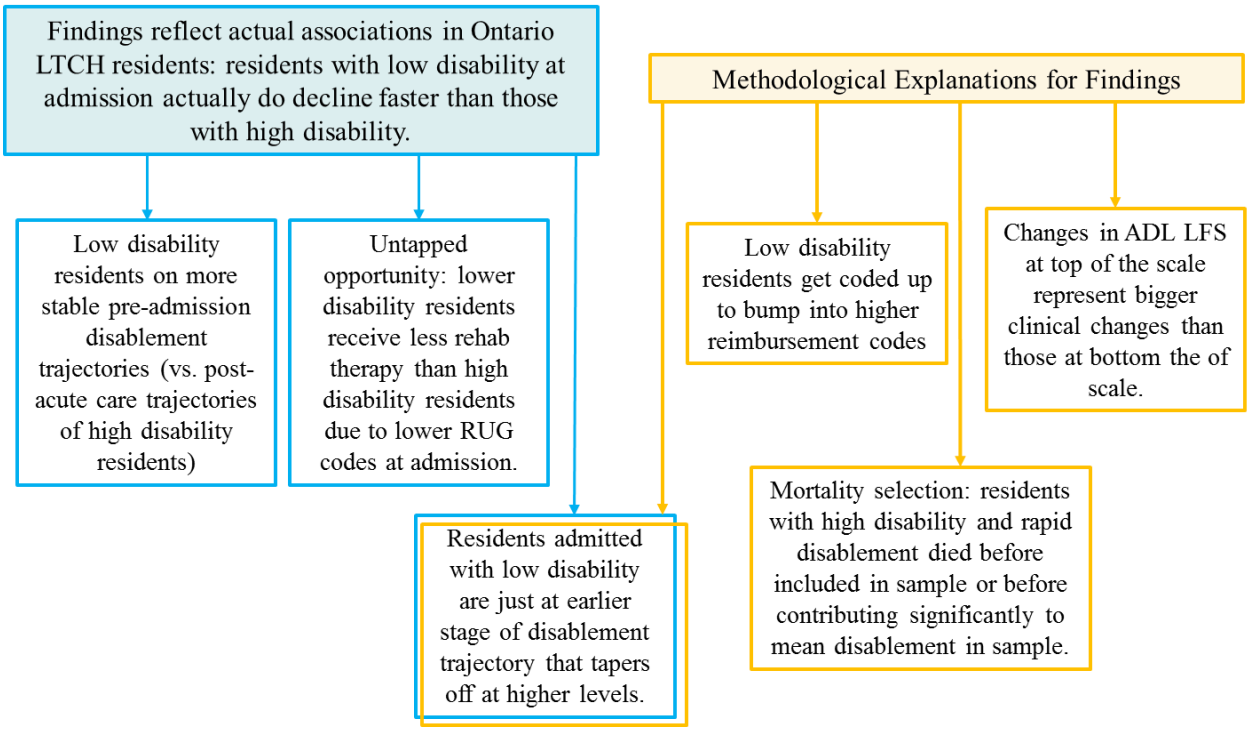


Figure 4.15: Possible Mechanisms Behind Study 3 Finding Regarding the Association between Lower Disability at Admission and Faster Disablement Over Two Years

Appendix 4.15: Staged Addition of Sociodemographic Variables to Simple Linear Regression of Model 1

To examine for possible confounding of variables' relationship with disability by other variables in the model, simple linear regressions adjusted for clustering of disability measures within residents were run. Disability scores from the entire observation period were the outcome (i.e. multiple disability scores per resident were included in outcome). Coefficients for time (month) since admission and admission disability above or below the median were entered first, followed by sociodemographic variables, followed by geriatric syndromes, chronic conditions, interactions between admission disability and time, geriatric syndromes and time, and long-term care home of residence, as follows.

