Assessing the Prevalence, Penetration and Performance of Hospital Physicians in Ontario

Implications for the Quality and Efficiency of Inpatient Care

by

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Abstract

Hospitalist physicians have emerged over the past two decades to become dominant providers of inpatient care in North American hospitals. Despite their widespread adoption, quantitative data characterizing the penetration of Canadian hospitalists or their influence on the quality of inpatient care within the Canadian context has not been explored. The primary objectives of this dissertation were to synthesize the existing findings on hospitalist performance, to describe the prevalence and penetration of hospital physicians working in the province of Ontario, and to assess the current performance of physicians practicing general hospital medicine within the province with regards to their clinical effectiveness and operating efficiency.

The three papers included in the dissertation demonstrated clear trends that hospital-based physicians are increasingly prevalent in Ontario hospitals and deliver a sizable proportion of the province's inpatient medical care. Increased inpatient workloads amongst

these physicians translated to lower mortality, fewer readmissions and longer lengths of stay for patients under their care.

There is a pressing need in Canadian healthcare to improve the processes of acute care provision in order to reduce unnecessary utilization, improve patient safety, and enhance patient experience. Findings in this dissertation provide support for the practice of hospital medicine and concentrated hospital care in Canada, suggesting that high-volume physicians practicing general hospital medicine, including hospitalists, could have a pivotal impact on quality improvement. Research can now turn to understanding the specific practice characteristics and processes of care that differentiate hospital generalists from their colleagues.

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Overview

Over the past two decades, escalating health care costs, a rising prevalence of chronic comorbid diseases and increasing dependence on medical technology have changed the nature of inpatient care in Canada and across the globe [(1)]. Acute care hospitals facing frozen operating budgets continue to trim lengths of stay and substitute outpatient for inpatient care [(2)], yet an aging population requiring critical and complex disease management has persisted in increasing overall hospital expenditures [(1)]. Faced with a growing need for cost-effective delivery, hospitals are exploring new methods of inpatient care provision including the use of hospitalists, which seek to enhance institutional flow and lower operating costs while improving the clinical quality of care provided to hospitalized patients [(3-7)]. These changes are occurring in a progressively competitive health care industry where the value of services is scrutinized over whether attempts to improve efficiency threaten clinical effectiveness and patient satisfaction [(4,5,8)].

First introduced in 1996, hospitalists - defined as physicians who specialize in delivering comprehensive medical care to hospitalized patients [(9)] - have emerged to become dominant providers of inpatient care across the world [(10-12)]. Under the hospitalist model, unattached patients and patients whose primary care physicians do not provide inpatient services are transferred to the care of a hospitalist upon admission to a given institution. Acting as the case-manager, the hospitalist becomes the patient's primary physician for the duration of hospitalization, generating and reviewing clinical data, making decisions regarding necessary tests, treatments and procedures and facilitating access to subspecialty and post-acute services [(13)]. Upon discharge, patients are returned to community under the care of their primary physician (if they have one) while the hospitalist goes on to care for the next admission.

Advocates of hospital medicine argue that properly structured hospitalist programs offer a number of advantages as compared with traditional models of inpatient care. Hospitalists are distinct from primary care physicians in that they do not maintain an office-based practice while attending on the inpatient service but instead practice full-time within the institutional setting [14]. As the hospitalist works routinely at the site of care, they are considered to have enhanced knowledge of hospital operating procedures and greater familiarity with staff and community resources. This can result in improved efficiency when navigating the acute and post-acute care systems relative to primary care providers who manage fewer cases of a given condition over the same period of time [7,15,16]. The routinization of inpatient care enhances the hospitalists' clinical expertise in complex disease management and ensures that a dedicated provider is available to answer questions, order and manage tests and respond during acute medical crises - all of which can reduce delays in inpatient stay and potentially improve clinical outcomes [7,15,17]. At the same time, the hospitalist model introduces handoffs at the time of admission and discharge, transitions in care which may increase the risk of adverse events and threaten continuity [7]. These transitions combined with the lack of knowledge about a patient's previous medical history could also incline hospitalists towards more aggressive, technology-based care, translating into greater numbers of diagnostic tests, higher costs and longer acute lengths of stay to establish the baseline health status of the patient [7]. While the potentially negative effect of hospitalist programs on patient, family and provider satisfaction have been cited as an important area of concern [7,18-20], several studies have suggested that satisfaction under hospitalist care is equivalent to that provided by primary providers [21-29].

In 1998, researchers began evaluating the performance of hospitalist programs, comparing hospitalists to traditional inpatient providers on core indicators of quality, effectiveness and efficiency [28,30]. Although multiple comparative studies on hospitalist performance have been published since this time, numerous questions regarding the overall 'value' of hospital medicine remain unanswered. While some research suggests this model may be associated with lower operating costs and shortened lengths of stay with similar or small improvements in clinical outcomes [31,32], the validity of published findings continues to be scrutinized as a result of inconsistent and vague definitions of hospitalist care models, underpowered study designs and inadequate risk-adjustment [33-35]. More importantly, although hospitalists have become one of the dominant providers of inpatient care in Canadian hospitals [10,36,37], quantitative data characterizing the penetration of Canadian hospitalists or their influence on the quality of inpatient care within the Canadian context has not been explored.

This dissertation describes the prevalence and penetration of hospital physicians working in the province of Ontario, Canada and assesses the current performance of physicians practicing general hospital medicine with regards to their clinical effectiveness and operating efficiency. Because Canada does not recognize the formal designation of a hospitalist physician, their role within the Canadian health care system is best described as that of a hospital generalist.

The first two chapters summarize the background literature on hospitalist care, synthesizing the findings on hospitalist performance and critiquing the methodological quality of evaluative studies published in the literature to date. Addressing the need for an improved functional definition on what constitutes a hospitalist practice, chapter three proposes a framework for defining hospital physicians using administrative claims data and applies this method at the population-level to look at the growth and prevalence of hospital physicians working in Ontario from 1996 to 2011. Chapter four provides a more nuanced interpretation of general hospital practice, assessing the system-level relationship between annual inpatient volume and clinical outcomes of care in select cohorts of hospitalized patients managed by family physicians and general internists working in the province. The dissertation concludes with a review of the overall findings and critical reflection of the literature. Limitations of the overall analyses are critiqued, suggestions for subsequent research are presented and a brief discussion of implications for patient safety, physician staffing and hospital policy are explored.

1 Background

1.1 Historical foundations of hospitalist medicine: filling the need for cost-effective care

Primary care has a longstanding history with the acute healthcare system and general practitioners have traditionally played an active role in the management of their hospitalized patients [20,38-40]. Up until the 1990s both Canada and the United States practiced a system of care where outpatient physicians - family physicians, general internists and pediatricians - served as the most-responsible physician when their patients were hospitalized [39,40]. For general medical admissions and common diagnoses such as respiratory infections, heart failure or complications stemming from chronic disease, the patient's primary care doctor would oversee all aspects of clinical inpatient care, calling in consultations for advice or procedures from specialists when required. For diagnoses that involved the expertise of specialty physicians such as cardiovascular or orthopedic surgery, primary care physicians remained involved on a supportive basis, checking in daily on their patient's progress and managing their general medical complaints. In the mid-1970s, the average primary care physician (PCP) had between 5 and 10 patients in hospital at any given time and approximately 30 percent of their clinical day was spent on hospital care provision [38]. Physicians would round on inpatients early in the morning, returning to their office for outpatient visits for the remainder of the day. Upon concluding office hours, physicians could return their attention to hospitalized patients, following up on tests results or consultations as required.

This system worked reasonably well for decades. Patients reported comfort and satisfaction having their regular doctor care for them in hospital, physicians enjoyed the complexity and variety of a comprehensive medical practice and valued the relational benefit of managing their patient's health care needs before, during and after hospitalization [39]. However, from an economic perspective, the pace of hospitalization under the PCP model was leisurely. Inpatient billings for primary care physicians were generally restricted to one fee per patient, per day. Under this fee ceiling, tests and consultations were frequently delayed, family members needed to time their visits to coincide with the physician's morning rounds and patients often remained in hospital longer than necessary depending on the time of day they were medically ready for discharge. By the mid 1980's, a confluence of factors ignited the need for a new delivery model to co-ordinate an increasingly fragmented system of inpatient care. These factors included an ageing population; the rising prevalence of chronic, comorbid diseases; growing numbers of unattached patients; and market trends towards the specialization of acute care including increasing dependence on technology, escalating healthcare costs and the subsequent need to improve operating efficiency [(41)].

In 1983 the United States reorganized the financial structure of Medicare, the national social insurance program that provides healthcare coverage for older residents and residents with recognized disabilities. Amending the Social Security Act, Medicare moved from a retrospective fee-for-service payment model which reimbursed hospitals for the actual cost of care to a prospective system that paid hospitals a set price linked to each patient's clinical condition at admission [(42,43)]. Facing intense pressure to shorten lengths of stay and reduce unnecessary spending [(44)], hospital leaders and health maintenance organizations (HMOs) began to cut costs by reducing excess capacity, lowering staff ratios and discontinuing non-profitable services [(41)]. Profitable procedures that had a low risk of complications and did not require hospital stays were transferred to specialized ambulatory care centers and with this change, patients who remained in hospital were, on average, more acutely ill [(45)]. In response to the change in reimbursement, hospital payments made by Medicare plummeted from 16.2% of total spending in 1980 to 6.5% in 1987 and hospital days stayed decreased by 20% [(46)].

By the mid 1990s, primary care physicians in the United States found it increasingly difficult to maintain hospital privileges. Fixed reimbursements no longer covered the opportunity and actual costs of providing hospital-based services and doctors were no longer comfortable with the clinical and organizational aspects of a cost-cutting approach to care [(47)]. Mounting malpractice concerns contributed to outpatient physician's avoidance of inpatient care and emergency department (ED) call due to a perceived increased liability risk associated with care provision in these settings [(48,49)]. As more physicians referred their complicated and acutely ill patients to EDs, increasing wait times and the need for improvements in operating efficiency began to mount [50].

At the same time, physician reimbursement in Canada was undergoing significant reform. Under Canada's Medicare system, the government is the sole payer of physician and hospital reimbursement. The federal government transfers annual funds to the provinces and territories, which in turn raise further financing through resident taxation. The proportion of the provinces' health expenditures then applied to physician payment is decided through negotiation between provincial governments and their respective medical associations, paid on a predominantly fee-for-service basis. Budgetary shortfalls in the early 1980s prompted the federal government to reduce provincial transfer payments. To control costs the provinces began to impose fee-control policies on physician expenditures. Annual ceiling caps were placed on provider incomes by discounting fee levels and imposing retroactive billing adjustments on overruns [51,52]. These caps created inequities in income distribution across physician specialties, penalizing low-volume lower-income providers - in particular, family physicians whose fixed practice expenses represented a larger share of their gross annual revenues [53]. The rapidity with which expenditure caps were introduced created another unintended side-effect: with few information systems capable of providing billing information within the time-frames necessary for fee adjustments, retrospective clawbacks became an added source of tension between medical practitioners and governments [51].

In 1991 the Barer-Stoddart report on physician human resources was released, recommending that a cap be placed on the number of physicians allowed to practice in Canada in a further attempt to control escalating physician costs [54]. In 1992 the Conference of Deputy Ministers of Health agreed with their analysis and implemented a 10% reduction in medical school enrolment across the country beginning in the fall of 1993 [51,52]. To dissuade new physicians from practicing within a given province, further supply policies were introduced by individual provinces including differential (reduced) fees for new medical graduates and restricted 'billing number' policies whereby new providers were required to meet stringent selection criteria before being granted the right to submit claims to their provinces' medical insurance plans [8,51,52]. As a consequence to these initiatives, the proportion of medical graduates entering family practice dropped from a high of 53% in 1993 to 40% in 2000 [52,55]. By the late 1990s, a new pattern in acute care medicine began to emerge: with shortages in the number of family physicians practicing in most areas of the country, greater numbers of 'orphaned' patients began requiring admission to hospital through emergency departments without regular physicians to oversee their care. Initially local physician groups agreed to manage these 'orphaned' inpatients on a rotating community-call basis, however once discharged, patients were still returned to the community without follow-up [39].

Over the next decade family physicians (GP/FPs) gave up their hospital privileges in alarming numbers, realizing it was more cost-effective to avoid inpatient care in favour of increasing outpatient volumes [5,56]. For the GP/FP, visiting one inpatient in 1995 including travel time to the office meant 1½ hours of work for the equivalent of a $17 insurance billing [57]. Stated eloquently by one Canadian physician: *"the parking charge for a 10 minute inpatient visit in an urban area is almost equal to the physicians' professional fee for such a visit"* [6]. As the number of physicians caring for hospitalized patients became smaller, each remaining physician's share of the community call load increased [39], impacting the amount of work remaining practitioners had to undertake during community call and reducing the available time they had to devote to their own outpatient practices [39,58]. Benevolence was soon accompanied by an appeal for compensation as a supplement to the inadequate fee schedule and to account for the loss of office hours due to increased time spent in the hospital [39]. Even with an agreed-upon stipend, fewer physicians were willing to participate in community call and a vicious cycle ensued: as more and more GP/FPs resigned their hospital privileges, those who remained increasingly relinquishing their hospital roles. According to the College of Family Physicians of Canada, by 2001 only 35% of Canadian family physicians were still providing inpatient care to their patients [39]. Of the remaining providers, 22% were planning to remit their privileges within a year, citing the stress of hospital practice and poor remuneration as key motives for resignation [39].

Over the same period of time, Canadian hospitals faced their own budget cutbacks [8,52]. Concerned with the rising cost of inpatient care, health restructuring initiatives forced hospitals in most provinces to reduce excess capacity by amalgamating sites and services, lowering staff-to-patient ratios, reducing the number of inpatient beds and shifting services to ambulatory and outpatient settings [8]. Like the United States, these cutbacks resulted in additional inefficiencies with inpatient care, including shortages in the number of inpatient beds and subsequent emergency department overcrowding [59-61].

In 1994, the Park Nicollet Clinic in Minneapolis, Minnesota created the first formalized hospitalist program with the underlying concept that hiring a small number of hospital-based physicians to manage the care of inpatients would improve the quality and coordination of care while simultaneously controlling escalating operational costs [62]. While academic hospitals had always had hospitalists in the form of faculty physicians supervising residents and medical students on clinical teaching units, the growing number of orphaned inpatients posed a unique challenge to non-teaching and rural hospitals. By the late 1990's individual hospitals in both Canada and the United States began recruiting family physicians and general internists on full and part-time contracts to provide inpatient care for hospitalized patients. Hospitals offered contracting physicians a guaranteed annual salary, agreeing to supplement professional billing fees to insurance providers with salary "top-ups" from their institutional operating budgets [10,63]. With these offers, the hospitalist practitioner and the field of hospital medicine was born.

1.2 Defining the hospitalist and their role in acute care delivery

In 1996 Drs. Wachter and Goldman published a pivotal editorial in the New England Journal of Medicine where they described the advent of a new physician specialty, the "*hospitalist*" [47]. The hospitalist was proposed to be a *"specialist in inpatient medicine",* whose clinical focus would center on the care of hospitalized patients and returning the care of those patients to office-based practitioners after hospitalization [47]. Less than two decades later, hospitalists have become the dominant providers of general inpatient care in North American hospitals. They are widely recognized as the fastest growing medical specialty in the history of American medicine with over 30,000 practitioners now employed in over 70% of U.S hospitals [10-12].

Like emergency medicine, hospital medicine is a site-specific specialty organized around a location of care (the hospital) as opposed to an organ (cardiology), a disease (oncology) or a population of patients (pediatrics). While doctors have emphasized inpatient specialty practice for years through the field of internal medicine, internal medicine can be practiced in both inpatient and outpatient settings with the majority of internists operating private consultation-based practices while maintaining hospital privileges [64]. As such, many internists provide some continuity of care to their patients, admitting them directly from their clinics and/or following up post-discharge. In contrast, hospital medicine represents a shift towards generalized hospital-based care where hospitalists practice exclusively within the hospital, addressing all routine medical needs throughout the course of hospitalization, but maintain minimal responsibility for outpatient or follow-up care.

Early definitions of hospitalists aimed to compare what hospitalists did (or would do) to analogous care models that were already known and accepted by the medical community. In their 1996 paper, Wachter and Goldman defined hospitalists as specialists *"who will be responsible for managing the care of hospitalized patients in the same way that primary care physicians are responsible for managing the care of outpatients"* [64]. Three years later, hospitalists were still being defined in relation to other physicians as *"physicians who assume the care of hospitalized patients in place of the patients' primary care provider"* [65]. In 1999 Wachter proposed a radical revision of the term:

> *"A hospitalist is a physician who spends at least 25% of his or her professional time serving as the physician-of-record for inpatients, during which time he or she accepts "hand-offs" of hospitalized patients from primary care providers, returning the patients to their primary care providers at the time of hospital discharge"* [66].

Two important elements were introduced in this definition. The first was recognition that a minimal amount of direct inpatient care was critical to distinguishing the hospitalist from their office-based colleagues. This temporal commitment allowed the hospitalist to become an expert in the care of common inpatient conditions, to become familiar with hospital staff/resources and to become invested in the cost, quality and efficiency of the hospital's operations. The second key element was that hospitalists were still to be defined by their relationship to the primary care physician's role in the form of hand-offs. Ironically, the hospitalist movement was seen as a purposeful introduction of discontinuity of care between the primary physician's practice and the hospital [(66)] and in the early days, several managed care organizations (HMOs) in the United States mandated the use of hospitalists for their hospitalized patients [(67)]. While many PCPs expressed concern over care fragmentation and the attempt to place profits before quality, hospitalist programs proliferated spreading rapidly across America.

Wachter's new definition laid the foundation for performance evaluation, offering a clinical formulation for identifying hospitalist practitioners on the basis of inpatient workload. But practitioners rejected it, stating that a definition that depended on volume could not encompass the wide range of roles and responsibilities that hospitalists held. For many hospitalists, the thought of caring for hospitalized patients only 25% of the time seemed outlandish. To others involved in leadership or research, the definition seemed too restrictive.

In 2003, the Society of Hospital Medicine formed as a professional society devoted to hospitalist practitioners and the hospital medicine movement. That year the Society released their own definition of a hospitalist: *"Physicians whose primary professional focus is the general medical care of hospitalized patients. Their activities include patient care, teaching, research, and leadership related to hospital medicine [(9)]"*. While their definition emphasizes professional focus as the care of hospitalized patients, it encompasses the broad range of professional activities that hospitalists perform and allows for hospitalists to engage in non-hospital activities including outpatient care.

Initially the term of "hospitalist" was reserved for family physicians and general internists who cared for patients only in hospital. However, use of the term has expanded over the years to now include any physician who works exclusively in the hospital. As such, specialties like neurology, pediatrics, obstetrics, surgery and psychiatry are increasing reporting hospitalist practice arrangements. All hospitalist programs operate under the common auspice of providing general medical care to unattached inpatients and patients who are either admitted from the emergency department (ED) or repatriated from other hospitals whose outpatient physicians do not maintain active privileges at a given institution [(10)]. In addition to patient care duties, hospitalists are increasingly involved in other areas of hospital practice and policy including teaching, research and managing administrative aspects of hospital operations such as inpatient flow, safety and quality assurance programs [(9)]. As the field of hospital medicine has matured, many programs have broadened their clinical roles, providing newborn or pediatric care, medical co-management for surgical patients, palliative and psychiatric care, and pain management [(68,69)].

More recently, researchers have attempted to re-introduce a functional definition of the hospitalist clinical practice. In 2009, Yong-Fan Kuo and colleagues published an influential paper in the New England Journal of Medicine, where they used Medicare billings to identify hospital-based practitioners in the absence of known hospitalist specialty [(70)]. Using a 5% sample of Medicare beneficiaries, they defined hospitalists as *"general internists who derived 90% or more of their Medicare claims from the care of hospitalized patients"* [(70)]. While the Society of Hospital Medicine's definition still predominates, Kuo's functional approach is slowly gaining acceptance among researchers and has since been applied in several publications [(71-77)].

Hospital medicine is not formally recognized as a medical specialty and as such, hospitalists may hold certification in any recognized field. In January 2010, the American Board of Internal Medicine (ABIM) launched the first certification program, granting a Recognition of Focused Practice (RFP) in Hospital Medicine to general internists licensed in the United States through their Maintenance of Certification (MOC) program. Diplomates are required to complete a minimum of three years practical experience and pass an MOC examination in Hospital Medicine prior to receiving their certification. The Royal College of Physicians and Surgeons of Canada and the College of Family Physicians of Canada have yet to recognize hospitalists as a medical specialty. To date there are no board certification or training recommendations for Canadian hospitalists; however both Sunnybrook Health Sciences Centre and the University Health Network in Toronto are now offering one-year fellowships in Hospital Medicine to physicians who have completed their training in family or general internal medicine.

Over the past six years, the hospitalist movement has begun to spread to several countries outside of North America. Hospitalist programs are a relatively new addition to health care delivery in Australia and New Zealand and these countries will likely be the next to adopt their widespread use (78,79). Argentina, Brazil, Chile, Columbia, Spain, Sweden and Singapore are also in various stages of developing hospitalist programs (41,80-82). While the health care systems and populations served in these nations differ, supporters' reasons for wanting hospital medicine to flourish there are often the same—improved efficiency, better patient care and enhanced quality of life for their physicians (41,82).

1.3 Canadian hospitalists

Fifteen years after hospitalists entered Canadian institutions, hospital medicine has become the dominant delivery model for inpatient care in many community hospitals. Nevertheless, significant variations in program design and workload models exist depending on the history, culture and patient communities they were designed to serve.

According to the 2007 Canadian National Hospitalist Survey, seven of the ten provinces and zero of the three territories employ hospitalists in acute institutions (10). Ontario reportedly has the largest number of hospitalist programs in operation with more than 64 programs and 120 practitioners, followed by British Columbia with over 15 programs and 95 practitioners, although these numbers are likely to be significantly under reported (10,36,63). It is estimated that 90% of Canadian hospitalists hold a general medical license (10,14), however the number of general internists practicing hospital medicine is increasing [83]. One pediatric hospitalist program has been formally described [84].

All programs provide 24 hour coverage, 7 days a week in one form or another, ranging from self-contained (full-time day, evening and weekend call) or mixed hospitalist models (full-time day with community or resident coverage for evening/weekend-call) to those consisting almost entirely of part-time hospitalists [10,63]. Hospitalist programs are thought to predominate in small-and mid-sized community hospitals lacking academic affiliations [10,14,63].

A minority of Canadian hospitalists are compensated through fixed salary capitation; most hospitalists work as independent contractors to individual hospitals, submitting professional fees to provincial Health Insurance Plans and receiving income top-ups from their contracting institutions, paid from the hospitals' global operating budget [10,85]. While the amount of cost recovery in full-time programs is variable, on average only 30% - 40% of hospitalists' incomes are recuperated through provincial insurance billings [10,14,85], representing a significant source of spending for most hospitals [14].