Model 1: Disability = time (months since admission)

Model 2: Disability = time (months since admission) + **admission disability**

Model 3: Disability = time + admission disability + **age + sex + marital status + pre-admission neighbourhood income quintile**

Model 4: Disability = time + admission disability + age + sex + marital status + pre-admission neighbourhood income quintile + **geriatric syndromes**

Model 5: Disability = time + admission disability + age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + **chronic conditions**

Model 6: Disability = time + admission disability + age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + chronic conditions + **Interaction term between admission disability and time**

Model 7: Disability = time + admission disability + age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + chronic conditions + Interaction term between admission disability and time + **interaction terms between geriatric syndromes and time**

Model 8: Disability = time + admission disability + age + sex + marital status + pre-admission neighbourhood income quintile + geriatric syndromes + chronic conditions + Interaction term between admission disability and time + interaction terms between geriatric syndromes and time + **Long-term care home of residence**

Results for Model 8 note shown because R^2 (0.4346) and model coefficients completely unchanged from Model 7 and effect size of LTCH negligible (0.00002, 95% CI: -0.00004, 0.00008).

The staged build-up of models below reveal several noteworthy findings. The addition of geriatric syndromes in Model 4 significantly reduced the positive association of disability at admission while

reducing the negative association of being a widow with disability measures across the observation period.

Examination of the R^2 value for Model 3 shows that disability score at admission and resident demographic characteristics accounted for approximately 35% of variance in disability scores from the whole observation period. Addition of geriatric syndromes to the model explained an addition 4% of variance and chronic conditions explained an addition 1% on top of that. Addition of interaction terms for geriatric syndromes and time explained an additional 1%, while and variables for the long-term care homes in which residents lived did not explain any additional variance.

Appendix Table 4.15: Staged Addition of Variables to Simple Linear Regression of Model 1

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Constant	13.27 (13.14, 13.40)‡	8.73 (8.59, 8.86)‡	8.63 (8.24, 9.01)‡	5.63 (5.15, 6.12)‡	5.63 (5.15, 6.12)‡	4.20 (3.69, 4.71)‡	4.10 (3.60, 4.61)‡
Time since admission (months)	0.16 (0.15, 0.16)‡	0.17 (0.17, 0.18)‡	0.17 (0.17, 0.18)‡	0.18 (0.17, 0.18)‡	0.18 (0.17, 0.18)‡	0.27 (0.26, 0.28)‡	0.28 (0.27, 0.29)‡
Disability at baseline							
0 – 13		Reference	Reference	Reference	Reference	Reference	Reference
14 – 27		9.06 (8.88, 9.24)‡	8.99 (8.81, 9.17)‡	6.35 (6.14, 6.55)‡	6.24 (6.03, 6.44)‡	8.38 (8.18, 8.58)‡	8.37 (8.17, 8.56)‡
Age							
65 – 74			Reference	Reference	Reference	Reference	Reference
75 – 84			0.34 (0.02, 0.66)*	0.25 (-0.04, 0.55)	0.17 (-0.12, 0.47)	0.16 (-0.13, 0.46)	0.17 (-0.13, 0.46)
85 – 94			0.49 (0.17, 0.81)†	0.41 (0.11, 0.71)†	0.39 (0.08, 0.70)*	0.38 (0.07, 0.69)*	0.38 (0.07, 0.69)*
95+			1.21 (0.76, 1.66)‡	1.07 (0.64, 1.50)‡	1.11 (0.67, 1.55)‡	1.08 (0.64, 1.52)‡	1.08 (0.64, 1.52)‡
Sex							
Female			Reference	Reference	Reference	Reference	
Male			0.01 (-0.20, 0.22)	0.08 (-0.11, 0.28)	0.003 (-0.19, 0.20)	-0.002 (-0.20, 0.19)	-0.002 (-0.20, 0.19)
Marital Status							
Married			Reference	Reference	Reference	Reference	Reference
Widowed			-0.78 (-1.01, -0.55)‡	-0.47 (-0.68, -0.26)‡	-0.43 (-0.64, -0.22)‡	-0.44 (-0.64, -0.23)‡	-0.43 (-0.64, -0.23)‡
Never married, separated or divorced			-1.18 (-1.50, -0.87)‡	-0.89 (-1.17, -0.61)‡	-0.76 (-1.04, -0.47)‡	-0.76 (-1.04, -0.47)‡	-0.76 (-1.04. -0.47)‡
Missing data on marital status			-1.11 (-1.74. -0.48)†	-0.90 (-1.47, -0.32)†	-0.83 (-1.39, -0.26)†	-0.83 (-1.40, -0.26)†	-0.83 (-1.40, -0.26)†
Pre-LTC Income Quintile							
1 (low)			Reference	Reference	Reference	Reference	Reference
2			0.36 (0.08, 0.64)*	0.29 (0.03, 0.55)*	0.30 (0.05, 0.56)*	-0.83 (-1.40, -0.26)*	0.30 (0.04, 0.55)*
3			0.21 (-0.08, 0.51)	0.18 (-0.09, 0.45)	0.20 (-0.07, 0.47)	0.20 (-0.07, 0.47)	0.20 (-0.07, 0.47)
4			0.33 (0.03, 0.64)*	0.28 (0.002, 0.55)*	0.27 (-0.004, 0.54)	0.27 (-0.0004, 0.55)	0.28 (0.002, 0.55)*
5 (high)			0.53 (0.21, 0.85)†	0.47 (0.18, 0.76)†	0.46 (0.17, 0.75)†	0.47 (0.18, 0.76)†	0.46 (0.18, 0.75)†
Missing data			0.56 (0.25, 0.86)‡	0.50 (0.22, 0.78)‡	0.47 (0.19, 0.75)†	0.48 (0.20, 0.76)†	0.48 (0.20, 0.76)†
Prevalent Geriatric Syndromes							
Balance impairment				1.72 (1.51, 1.92)‡	1.69 (1.48, 1.89)‡	1.70 (1.49, 1.90)‡	1.87 (1.68, 2.06)‡
Bowel incontinence				1.61 (1.42, 1.81)‡	1.60 (1.40, 1.80)‡	1.60 (1.40, 1.80)‡	1.60 (1.40, 1.80)‡
Cognition							
Intact or borderline				Reference	Reference	Reference	Reference