In 2008, Alberta became the first province to implement an Alternative Relationship Plan (ARP) for hospitalist physicians working in Calgary [86,87]. Funds are used to pay the overhead, site-based funds and an hourly rate to physicians, based on full-time equivalents (FTEs) [86]. One FTE in the ARP is defined as 8 hours of work/day for 241 days/year (1,928 hour/year) where one hour of work equates to rounding on three patients during a weekday [86]. Weekend, nighttime and on-call hours are paid on top of weekday rounding hours [86]. In 2011, the province expanded ARP funding, opening two new family medicine hospitalist programs. Ninety hospitalists now cover approximately 30% of acute adult beds operating within the funded sites [88].

In June 2006, hospitalists working for the Fraser Health Authority in British Columbia threatened to return to community practice after the provincial government placed fee-for-service hospitalists on a lower pay scale than their community-based colleagues [89,90]. Requesting a new pay-for-performance approach to reimbursement over current fee-for-service billings, the BC Ministry of Health agreed to re-examine the funding model [90]. An interim contract was signed in September 2007 with the next round of negotiations to begin early 2010. No information has been publically disclosed since 2010 on the state of hospitalist negotiations or funding arrangements in BC; however, once well-known Canadian hospitalist recently disclosed that BC hospitalists are still in negotiations over a hospitalist funding agreement and current hospitalists are not permitted to use enhanced inpatient fees recently introduced for family physicians despite that fact that the majority of BC hospitalists are credentialed as such [(87)].

Hospitalists in Ontario underwent similar reimbursement negotiations with the Ontario Ministry of Health in September 2008 [(36,91)]. To date, the Ontario MOHLTC has refused to discuss the possibility of an alternate funding plan for hospitalist physicians, agreeing instead to adjust the most-responsible physician funding model beginning in 2010 through application of an optional 30% billing premium which would be applied to a select list of fee-codes claimed by the most-responsible-physician of record [(36,91,92)]. The MOHLTC initially stipulated these fee increases would apply to all physicians providing hospital care and could only be billed if the provider agreed to forego their income top-ups from their contracting hospitals. When the majority of Ontario hospitalists opted against billing the MRP premiums, choosing instead to keep their higher negotiated salary top-ups, the MOHLTC recanted, agreeing to pay the premiums to hospitals who could show that their hospitalists' remuneration had been reduced by an amount equal to the billings that would be generated from claiming the MRP premiums [(92)]. An additional $33 million was allocated in 2010/2011 under the MRP Collaboration Incentive Fund, aimed at rewarding physician groups to provide and improve MRP services for unattached inpatients [(92)]. Participating MRPs had to commit to ensuring "24/7/365" coverage for unscheduled patients; develop and implement a quality improvement plan; and provide a review of their performance on key quality indicators, such as length of stay, readmission rates and patient satisfaction [(93)]. Formal evaluation of the MRP billing premiums have not been assessed; however, with no accountability framework, metrics or deliverables attached to the initiative, it is unclear whether MRPs and their institutions could be held accountable for improving quality of care.

1.4 Theoretical foundations: measuring performance in health care

Performance measurement plays an essential role in a health system's ability to improve health for its population. The role of performance measurement is to guide stakeholders (patients, clinicians, managers, researchers, governments and citizens) towards the achievement of better health through improved outcomes and enhanced accountability [94]. It can be applied to a diversity of tasks, including tracking public health, monitoring health care safety, determining appropriate treatment/care pathways for patients, promoting professional improvement in care delivery, supporting managerial control and cultivating accountability in the health care system to the public. While performance measurement appears to be a relatively young field, the task of measuring and monitoring hospital care and health outcomes has existed for generations [94-96]. The origins of performance measurement are often traced back to the University of Pennsylvania hospital where in 1754, staff began collecting and recording data on patient outcomes, crudely tabulated by diagnostic group [96]. Although isolated efforts at performance measurement continued throughout the 18th and 19th centuries, it wasn't until the early part of the 20th century that performance measurement began to emerge as a viable tool for assessing health outcomes and in particular, the role of physician care in achieving these outcomes [96]. In 1910, Ernest A. Codman, a surgeon at Massachusetts General Hospital, proposed a novel system of record keeping whereby individual hospitals would track every patient for a set period of time to determine treatment effectiveness [94,96]. Termed the "*End Result System of Hospital Standardization*", Codman believed that by tracking a patient's progress through the course of hospitalization, it was possible to determine which clinical interventions were effective [94,96,97]. In addition, Codman advocated for transparency in provider performance, arguing that this information could and should be used to identify factors that contributed to the failure of a procedure which in turn would promote quality improvement, patient choice and physician learning [94,96,97]. His system allowed for the first identification of 'best' and 'worst' providers based on the actual results of their care and inter-hospital comparisons of outcomes performance. Three years later, the newly founded American College of Surgeons (ACS) incorporated Codman's system into their recommended guidelines on *Minimum Standards for Hospitals* and were used as evaluation criteria in determining facility-level compliance with ACS guidelines (97).

Later in the 20th century, management theorists began to shift their attention away from the processes of hospital care to understanding the role of management and the structure of organizations in creating both opportunities for and obstacles against productivity, efficiency and effectiveness within health care organizations (94). Prominent early scholars including Henri Fayol, Max Weber and Chester Barnard helped to establish the basic principles we now use to describe the role and function of organizational context in shaping efficiency and effectiveness. Together, they suggested that organizational structures, interpersonal relationships and management roles create an environment that influences the successful accomplishment of work tasks. Over time, health researchers have increasingly recognized that organizations seeking to improve their performance through changes in clinical practice must do so within the underlying structures and organizational culture through which health care is delivered.

In 1966, Dr. Avedis Donabedian combined these ideas into what is commonly regarded as the most accepted and widely cited theoretical framework for understanding and evaluating the quality of health care delivery (98). Donabedian proposed a three-concept model associated with quality improvement wherein the organizational structures of health care settings interact with the processes of care delivery to examine their combined influence on technical, clinical and interpersonal outcomes (98). Most of our current approaches for evaluating provider performance are based to some extent on Donabedian's tripartite model and the one core concept embodied in his framework: that the quality of health care delivery can be examined and measured by assessing relationships and interactions between these three components.

Despite the clear benefits of performance measurement, the act of measurement is not a neutral activity. It evokes considerable anxiety, frustration and worry amongst all stakeholders concerned: those being measured, those who are doing the measuring and those who are seeking to use the data for a variety of purposes. There is still little agreement on the underlying philosophies and methodological challenges of measuring performance: what to measure, how the data should be analyzed, which indicators should be used, how to deal with collinearity among indicators, the quality of available data, how to account for external factors that impact performance but cannot be measured, and of course, the ultimate question of what 'value' measurement can bring to improving the health of populations.

1.5 Prior research on hospitalist performance

In 1998, researchers began evaluating the performance of hospitalist programs, comparing them to traditional models of inpatient delivery on core indicators of quality, effectiveness and efficiency [28,30]. In fifteen years, the published literature on hospitalist performance has grown to include more than 1,000 editorials, letters and interviews and over 180 descriptive, comparative and qualitative evaluations of hospitalist physicians or programs. More than 85 peer-reviewed articles have examined the quality of hospitalist care by comparing quantitative data between hospitalists and traditional care providers [31]. Most often, physicians were defined by their self-identified specialty as 'hospitalists' and then compared categorically to their colleagues on core indicators of quality measured at the patient-level (e.g.: hospital costs, length of stay). The majority of hospitalist evaluations have been single site evaluations conducted in American hospitals with academic affiliations; however, three studies have evaluated hospitalists in Canadian institutions [84,99,100]. In 2005, Coffman and Rundall published the first systematic review of hospitalist performance, finding that patients managed by hospitalists had lower hospital costs achieved primarily through a reduction in length of stay with no difference in the quality of clinical care [33]. Despite these promising findings, weaknesses in the methodological design of included studies led the authors to conclude that the lack of random assignment *"limits the ability to draw causal inferences regarding the impact of hospitalists' from many of the evaluations"* [33].

Despite more than a decade of research on hospitalist performance and numerous calls to improve the methodological quality of published reports [33,101], the validity of findings continues to be scrutinized as a result of poor study designs, vague descriptions of hospitalist interventions and inadequate risk-adjustment [33,34,41]. The methodological quality of the hospitalist literature has never been formally assessed.

1.6 Rationale for research

> *"There can be no greater justification for performance measurement than its power to impact that which it is measuring."*
>
> *Vahé A. Khzanjia, 1999 p. 119* [102]

Hospital medicine is at the forefront of many changes occurring in the way inpatient care is delivered and funded in Ontario. The province has introduced changes to hospital funding models through Health Systems Funding Reform (HSRF), tackling rising health care costs by tailoring hospital budgets to match the demographics and health needs of the communities they serve while subsequently rewarding them for better performance [103]. Termed Ontario's Health Based Allocation Model (HBAM), this approach aims to replace global operating budgets with a model that re-directs funding to hospitals serving larger, older and high-risk patient populations which are expected to have higher health care costs [103]. Financial incentives have similarly been introduced through Ontario's Pay for Results Program, where hospitals who boost their productivity by improving the cost-effectiveness of care delivery are rewarded with additional funds [103]. As previously described, adjustments to remuneration are also underway for Ontario's hospital-based physicians which include a 30% increase in fees paid to the most-responsible physician of record and the establishment of the MRP Collaboration Incentive Fund [104]. In many institutions, hospitalists have become instrumental to achieving negotiated performance targets and thus receiving HSFR funding. As such, hospitalist programs and their institutions must demonstrate their 'value' through the provision of high quality, efficient care. To do so successfully demands a focused and rigorous approach to performance monitoring, measurement and improvement.

In the fifteen years that hospitalists have worked in Canadian institutions, only three publications have described the quality of hospitalist care within Canadian hospitals. In the most comprehensive evaluation conducted to date, Dwight and colleagues compared outcomes from a staff-only hospitalist team to a traditional academic attending/housestaff model operating at the Hospital For Sick Children in Toronto for the fiscal year 1996. They reported a 14% reduction in the median length of stay for pediatric patients managed by the hospitalist team with no differences in clinical outcomes between providers [(84)]. An earlier study by Abenhaim and colleagues found shorter lengths of stay and reductions in mortality and readmissions on a hospitalist-run short-stay unit in one Montreal hospital; however, patients were preferentially admitted to the hospitalist-unit based on a brief expected length of stay and no form of risk-adjustment was used in their analyses [(99)]. Both evaluations are over a decade old and were limited to single-site investigations of specialty populations, which cannot be generalized to the majority of hospitalist programs currently operating in Ontario. In 2013, Dr. Vandad Yousefi, a practicing hospitalist, published a comparative evaluation of the hospitalist program operating at his employing institution of Lakeridge Health, located in Southern Ontario [(100)]. Combining six year's worth of admissions data, Yousefi found that hospitalists demonstrated lower in-hospital mortality and 30-day readmissions with similar lengths of stay compared to traditional care providers. Dr. Yousefi is the only researcher to have actively published on the topic of Canadian hospitalists in the past ten years. There has yet to be a systematic, population-based assessment describing the scope of hospital medicine in Canada, the practice characteristics of Canadian hospitalists or the quality of hospitalist care in Canadian institutions. Clearly, there is a need to identify the types of physicians delivering care in Ontario hospitals and to begin the task of monitoring and tracking their performance. As hospital CEOs, administrators and governments continue to explore the viability of hospitalists for improving the clinical quality and efficiency of inpatient care, quantitative evidence supporting their value needs to enter into the policy agenda

The three papers included in this dissertation synthesize the existing literature on hospitalist performance; describe the provision of inpatient care by hospital physicians within Ontario hospitals over time; and assess the performance of these providers with regards to their clinical effectiveness and their operating efficiency. This work develops a method of identifying hospital physicians based on the volume of inpatient clinical care delivered each year and the proportion of the providers' total practice spent on hospital care provision. Using routinely collected, population-based data, this method is then applied at the systems-level, contributing evidence that supports the practice of hospital specialization among general practitioners working in the province.

2 Do hospitalist physicians improve the quality of inpatient care delivery? A systematic review of process, efficiency and outcome measures

2.1 Abstract

Background: Despite more than a decade of research on hospitalists and their performance, disagreement still exists regarding whether and how hospital-based physicians improve the quality of inpatient care delivery. This systematic review summarizes the findings from 65 comparative evaluations to determine whether hospitalists provide a higher quality of inpatient care relative to traditional inpatient physicians who maintain hospital privileges with concurrent outpatient practices.

Methods: Articles on hospitalist performance published between January 1996 and December 2010 were identified through MEDLINE, Embase, Science Citation Index, CINAHL, NHS Economic Evaluation Database and a hand-search of reference lists, key journals and editorials. Comparative evaluations presenting original, quantitative data on processes, efficiency or clinical outcome measures of care between hospitalists, community-based physicians and traditional academic attending physicians were included (n = 65). After proposing a conceptual framework for evaluating inpatient physician performance, major findings on quality are summarized according to their percentage change, direction and statistical significance.

Results: The majority of reviewed articles demonstrated that hospitalists were efficient providers of inpatient care observed by reductions in the average lengths of stay (69%) and total hospital costs (70%) of their patients; however, the clinical quality of hospitalist care appeared to be comparable to that provided by their colleagues. The methodological quality of hospitalist evaluations remains a concern and has not improved over time.

Persistent issues included insufficient reporting of source/sample populations (*n* = 30), losses to follow-up (*n* = 42) and estimates of effect/random variability (*n* = 35); inappropriate use of statistical tests (*n* = 55) and failing to adjust for established confounders (*n* = 37).

Conclusions: Future research should include an expanded focus on the specific structures of care that differentiate hospitalists from other inpatient physician groups and the development of better conceptual and statistical models that identify and measure underlying mechanisms driving provider-outcome associations in quality.

Citation

White HL, Glazier RH. Do hospitalist physicians improve the quality of inpatient care delivery? A systematic review of process, efficiency and outcomes measures. *BMC Medicine.* 2011; 9:58.

2.2 Background

In recent years, escalating health care costs, a rising prevalence of chronic comorbid diseases and increasing dependence on new technologies have combined to change the nature of inpatient care in North America. Faced with a growing need for cost-effective delivery, hospitals increasingly require that their practicing physicians enhance patient flow and lower operating costs while improving the clinical quality of care provided to their patients. In light of these demands, many hospitals have adopted the hospitalist model as one of the primary methods of achieving these objectives. First introduced in 1996, hospitalists, defined as physicians who specialize in delivering comprehensive medical care to hospitalized patients, have become one of the dominant groups of health care providers of inpatient care in North American hospitals [(9)]. Under the hospitalist model, unattached patients and patients whose primary care physicians do not provide inpatient services are transferred to the care of a hospitalist upon admission to a given institution. Acting as the case-manager, the hospitalists' role is to co-ordinate and integrate care for their assigned patients, which includes generating and reviewing clinical data; making decisions regarding necessary tests, treatments and procedures; and facilitating access to subspecialty and post-acute services [(13)]. Upon discharge, patients are returned to community under the care of their primary care physician (if they have one), while the hospitalist goes on to care for the next hospital admission. This defining characteristic differentiates hospitalists from their colleagues. Historically, inpatient physicians managed the day-to-day care of their hospitalized patients while maintaining active outpatient practices in either an office or a clinic-based setting. This provided both physicians and patients with some continuity of care, allowing for the development of relationships and medical histories between patient and provider. In contrast, the hospitalist movement represents a shift towards generalized hospital-based care where hospitalists provide attention to all routine medical needs throughout the course of hospitalization but maintain minimal responsibility for outpatient or follow-up care once a patient is discharged [(14,47)].

Advocates of the hospitalist model argue that hospitalists offer a number of advantages compared with traditional inpatient physician models. The on-site availability of a hospitalist ensures that a dedicated provider is readily available to answer questions, order and manage tests and respond during acute medical crises. By specializing in the management and treatment of common inpatient conditions, this routinization of care is also argued to enhance hospitalists' clinical expertise in complex and comorbid disease management, translating into improved clinical processes and potentially better outcomes in comparison to their colleagues, who manage fewer cases of a given condition over the same period of time [(7,15,17)]. On-site availability could also condense the timing of treatments and consultations, increasing the efficiency of discharge planning and allowing the hospitalist more time to communicate with patients, their families and the patients' primary care provider [(105)]. At the same time, the hospitalist model represents the purposeful introduction of discontinuity in care. Patients are transferred between providers at admission, discharge and throughout the course of hospitalization. Each transition increases the risk for medical errors and adverse events and jeopardizes both the continuity and quality of care [(7,106)]. Since the hospitalist enters with no first-hand knowledge of a patient's medical history, he or she may be inclined toward more aggressive, technology-based care, which could translate to the use of more diagnostic tests and higher costs to establish the baseline health status of the patient. Hospitalists may not always be aware of a patient and family's wishes regarding resuscitation or rescue measures [(106)], and while each transfer of care provides an opportunity for improved communication between providers, delayed communication or inaccuracies in information transfer may have substantial implications for outpatient follow-up, patient safety, provider satisfaction and overall system utilization [(107-109)].

In 1998, researchers began evaluating the performance of newly instituted hospitalist programs by comparing full-time hospitalists to traditional academic attending physicians or community-based physicians on the basis of core indicators of effectiveness and efficiency [(30,110)]. While multiple comparative studies of hospitalists' performance have been published since 1998, substantial disagreement still exists regarding whether and how hospitalists improve the quality of inpatient care delivery. While previous reviews have suggested that hospitalists can lower operating costs and reduce the average length of stay without adversely affecting clinical outcomes [31,32,111], the validity of findings continues to be scrutinized as a result of inconsistent and vague definitions of hospitalist interventions, poor study designs and inadequate risk adjustment [33,41,112].

The current systematic review synthesizes the findings of 65 evaluations of hospitalist performance to determine whether the hospitalist model improves the quality of inpatient care delivery compared to traditional inpatient physician models. After proposing a conceptual framework for evaluating hospitalist performance, major findings are summarized according to three core areas of quality: the processes of care delivery, operating efficiency and clinical outcomes of treatment. We also critique the methodological quality of selected publications, exploring whether the quality of hospitalist evaluations have improved over time and offering recommendations to guide the design and analysis of future comparative evaluations.

2.2.1 *New Contribution*

Although several systematic reviews of hospitalist care have been published, most recent reviews were restricted to specific subsets of the hospitalist literature (high-quality articles using adult inpatient populations [31], communication and information transfer at discharge between hospital-based and primary care physicians [113] and pediatric hospitalists [112]), warranting an updated, in-depth synthesis of the larger body of evidence on overall hospitalist performance. A comprehensive, systematic review incorporating all hospitalist practice styles and inpatient populations was published by Coffman and Rundall in 2005 [33]. Since publication of their review, the number of peer-reviewed comparative studies of hospitalists' quality has tripled. These recent evaluations are important additions to the literature as they include an expanded focus on the processes of care delivery and on the performance of hospitalists relative to primary care physicians who choose to maintain hospital privileges, both of which improve the generalizability of new evidence for the growing sector of nonacademic hospitals interested in implementing and evaluating hospitalist programs.

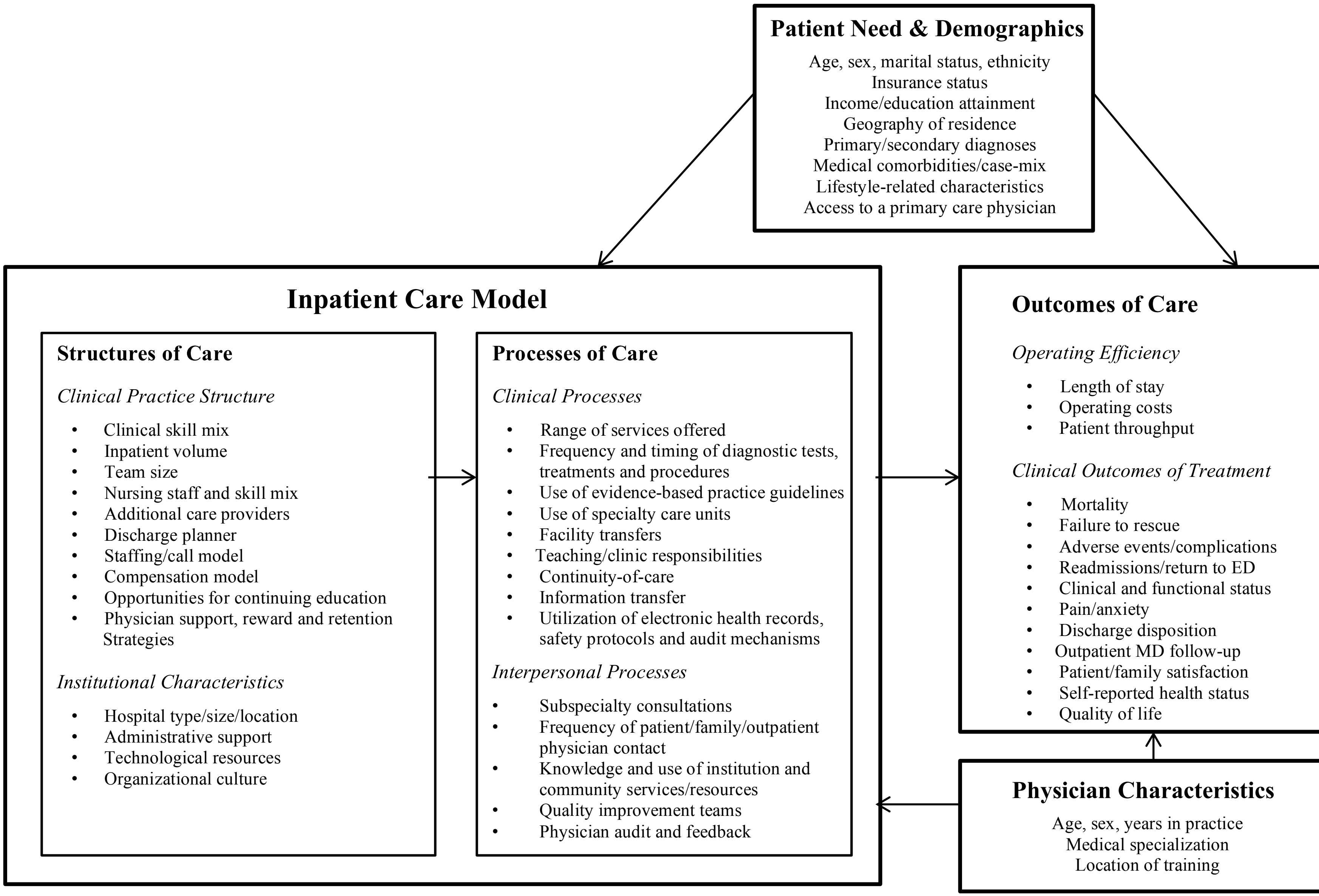
In addition, many hospitalists have begun broadening their clinical roles, providing newborn or pediatric care; medical comanagement of surgical, cardiac, psychiatric and intensive care unit (ICU) patients; and long-term palliative care [10,114-116]. This review includes the addition of 12 never-reviewed studies focused solely on these areas of role diversity; many of whose findings deviate from the performance trends seen among hospitalists in a general medical service. This review also includes the first formal methodological critique of the literature, highlighting reporting and analytic concerns which persist and threaten the internal and external validity of reported findings. Finally, we propose a novel conceptual framework for evaluating and synthesizing hospitalist performance on the basis of Donabedian's [98] structure-process-outcome framework for assessing quality in healthcare settings. By situating the empirical findings within an underlying framework, we are able to clarify which structural characteristics of physicians' practices may drive variations in provider performance, which in turn can aid future researchers in organizing and controlling for potential determinants of quality.