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Moderate impairment				1.38 (1.17, 1.59)‡	1.27 (1.06, 1.49)‡	1.26 (1.05, 1.48)‡	1.26 (1.05, 1.48)‡
Moderate-severe/severe impairment				3.52 (3.25, 3.79)‡	3.41 (3.12, 3.69)‡	3.39 (3.10, 3.67)‡	2.71 (2.43, 2.99)‡
Hearing impairment							
None				Reference	Reference	Reference	Reference
Hearing impaired				-0.11 (-0.35, 0.13)	-0.06 (-0.30, 0.17)	-0.07 (-0.30, 0.17)	-0.07 (-0.30, 0.17)
BMI							
BMI < 18.5				Reference	Reference	Reference	Reference
18.5 ≤ BMI ≤ 25				0.06 (-0.23, 0.35)	0.01 (-0.28, 0.31)	0.03 (-0.26, 0.33)	0.04 (-0.26, 0.33)
25 < BMI <30				0.04 (-0.27, 0.35)	0.01 (-0.31, 0.32)	0.02 (-0.29, 0.34)	0.02 (-0.29, 0.34)
BMI ≥ 30				0.05(-0.28, 0.39)	0.05 (-0.29, 0.38)	0.07 (-0.27, 0.40)	0.07 (-0.27, 0.40)
Pain							
None or				Reference	Reference	Reference	Reference
Less than daily pain				-0.17 (-0.37, 0.03)	-0.13 (-0.33, 0.07)	-0.12 (-0.32, 0.08)	-0.12 (-0.32, 0.08)
Daily or severe daily pain				-0.08 (-0.32, 0.16)	-0.01 (-0.26, 0.23)	-0.002 (-0.25, 0.24)	0.48 (0.25, 0.72)‡
Pressure ulcer				1.27 (0.94, 1.59)‡	1.28 (0.95, 1.61)‡	1.24 (0.91, 1.56)‡	1.23 (0.91, 1.56)‡
Urinary incontinence				1.99 (1.78, 2.19)‡	1.93 (1.72, 2.13)‡	1.94 (1.73, 2.14)‡	1.94 (1.74, 2.14)‡
Visual impairment							
None				Reference	Reference	Reference	Reference
Moderate impairment				0.25 (0.07. 0.43)†	0.24 (0.06, 0.42)†	0.24 (0.06, 0.42)†	0.24 (0.06, 0.42)†
Severe impairment				0.77 (0.38, 1.17)‡	0.83 (0.43, 1.22)‡	0.82 (0.42, 1.22)‡	0.83 (0.43, 1.22)‡
Prevalent Chronic Conditions							
Arthritis					0.09 (-0.08, 0.27)	0.09 (-0.08, 0.27)	0.10 (-0.08, 0.27)
Asthma					0.04 (-0.33, 0.40)	0.04 (-0.33, 0.40)	0.04 (-0.32, 0.41)
Cancer					0.07 (-0.10, 0.25)	0.05 (-0.18, 0.29)	0.07 (-0.10, 0.25)
Chronic kidney disease					0.18 (-0.03, 0.40)	0.07 (-0.10, 0.25)	0.17 (-0.04, 0.39)
Coronary artery disease					-0.05 (-0.24, 0.13)	-0.05 (-0.24, 0.13)	-0.06 (-0.24. 0.13)
COPD					-0.30 (-0.54, -0.05)*	-0.30 (-0.54, -0.06)*	-0.30 (-0.55, -0.06)
Dementia					0.53 (0.33, 0.73)‡	0.53 (0.33, 0.73)‡	0.53 (0.33, 0.73)‡
Diabetes					0.11 (-0.07, 0.30)	0.11 (-0.08, 0.29)	0.11 (-0.08, 0.29)
Epilepsy					0.14 (-0.31, 0.60)	0.15 (-0.31, 0.60)	0.15 (-0.31, 0.60)

Variables	Model 1 Estimate (95% CI)	Model 2 Estimate (95% CI)	Model 3 Estimate (95% CI)	Model 4 Estimate (95% CI)	Model 5 Estimate (95% CI)	Model 6 Estimate (95% CI)	Model 7 Estimate (95% CI)
Heart failure					0.29 (0.07, 0.51)*	0.29 (0.07, 0.51)*	0.29 (0.07, 0.51)*
Limb paralysis or amputation					0.05 (-0.18, 0.28)	0.05 (-0.18, 0.29)	0.05 (-0.18, 0.29)
Mood disorder					-0.29 (-0.52, -0.06)*	-0.29 (-0.53, -0.06)*	-0.29 (-0.52, -0.06)*
Parkinson's disease					1.44 (1.15, 1.73)†	1.44 (1.14, 1.73)†	1.44 (1.15, 1.74)‡
Peripheral vascular disease					0.03 (-0.41, 0.47)	0.03 (-0.41, 0.47)	0.03 (-0.41, 0.47)
Psychiatric conditions other than depression and dementia					-0.28 (-0.49, -0.07)*	-0.28 (-0.49, -0.07)†	-0.28 (-0.49, -0.07)†
Stroke					0.37 (0.16, 0.57)‡	0.36 (0.15, 0.56)†	0.36 (0.16, 0.57)†
Interaction Terms							
Low vs. high disability at admission						-0.20 (-0.21, -0.19)‡	-0.20 (-0.21, -0.19)‡
Balance impairment* time							-0.02 (-0.03, -0.002)*
Daily or severe daily pain*time							-0.04 (-0.06, -0.03)‡
Moderate-severe to severe cognitive impairment* time							0.06 (0.05, 0.08)‡
R^2	0.0217	0.3507	0.3550	0.4209	0.4249	0.4249	0.4346

***R*²**: The proportion of estimated total residual variance explained by variables in the model

*p-value <0.05

†p-value <0.01

‡p-value <0.0001

Appendix 5.1: Variable Location in Causal Diagrams According to Critical Review in Study 1

Table 5.1a below defines possible variable locations in the Disablement Process. Table 5.1b provides a summary of variables hypothesized roles in the Disablement Process based on the critical review in Study 1. Because these variable locations were described in a segment of Study 1 that was subsequently edited out, they were not explored earlier in the thesis.