2.2.2 *Conceptual Framework*

In 1966, Donabedian [98] proposed a three-concept framework for analyzing quality improvement wherein the organizational structures of healthcare settings interact with the processes of care delivery to influence clinical, interpersonal and organizational outcomes. According to Donabedian [98], structural indicators of quality refer to the professional, institutional and organizational resources and policies associated with the provision of care and include staffing models, training, credentials and facility resources. Process indicators refer to the things done to and for the patient by providers during the healthcare encounter [117] and can be categorized into two broad types: (1) clinical processes, which include the types of services delivered as well as the appropriateness and timeliness of those services, and (2) interpersonal processes, which include patient-provider and provider-provider communications, patient education and the cultural sensitivity of care [117]. Finally, outcome indicators of quality refer to the end states resulting from care, which may include changes in patient morbidity, mortality, resource utilization, satisfaction and overall quality of life [117].

Donabedian [98,118] noted that these three categories are not independent, but linked in an underlying framework whereby good organizational structures should promote good processes, and good processes in turn should drive better outcomes. It is important to note that while the presence of either structures or processes alone can enable the provision of quality healthcare, they cannot in isolation ensure it [119]. We propose the conceptual framework illustrated in **Figure 2.1** as a map for understanding, evaluating and synthesizing the quality of hospitalist care while accounting for differences in program designs, institutional resources, provider characteristics and clinical risk. Within the hospitalist literature, the physicians' clinical practice structures represent the key comparative measure of interest, along with institutional characteristics, resources and policies that support the provision of care. While the specific structure of hospitalist programs vary across institutions, common components that distinguish hospitalists from their colleagues include their enhanced expertise and experience in managing common inpatient conditions, greater in-hospital availability and higher volume of inpatient care delivered. Equally important but not often explored factors include nursing staff to patient ratios, administrative resources and organizational cultures that support hospitalist hiring and retention. Process measures reflecting the quality of hospitalist care may include the frequency and timing of diagnostic tests; treatments, procedures and consultations; adherence to evidence based clinical practice guidelines; utilization of safety protocols, error detection mechanisms and use of electronic medical records; regularity of patient, family and outpatient physician consultations; and opportunities for physician audit and feedback. Finally, outcome measures of quality can reflect both the efficiency of care delivery (for example, length of stay, hospital costs, emergency department processing time) as well as clinical outcomes of treatment (for example, mortality rates, patients' pain and functional status, and patient and family satisfaction). Post-hospital outcomes, such as readmission rates, returns to the emergency department and continuity of care/follow-up, can also be examined. Recognizing that patient assignment to providers and subsequent health outcomes are rarely influenced by structural and process inputs alone, we expand on Donabedian's [98] framework to include patients' need for care, patients' basic demographics and the characteristics of physicians involved in the care process.

Figure 2.1 Conceptual framework for evaluating hospitalist performance integrating structures, processes, and outcomes of care.



2.3 Method

2.3.1 *Search Strategy*

A comprehensive search of the literature was conducted using MEDLINE, Embase, Science Citation Index, CINAHL and the NHS Economic Evaluation Database for the following exploded medical subject heading terms and keywords: " hospitalist" and "hospital-based medicine." The search was restricted to abstracts published between January 1996 and December 2010, excluding conference abstracts. No language restrictions were imposed. Additional citations were identified through manual searches of the references and works cited lists of selected articles as well as previous systematic reviews, relevant journals (Journal of Hospital Medicine; Journal of General Internal Medicine) and key editorials.

2.3.2 *Article Selection*

The above-described strategy identified 1,411 electronic citations for which the abstracts were subsequently retrieved and screened. Selection criteria for inclusion were as follows: eligible articles had to (1) describe a comparative analysis between physicians identified or labeled as 'hospitalists' and traditional inpatient physician models involving community-based physicians, traditional academic attending physicians or a combination of both; (2) generate original, quantitative data in one of the three healthcare quality areas of interest (that is, processes of care, operating efficiency and/or clinical outcomes of treatment); (3) differentiate hospitalists from their counterparts in terms of their structural attributes (that is, time spent on-site, patient volume, clinical skill mix); and (4) include a sample population of hospitalized patients. Using these pre-specified criteria, abstracts were independently assessed, with any discrepancies resolved by consensus. Seventy-seven articles met these initial inclusion criteria. Upon examination of the full papers, five of these articles were excluded because control patients received significant cross-over of care from the hospitalist physicians [120-124], and three other articles were excluded because healthcare quality was examined among hospitals with and without hospitalists, regardless of whether the sampled patients actually received direct hospitalist care [125-127]. Two papers were excluded because the intervention involved the addition of a hospitalist medical director, as opposed to a hospitalist physician providing direct inpatient care [128,129], and one paper was excluded because the intervention did not meet a widely accepted definition of a hospitalist program in that no physician spent more than 25% of his or her professional time working as an inpatient specialist [130]. Finally, one methodological paper was excluded because unsourced data on hospitalist performance were used to illustrate the application of a risk adjustment strategy [131]. This left 65 comparative evaluations included in our review. The flow of information throughout the selection process is shown in **Figure 2.2**.

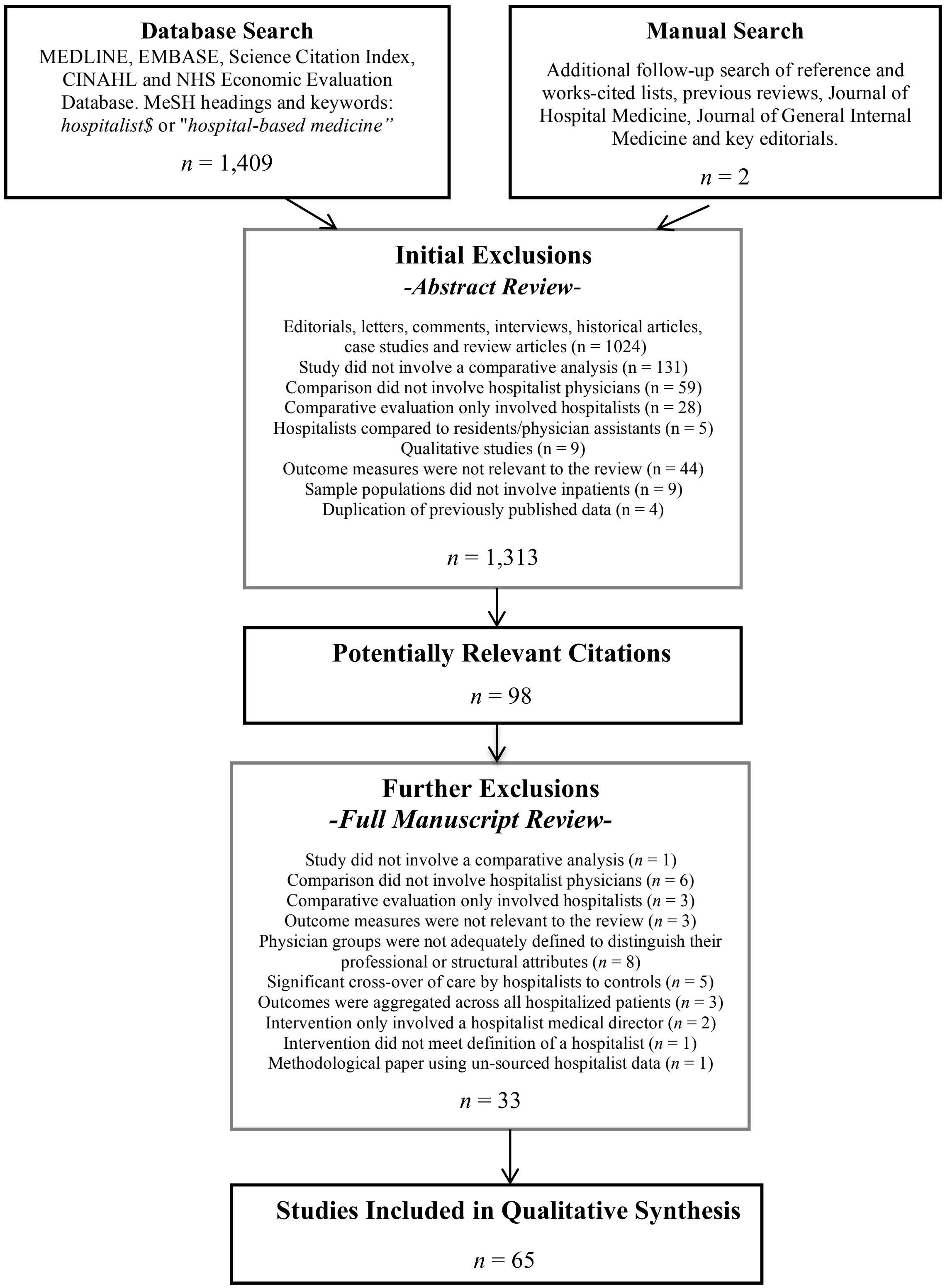
2.3.3 *Data Extraction*

Data were extracted on each study' s design, sample and source population characteristics, institutional setting, a description of hospitalist and comparative care models, risk adjustment techniques employed, and relevant findings. Hospitalist practice models were then classified into three broad design types: private hospitalists hired on contract to provide inpatient care at one or more institutions, salaried faculty hospitalists with no teaching responsibilities, and academic hospitalist attending physicians who worked on the inpatient unit for three to twelve months per year and were involved in the training of residents and medical students. Comparison physicians were similarly classified according to the following traditional practice models: outpatient practices (general practitioners/family physicians, general internists, and pediatricians) and traditional academic attending physicians who served on the inpatient unit for one to three months per year supervising residents and medical students and maintaining outpatient clinic hours while on-service. Multiple practice types and the use of comanagement models, physician assistants, nurse practitioners, and discharge planners are indicated where appropriate.

2.3.4 *Synthesis of Evidence*

Major findings from included studies were synthesized within our conceptual framework according to the following three areas of quality: the processes of care delivery;

Figure 2.2 Flow of information throughout the article selection process



operating efficiency and clinical outcomes of treatment. Relationships are summarized by each indicators percent change, direction and statistical significance. A summary of the 65 included articles and their overall findings are presented in **Table 2.1** while detailed results from individual analyses can be found in **Appendix 2.1 [A-C]**. Where available, results are presented from the authors' risk-adjusted models and are considered significant when a *p*-value ≤ 0.05 was reported in the literature. Summary measures based on unadjusted analyses are indicated by an asterisk (*) and those without accompanying *p*-values or confidence intervals are indicated by an alveolar click (ǂ).