Appendix Table 5.1a: Descriptions of possible variable locations in the causal pathway between impairments and functional dependence or decline

Variable Location in Causal Pathway	**Description**	**Example**
Antecedent (a.k.a. risk factors)	Precedes impairments in the causal pathway. Impairments (at least in part) mediate the relationship between the antecedent and disablement outcomes	age
Mediator	Exists between impairment and disablement outcome. Impairments have (at least part of) their effect on disablement outcomes via the mediator.	hospitalizations
Confounder	Is associated with impairment and is an independent risk factor for disablement outcomes, but is not an antecedent or a mediator.	sex
Moderator (or: Effect Modifier)	Impairment has different effects on disablement outcomes for individuals with different values of the moderator.	sex
Sequelae of functional outcomes	These variables are downstream effects of disablment outcomes.	self-rated health

Table 5.1b: Variable Locations in the Disablement Process

Variable	Variable Location in the Disablement Process					
	Antecedent (risk factor)	Exposure	Mediator	Confounder	Moderator	Sequela of functional outcomes
Predisposing Characteristics (includes Intra-Individual Factors)						
Demographics						
Increasing age				✓	✓	
Female sex				✓	✓	
Minority ethnicity/race	✓					
Social						
Not currently married.				✓		
Living alone prior to admission to LTC	✓			(✓)		
Fewer years of Education				✓		
Low income				✓		
Lifestyle/Behavioural						
Low physical activity level			✓	✓		✓
Psychological						
Self-rated health			✓	✓		✓
Extra-Individual Factors						
Medical Care and Rehabilitation						
Hospitalizations			✓	✓	✓	✓
Length of hospitalization				✓		
Medications (*type used*)			✓			
Receipt of rehabilitative therapy			✓	✓		✓
Presence of an indwelling catheter				✓		
Built Physical and Social Environment						
Properties of LTC facility				✓		
Rural location of dwelling	✓					
Pathologies and Impairments						
Chronic Conditions						
Higher number of chronic conditions		✓				
Alzheimer's disease		✓				
Angina		✓				
Anxiety and panic disorders		✓				
Arthritis (*type unspecified*)		✓			✓	
Asthma		✓	✓		✓	
Atrial fibrillation		✓				
Bone disease		✓				

	Variable Location in the Disablement Process					
Variable	Antecedent (risk factor)	Exposure	Mediator	Confounder	Moderator	Sequela of functional outcomes
Cancer (*type unspecified*)		✓			✓	
Cardiovascular disease (*type unspecified*)		✓			✓	
Coronary artery disease		✓				
Chronic obstructive pulmonary disease		✓			✓	
Degenerative disc disease (back disease, spinal stenosis)		✓				
Dementia		✓				
Depression	✓	✓			✓	✓
Diabetes (*type unspecified*)		✓				
Diabetes mellitus		✓	✓			
Heart failure		✓				
Hypertension		✓			✓	
Kidney failure		✓				
Limb impairment (paralysis, amputation)		✓				
Lung disease (*type unspecified*)		✓				
Myocardial infarction		✓				
Parkinson's disease		✓				
Peripheral vascular disease		✓				
Psychiatric conditions (*type unspecified*)		✓	✓			
Seizures		✓				
Stroke		✓			✓	
Geriatric Syndromes						
High number of geriatric syndromes		✓	✓		✓	
Balance impairments		✓	✓			
Bowel incontinence		✓				
Cognitive impairment		✓			✓	
Hearing impairment		✓				
Obesity		✓				
Pain		✓	✓			
Pressure ulcers		✓				
Sensory impairments (*type unspecified*)		✓				
Sleep disturbance		✓				
Urinary incontinence		✓			✓	
Visual impairment		✓			✓	
Weight change/malnutrition		✓	✓			

	Variable Location in the Disablement Process					
Variable	Antecedent (risk factor)	Exposure	Mediator	Confounder	Moderator	Sequela of functional outcomes
Acute Health Events						
Delirium		✓	✓		✓	✓
Falls		✓				
Hip Fracture		✓	✓			
Lower respiratory tract infection		✓				✓