To assess the methodological quality of the included literature, we used a 27-item checklist developed by Downs and Black [(132)] that was designed and validated to gauge the following four areas of methodological quality in both randomized and nonrandomized studies of healthcare interventions: disclosure and/or reporting; internal validity; external validity; and study power. To capture methodological issues specific to reporting within hospitalist interventions, we added five additional questions to the original 27-item checklist regarding the authors' disclosure of (1) funding sources, (2) location of the intervention, (3) whether hospitalists were used exclusively for managing the care of specific inpatient populations, (4) whether incentives (monetary or otherwise) were provided for physicians to enhance their performance, and (5) the role of additional providers in the provision of inpatient care. We added one additional question regarding whether the authors included a power assessment in their article, and one question was excluded on the blinding of participants to intervention allocation because patients are generally aware of who is managing their day-to-day care. To score the methodological quality of each article, a score of 1 was assigned for each of the 32 questions in the checklist answered 'yes' and a score of 0 for each question answered either 'no' or 'unable to determine'. Marks were then summed to provide a total quality score (maximum = 32). The modified checklist and evaluation criteria used to assign all quality ratings are given in **Appendix 2.2.** The systematic review was performed according to the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [(133)], **Appendix 2.3.**

Table 2.1 Summary of articles evaluating hospitalist performance (n = 65)[a]

Source	Design	Hospital type	Study population	Sample	Comparison	Quality score	Hospitalist performance: Processes of care	Hospitalist performance: Operating efficiency	Hospitalist performance: Patient outcomes
Abenhaim *et al.* (99)	RC	Teaching	Adults admitted to either GMS or medical short-stay unit	2,722	F vs. TWS	8	↑,*,ǂ	↑,*,ǂ	↑,*,ǂ
Auerbach *et al.* (134)	RC	Teaching	Adults admitted to GMS	5,308	A vs. C	24	–	↑	↑
Auerbach and Pantilat (135)	RC	Teaching	Adults admitted to GMS who died while in hospital	148	A vs. C	21	↑		↑
Batsis *et al.* (136)	B/A	Teaching	Seniors admitted for surgical repair of hip fracture	466	F[b] vs. TWS	13			–,*
Bekmezian *et al.* (16)	RC	Pediatric teaching	Pediatric patients with oncologic, hematologic or gastroenterologic disease	925	F vs. TWS	17		↑	↓,*
Bell *et al.* (137)	QE	Teaching (six sites)	All patients admitted to GMS	1,078	Mixed practice types	6	–,*		
Bellet and Whitaker (138)	B/A	Pediatric teaching	Pediatric patients admitted to GMS	1,440	A vs. TWS and C	24	–,*	↑	↓,*
Boyd *et al.* (139)	RC	Teaching	Pediatric patients admitted to GMS	1,009	P vs. TWS	16		↓	
Carek *et al.* (140)	RC	Community	Adults admitted to GMS	5,453	P vs. C	21		↓,*	–,*
					P vs. TWS			↓	–

Craig *et al.* [141]	RC	Community (16 sites)	Adults admitted from one HMO to GMS		P vs. C	8		↑,‡	−,‡
Davis *et al.* [142]	RC	Community	All patients admitted to GMS	2,124	P[c] vs. C	13	↑,*	↑	−
Dhuper and Choksi [143]	B/A	Teaching	All patients admitted to GMS	10,966	A[c] vs. TWS	14			↑,*
Diamond *et al.* [30]	B/A	Teaching	Adults admitted to GMS	3,299	A vs. C	16		↑,*	↑,*
Dwight *et al.* [84]	RC	Pediatric teaching	Pediatric patients admitted to GMS	3,807	F vs. TWS	22	−	↑	−
Dynan *et al.* [144]	RC	Teaching	All patients admitted to GMS	5,543	F[c] vs. TWS	14		↑	−
Everett *et al.* [145]	RC	Community	All patients admitted to GMS	11,750	P vs. C	15		↑	−
Everett *et al.* [146]	RC	Teaching	All patients admitted to GMS	22,792	P vs. C	14		↑	−
					P vs. TWS			↓	↑
Freese *et al.* [62]	B/A	Community	All patients admitted to GMS		P vs. C	6	↑,*,‡	↑,*,‡	
Gittell *et al.* [147]	RC	Community	All patients admitted to GMS	6,686	P vs. C	7		↑	↑
Go *et al.* [148]	QE	Teaching (six sites)	Adults admitted to GMS with diagnosis of acute upper gastrointestinal hemorrhage	450	A vs. TWS	22	−,*	↓	−
Gregory *et al.* [4]	B/A	Teaching	All patients admitted to GMS	402	F vs. TWS	8		↑,*	−,*

Hackner *et al*. [149]	PC	Teaching	Adults on Medicaid admitted to GMS	1,637	A vs. C	19	↑,*	↑,*	−,*
Halasyamani *et al*. [150]	RC	Teaching	Adults admitted to GMS	10,595	P vs. C	21		↑	−
					A vs. C			↑	−
Huddleston *et al*. [22]	RCT	Teaching	Adults undergoing elective hip or knee arthroplasty	469	F[b] vs. TWS	26		↑	↑
Kaboli *et al*. [151]	QE	Teaching	All patients admitted to GMS	1,706	A vs. TWS	23		↑	−
Kearns *et al*. [152]	QE	Teaching	All patients admitted to GMS	4,455	A vs. TWS	26	−,*	−	−
Khasgiwali *et al*. [153]	RC	Teaching	All patients admitted to GMS	1,916	P and A vs. TWS	14	−,*	−,*	−,*
Krantz *et al*. [154]	B/A	Teaching	All patients admitted to chest pain observational unit	493	P[b] vs. TWS	19		↑,*	−,*
Kulaga *et al*. [155]	RC	Teaching	All patients admitted to GMS	2,707	A vs. C	8		↑,*,ǂ	↑,*
Kuo *et al*. [156]	RC	Mixed (4,359 sites)	5% national sample of admissions among Medicare beneficiaries	314,590	Mixed practice types	16		↑	
Landrigan *et al*. [23]	TS	Pediatric teaching	Pediatric patients admitted to GMS from three HMOs	7,748	A[c] vs. C	15		↑	−
Lindenauer *et al*. [157]	RC	Teaching	Adults admitted with heart failure	326	P and A vs. C	14	↑	↑	−,*

Lindenauer *et al*. [158]	RC	Mixed (45 sites)	Adults admitted with pneumonia, heart failure, chest pain, stroke, UTI, COPD or acute MI	76,926	Mixed practice types	20		↑	−
Maa *et al*. [159]	B/A	Teaching	Adults undergoing surgical appendectomy		A vs. TWS	7		↑,*	
Meltzer *et al*. [160]	QE	Teaching	All patients admitted to GMS	6,511	A vs. TWS	20		↑	↑
Molinari and Short [161]	B/A	Community	Adults admitted from one HMO	1,319	P[c] vs. C	8		↑	
Ogershok *et al*. [162]	B/A	Pediatric teaching	Pediatric patients admitted to GMS	2,177	A vs. TWS	14	↑,*	↑,*	−,*
Palacio *et al*. [163]	RC	Teaching	All patients admitted to GMS	5,943	F vs. TWS	11		↑,*	↑
Palmer *et al*. [24]	QE	Teaching	All patients admitted to GMS	2,464	A[c] vs. TWS	25	↑,*	↑	↑
Parekh *et al*. [164]	RC	Teaching	All patients admitted to GMS	2,552	A vs. TWS	19		−	−
Phy *et al*. [165]	B/A	Teaching	Older adults admitted for surgical repair of hip fracture	466	F[b,c] vs. TWS	15		↑	−,*
Pinzuer *et al*. [166]	B/A	Teaching	Adults admitted for lower-extremity salvage or reconstructive surgery	140	F[b] vs. TWS	9		↑	↓,‡,*

Ravikumar *et al*. [167]	B/A	Teaching (four sites)	Adult surgical patients	39,769	F[b,c] vs. TWS	8		↓,ǂ,*	↓,*
Reddy *et al*. [168]	RC	Teaching	All patients admitted with community-acquired pneumonia	151	A vs. C and TWS	9	–	–	
Rifkin *et al*. [169]	RC	Community	Adults admitted with community-acquired pneumonia	455	P vs. C	20	↑,*	↑	–,*
Rifkin *et al*. [170]	RC	Teaching	All patients admitted to GMS	11,388	F vs. C	18		–	
Rifkin *et al*. [171]	RC	Community	All patients admitted with community-acquired pneumonia	158	F vs. C	11	↑,*		
Roy *et al*. [120]	RC	Teaching	Adults admitted with hip fracture	118	F vs. C	9		↑,*	
Roytman *et al*. [172]	RC	Teaching	Adults admitted with congestive heart failure	342	F vs. C	20	↑	↑	↑
Salottolo *et al*. [173]	B/A	Teaching	Adult trauma admissions	500	F vs. TWS	5		↓	–
Scheurer *et al*. [174]	RC	Mixed (29 sites)	All patients admitted with bacterial pneumonia	11,969	Mixed practice types	7		↑,*	
Schneider *et al*. [25]	QE	Teaching (six sites)	All admissions to GMS with HIV infection	1,207	A vs. TWS	17	–	–	–

Sharma *et al.* [106]	RC	Mixed (11 sites)	Older adults on Medicaid with advanced lung cancer	21,183	Mixed practice types	14	↓		
Simon *et al.* [175]	B/A	Pediatric teaching	Pediatric patients undergoing spinal fusion	759	F[b] vs. TWS	8		↑	
Sloan *et al.* [115]	B/A	Community VA	Adults admitted to inpatient psychiatric unit	1,409	F[c] vs. C[c]	18		−,*	↑,*
Smith *et al.* [176]	RC	Teaching	Adults admitted with community-acquired pneumonia	45	P vs. C	14	−	↓	−,*
Somekh *et al.* [177]	RC	Teaching	Admissions to GMS or cardiac observational unit for chest pain	750	F vs. C	11	↑,*	↓,‡	−
					F vs. cardiologist		↓,*	↓	↓
Southern *et al.* [178]	RC	Teaching	All patients admitted to GMS	9,037	A vs. TWS	19		↑	−
Srivastava *et al.* [179]	B/A	Pediatric teaching	Pediatric patients from one HMO admitted with asthma, dehydration or viral illness	1,970	A vs. TWS	19		↑	
Stein *et al.* [180]	RC	Teaching	Adult admitted with community-acquired pneumonia	237	A vs. C	11	−,*	↑,*	−,*
Tenner *et al.* [181]	B/A	Pediatric teaching (two sites)	Pediatric admissions to ICU	1,211	P vs. TWS	17		↑	↑

Tingle and Lambert (182)	RC	Teaching	Adults admitted to GMS	529	F vs. TWS	14		−	−,*
Vasilevskis *et al*. (183)	RC	Teaching (six sites)	Adults with heart failure admitted to GMS	372	Mixed practice types	18	−	−	↑
Wachter *et al*. (184)	QE	Teaching	All patients admitted to GMS	1,623	A vs. TWS	18	−,*	↑	−
Wells *et al*. (26)	PC	Community	Pediatric patients admitted to GMS	181	P vs. C	5		↑	−,*

[a] RCT, randomized, controlled trial; QE, quasi-experimental design; TS, time series; PC, prospective cohort; RC, retrospective cohort; B/A, before versus after; CS, cross-sectional survey; GMS, general medical service; HMO, health maintenance organization; UTI, urinary tract infection; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; HIV, human immunodeficiency virus; ICU, intensive care unit; P, private hospitalist attending physician; F, nonacademic faculty hospitalist attending physician; A, academic hospitalist attending physician; C, community-based physician; TWS, traditional academic attending physicians with teaching responsibilities.

[b] Hospitalists were comanaging their patients' care with comparison healthcare providers.

[c] Use of physician's assistants, nurse practitioners and/or discharge planners in the provision of care.

↑ indicates improved performance by hospitalists; − indicates no difference in performance between providers.↓ indicates worse performance by hospitalists; ǂ indicates that a *P* value or confidence interval was not provided, so results may or may not be statistically significant; *indicates that results are unadjusted.

2.4 Results

2.4.1 *Study Characteristics*

Descriptive characteristics summarizing the 65 articles are presented in **Table 2.2.** Sixty-three of the evaluations were conducted in the United States, and the remaining two studies utilized data from Canadian institutions [84,99]. After we screened the hospitalist literature for inclusion in our review, hospitalist programs were adopted in several countries outside North America, including Australia, New Zealand, Argentina, Brazil, Chile, Columbia, Spain, Sweden, and Singapore [41,78,79]. While several editorials and descriptive papers have been published on programs within these countries, no comparative analyses conducted in these countries have appeared in the literature to date.

Only one of the sixty-five reviewed articles employed a true randomized, controlled study design in which the first patient enrolled was randomly allocated to either hospitalist or traditional care at the time of admission [22]. Subsequent patients were then assigned using concealed, dynamic allocation. Eight additional articles used quasi-randomized designs based on natural experiments in which patients were assigned to either hospitalist or comparative care according to their position in the physicians' call schedules [24,25,137,148,151,160,184] or alternating rotations [152]. Randomization appeared to be successful for all but two of these studies [137,148], reporting no statistically significant differences between the intervention and control groups with respect to baseline patient demographics, diagnoses, and underlying comorbidities (n = 7; 78%). The remaining 56 evaluations used one of the following observational designs: interrupted time series (n = 1; 2%), prospective cohorts (n = 2; 3.0%), retrospective cohorts (n = 35; 54%), and before and after (n = 18; 28%). In most observational studies, the design of the hospitalist intervention precluded randomization as community-based physicians elected to manage their own hospitalized patients.

The majority of studies were not restricted with respect of the ages of study participants (n = 27; 42%). Twenty-five evaluations examined outcomes among adults aged 18 and older, three were restricted to older adults (ages 65 and older), and ten focused on pediatric patients.

Table 2.2 Descriptive characteristics of 65 comparative evaluations of hospitalist performance[a]

Study characteristics	**Studies, *n* (%)**[b]
Country of research	
Canada	2 (3.0)
United States	63 (97.0)
Research design	
Randomized or quasi-randomized controlled trial	9 (13.8)
Interrupted time series	1 (1.5)
Prospective cohort	2 (3.1)
Retrospective cohort	35 (53.8)
Before and after	18 (27.7)
Patient eligibility	
Adult patients only	25 (38.5)
Pediatric patients only	10 (15.4)
Older adult patients only (age ≥65 years)	3 (4.6)
Medicare/Medicaid enrolment	3 (4.6)
HMO/VA enrolment	5 (7.7)
Diagnostic/disease eligibility	
Asthma/bronchiolitis	3 (4.6)
Chest pain	6 (9.2)
Cancer/hematology	2 (3.1)
Chronic obstructive pulmonary disease	4 (6.2)
Community-acquired or bacterial pneumonia	14 (21.5)
Gastrointestinal/digestive disorders	8 (12.3)
Heart failure	9 (13.8)
Human immunodeficiency virus	1 (1.5)
Hypovolemia/dehydration	2 (3.1)
Myocardial infarction	2 (3.1)
Nutritional/metabolic disorders	4 (6.2)
Orthopedic and other surgical procedures	9 (13.8)
Psychiatric illness/substance dependency	2 (3.1)
Stroke	4 (6.2)

Trauma	2 (3.1)
Urinary tract infection	4 (6.2)
Viral illness	2 (3.1)
Hospital type	
Teaching hospital	54 (83.1)
Community/rural hospital	11 (16.9)
Location of care	
General medical/surgical service	60 (92.3)
Chest pain observation unit	2 (3.1)
Intensive care unit	1 (1.5)
Medical short-stay observation unit	1 (1.5)
Psychiatric unit	1 (1.5)
Hospitalist practice structure[b]	
Private hospitalists	22 (33.8)
Nonacademic faculty hospitalists	26 (40.0)
Academic hospitalist attending physicians	33 (47.7)
Mix of practice structures	
Comparative practice structure[b]	
Community-based physicians	34 (52.3)
Traditional academic attending physicians	41 (63.1)

[a] HMO, health maintenance organization; VA, Veterans Affairs.

[b] Percentages may not sum to 100 due to rounding.

[c] Number of articles may not sum to 65 as several studies compared more than one physician structure.

Among the 63 evaluations conducted in the United States, insurance status was rarely used as an exclusion criterion (n = 8; 13%). Four studies examined outcomes of hospitalist care among commercial health maintenance organization (HMO) enrollees, three evaluated Medicare or Medicaid recipients, and one involved a source population who received care through Veterans Affairs hospitals [(115)]. Several evaluations also examined the quality of inpatient care among patients with specific diseases and conditions including orthopedic, trauma, and other surgical procedures; lung disease; cardiovascular disease; infectious gastrointestinal disease; metabolic and autoimmune disorders; and mental health issues or substance dependency (see **Table 2.2** for frequencies).

Eighty-three percent of all evaluations were conducted within teaching hospitals or units and involved single-site comparisons (*n* = 54). Of the eleven evaluations conducted across multiple facilities, ten included at least one teaching hospital (91%). While most articles evaluated quality of care among patients in a general medical or surgical service (*n* = 60; 92%), one was restricted to the provision of care within the ICU [(181)] and one to an inpatient psychiatric unit [(115)]. One study examined cooperative hospitalist or cardiologist care on a chest pain observation unit designed for patients at low risk for cardiovascular events [(154)], and one additional article compared hospitalist care on the general medical service to cardiologists working in a similar chest pain unit [(177)]. Finally, one Canadian study examined performance on a hospitalist-run, short-stay unit in comparison with care provided on a general medical service [(99)].

Considerable variation existed in the number of study participants and healthcare providers included across evaluations (see **Table 2.3** for summary statistics). The median number of sampled patients was 1,630 (reported in 62 studies), and the median number of hospitalist practitioners was six (reported in 51 studies). In three of the sixty-five evaluations, the overall sample size was not disclosed [(62,141,159)], and three additional authors did not report sample sizes within comparison groups [(106,147,179)]. The number of hospitalists and comparative physicians who provided care to included participants was not reported in 22% (*n* = 14) and 49% (*n* = 32) of publications, respectively. Thirteen evaluations compared the quality of inpatient care among patients managed on academic ward teams led by hospitalist attending physicians with those managed by traditional academic physicians attending on the inpatient service for one to three months per year (20%). Seventeen additional evaluations compared patients of nonteaching hospitalists with those managed by traditional academic attending physicians (26%), and seven compared patients of academic hospitalists to patients managed by community-based physicians (11%). Fourteen evaluations compared the performance of nonteaching hospitalists with community-based physicians (22%), and the fourteen remaining articles involved comparisons across several different physician models.

Table 2.3 Summary statistics of the 65 comparative evaluations on hospitalist performance

Study characteristics	**Value**
Study participants (*n* = 62)	
Median	1,630
Mean	10,272.1
Range	45 to 314,590
Hospitalist physicians (*n* = 51)	
Mean	15.4
Median	6
Range	1 to 284
Nonhospitalist physicians (*n* = 37)	
Mean	156.5
Median	46
Range	1 to 1,964
Number of outcomes studied	
Median	4
Mean	4.7
Range	1 to 17
Study quality score (maximum = 32)	
Median	15
Mean	14.9
Range	5 to 26
Significant improvement by hospitalists on ≥1 quality indicator, *n* (%)	
No improvement or worse performance	16 (24.6)
Better quality on ≥1 indicator	46 (70.8)
Unknown/significance not reported	3 (4.6)

Finally, seven articles examined hospitalist comanagement practices in which hospitalists provided general medical care to patients assigned to surgical (*n* = 6) or cardiac (*n* = 1) teaching teams.

2.4.2 *Quality of hospitalist care*

Overall, 46 (71%) of the 65 reviewed articles demonstrated improved quality under hospitalist care on at least one indicator. Three additional papers suggested similar trends in performance (4%); however, the authors failed to report the statistical significance of their findings [62; 4%,99,141]. Of the remaining nineteen articles, nine (14%) failed to demonstrate any variations in quality between providers, and seven (11%) indicated worse outcomes for patients managed by hospitalists.

Process indicators of hospitalist quality

Twenty-six comparative evaluations examined the processes of care delivery between hospitalists and their colleagues. Among these evaluations, twenty-two indicators of clinical processes and five indicators of interpersonal processes were examined. Clinical process indicators included measures of diagnostic and procedural utilization, adherence to evidence-based clinical practice guidelines for the treatment of common conditions, and ICU transfers, while interpersonal process indicators explored consultation rates to various subspecialty providers, the frequency of family contact, and communication patterns with patients' primary care physicians. Subspecialty consultation rates were the most commonly explored process indicator of hospitalist quality (n = 9; 35%), followed by several indicators of resource utilization, including radiology (n = 8; 31%), laboratory testing (n = 7; 27%), and the use of hematology services (n = 6; 23%). These outcomes were frequently identified retrospectively on the basis of hospital administrative and financial databases, although primary chart abstraction was used for some indicators in 11 evaluations (42%). On the basis of our review of the literature, there appear to be few differences in the processes of care delivery between hospitalists, traditional academic attending physicians, and community-based physicians. Of the eleven studies conducted to evaluate the utilization of ancillary services (defined as support services other than medical and nursing staff provided to patients in the course of care including diagnostic testing and therapeutic services), only four studies reported significant declines in the number of services used by hospitalists, three of which were based on unadjusted analyses [24,142,162]. None of the authors of these articles found significant differences in sputum culture or oxygen pressure testing, occupational and/or physical therapy, or dietitian utilization (*n* = 4). One of three articles reported minor improvements in cardiac testing among nonacademic hospitalists compared to community-based physicians; however, the utilization of diagnostic testing by hospitalists remained higher and more invasive than that provided by cardiologists [177].

Only two of nine studies found significant declines (22%) in subspecialty consultation rates [149,172], one of which was based on unadjusted analyses [149]. None of the reviewed articles described improvements in ICU use (*n* = 6), and one article described increased use of ICUs by hospitalists for patients with advanced stage lung cancer during these patients' final hospitalization [106]. While only two comparative studies have looked at communication patterns between inpatient physicians and the patients' primary care providers [25,137], there is no evidence to suggest that hospitalists communicate any better or worse than their colleagues.

Hospitalist and nonhospitalist physicians were equally likely to provide core measures of care for patients with pneumonia and immunosuppression. While Rifkin *et al*. [171] found that hospitalists were more likely to provide deep vein thrombosis prophylaxis and pneumococcal vaccination (or to have documented patients' ineligibility for these treatments), there were no significant differences in door-to-needle time for antibiotic initiation, the appropriateness of antibiotic use, the number of infectious disease or pulmonary consultations, serial chest radiography, ICU use, or smoking cessation counselling in several studies [168,169,171,176,180]. Similarly, in a large multisite trial examining the quality of care provided to inpatients with human immunodeficiency virus (HIV), Schneider *et al*. found no significant differences in processes of care between managing physicians, regardless of the physicians' prior experience in managing patients with known HIV infection [25]. Hospitalists showed no clearer trends in improvement with regards to adherence to evidence-based practice guidelines for cardiac care. While one study reported a slight increase in the assessment of left ventricular ejection fraction among patients with decompensated heart failure [157], another study failed to establish a significant effect [183].

Neither study found differences in angiotensin-converting enzyme inhibitor (ACE-I), angiotensin II receptor blocker (ARB), β-blocker, or warfarin utilization. A third study did report increased use of ACE-I and ARB use by hospitalists within 24 hours of admission; however, hospitalists were also less likely to initiate β-blocker use during hospitalization [172]. No significant differences in cardiac testing, sodium or fluid restriction, or lifestyle counselling were reported in any of these studies.

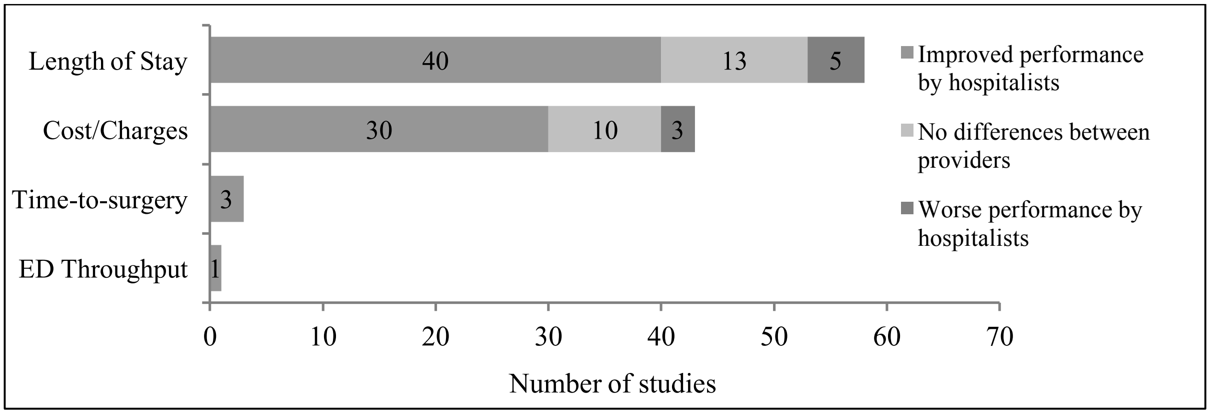
While less evidence is available regarding best practices for palliative care, the on-site availability of hospitalists may lead to enhanced efforts to communicate with dying patients and their families, resulting in improvements in the quality of end-of-life care. In a comprehensive study of palliative care patterns by academic hospitalists and community-based physicians, Auerbach and Pantilat [135] found that hospitalists were more likely to have documented discussions with patients and/or their families regarding their wishes for care. Although a higher proportion of hospitalist-treated patients were full code at admission, there was a trend toward more hospitalist patients' receiving comfort care at the time of death ($P = 0.14$). Nonhospitalist healthcare providers were similar in their use of opioids, although hospitalists were more likely to prescribe long-acting benzodiazepines in the 48 hours prior to death to aid patients' comfort and anxiety.

Hospitalists as efficient providers of inpatient care

Fifty-nine articles examined the efficiency of care delivery between inpatient physician models, the findings of which are summarized in **Figure 2.3.** Length of stay and total hospital costs were the two main indicators used to assess the efficiency of hospitalist care, although two additional indicators for emergency department processing and time to surgery were also examined. Outcomes were often identified retrospectively from hospital financial databases.

As illustrated in **Figure 2.3**, the majority of reviewed articles suggest that hospitalists can improve the quality of inpatient care delivery by enhancing their hospital's operating efficiency. Thirty-five of the fifty-eight articles that examined average or median length of stay found that patients managed by hospitalists had significantly shorter hospital stays compared to those who received traditional models of inpatient care (60%). Five additional papers suggested similar declines (9%); however, the authors failed to disclose the statistical significance of their findings [62,99,141,155,166].

Figure 2.3 Summary of findings regarding hospitalist performance and the efficiency of inpatient care.



Shorter lengths of hospital stays persisted across all hospitalist practice models: Twelve (80%) of fifteen articles comparing nonacademic hospitalists to community-based physicians and eleven (61%) of eighteen articles comparing nonacademic hospitalists with traditional academic attending physicians showed shorter patient stays under hospitalist care. Eighty-eight percent of studies demonstrated shorter lengths of stay among patients treated by academic hospitalists compared to those treated by community-based physicians (seven of eight studies), and the figure was 62% among academic hospitalists compared to traditional academic attending physicians (eight of thirteen studies). Only 55% of evaluations demonstrating shorter lengths of stay reported adjusted measures of effect estimated on the basis of various regression models (n = 22), and less than one-third of these used methods to adjust for the clustering of patients within physicians (n = 6). Thirteen evaluations found no significant differences in length of stay between healthcare providers (22%), the majority of which involved comparisons between hospitalist and traditional academic attendings (n = 9, 69%), and seven evaluations reported longer lengths of stay among hospitalists (12%). Fifty-seven percent of these evaluations involved comparisons between private hospitalists hired on contract and traditional academic attending physicians (*n* = 4).

Of the 43 articles examining hospital costs or charges, 27 showed significant reductions in the average or median cost of care under the hospitalist model (63%). Three additional papers suggested similar cost savings; however, the authors of these papers failed to disclose the statistical significance of their findings [62,141,155]. Cost reductions were reported in eight (67%) of twelve articles among nonacademic hospitalists compared to community-based physicians and in four (44%) of nine articles among nonacademic hospitalists compared to traditional academic attending physicians. All studies showed lower costs of care for patients treated by academic hospitalists compared to those treated by community-based physicians (*n* = 7), and 63% of investigations showed similar cost reductions between nonacademic hospitalists and traditional academic attending physicians (seven of eleven studies). Three evaluations reporting lower costs by hospitalists added length of stay as a covariate to their regression analyses [16,138,184]. In doing so, cost savings were no longer significant, suggesting that reductions in cost are likely the result of shorter length of stay as opposed to a reduction in the type and intensity of services provided, a finding supported by our previous analysis of process indicators which showed no reductions in the utilization of ancillary services by hospitalists.

Hospitalists may also improve the timeliness of emergency surgical care. In three studies where admission and preoperative assessments were conducted by hospitalists as opposed to a member of the surgical team, mean time to surgery was reduced by 35% to 50% [120,159,165]. Along with improvements in efficiency prior to surgery, overall lengths of stay for surgical patients comanaged by hospitalists were reduced in all studies [22,165-167,175], although none demonstrated associated reductions in costs [22,166]. Last, while hospitalist teams are often argued to improve emergency department flow through active and ongoing bed management, only one evaluation to date has reported significant improvements in emergency department processing [154], but no form of risk adjustment was used in their analyses.

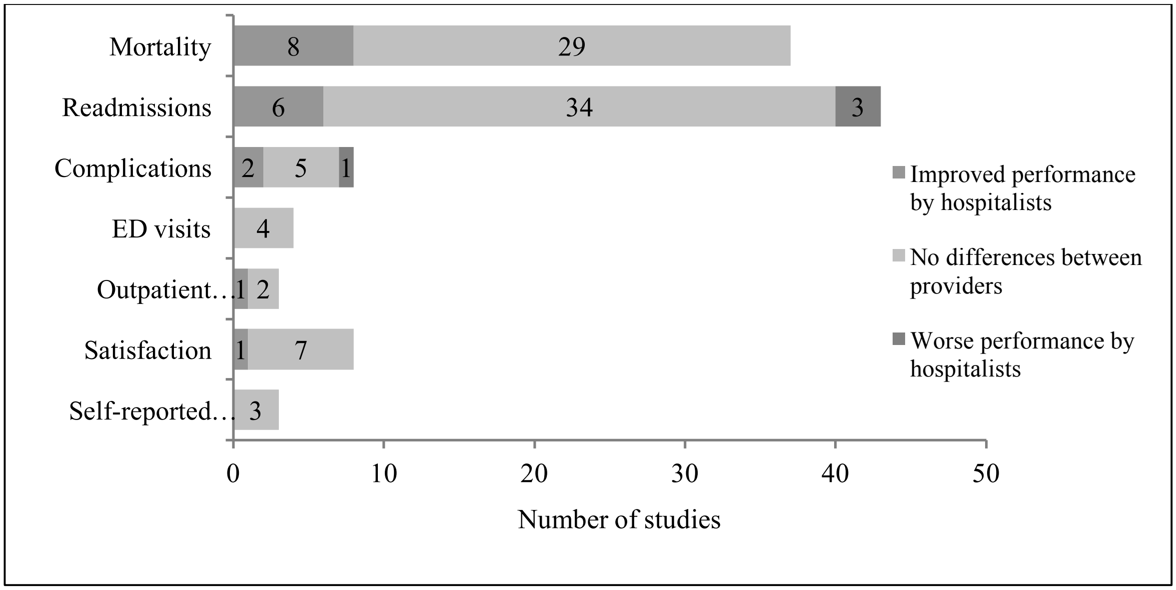
Clinical outcomes under hospitalist care

Fifty-one evaluations examined the relationship between hospitalist delivery models and clinical outcomes of treatment. Outcomes were frequently identified retrospectively using patient-level data captured in discharge databases and/or death registries (*n* = 35; 69%), and chart validation occurred in five of these evaluations (*n* = 14%). A summary of the findings is displayed in **Figure 2.4.**

Although our analysis suggests that hospitalists can improve the efficiency of inpatient care delivery, there is little evidence to suggest this translates into measurable improvements in the effectiveness of care provision to their patients. Thirty-seven studies analyzed mortality or survival rate as one indicator of hospitalist quality. Mortality was most frequently defined as occurring 'in-hospital' (*n* = 35; 95%), although seven studies looked at death within other periods after discharge (thirty days, sixty days, six months, and one year; 19% overall). Seven of the thirty-five evaluations reported significant declines (20%) in mortality rates among hospitalist providers, including two quasi-experimental studies [24,160] and five observational studies [134,143,167,172,181]. Readmissions, usually to the same facility, were examined in 43 evaluations (within seventy-two hours; seven, ten, fourteen, or thirty days; and one year), with the majority finding no differences between providers (*n* = 34; 79%). Six authors reported declines in readmissions within 30 days of discharge [99,115,146,154,163]; however, only two were from risk-adjusted regression models [146,163] and one author failed to disclose the statistical significance of the relationship [99]. In addition, three studies reported higher readmissions among hospitalists, all of which involved comparisons to traditional academic attending physicians [16,138,177].

Additional outcome indicators included in-hospital complications and adverse events (*n* = 8), emergency department and outpatient follow-up visits within 30 days of discharge (*n* = 4 and *n* = 3, respectively), patient and/or parent satisfaction (*n* = 8), and patients' self-reported health (*n* = 3). Five of the eight articles that examined complications or adverse events found no significant differences between providers [143,148,165,172,173].

Figure 2.4 Summary of findings regarding hospitalist performance and clinical outcomes of treatment.



Huddleston *et al*. [22] observed a reduction in surgical complications in orthopedic patients whose postoperative medical care was managed by hospitalists. Abenhaim and colleagues [99] also reported reductions in complications; however, patients in that study were preferentially admitted to hospitalist care based on a shorter anticipated length of hospital stay, and the analyses did not adjust for differences in the severity of patients' conditions or for case mix. Finally, a recent study published by Pinzuer *et al*. [166] found that high-risk patients undergoing lower-extremity salvage or reconstructive surgery had higher complication rates when comanaged by hospitalists as compared to prior management by the surgical team alone. No differences were found between care providers on any of the remaining outcomes, including rates of return to emergency department, outpatient follow-up visits to the patient's primary care provider, patient satisfaction, or patient self-reported health.

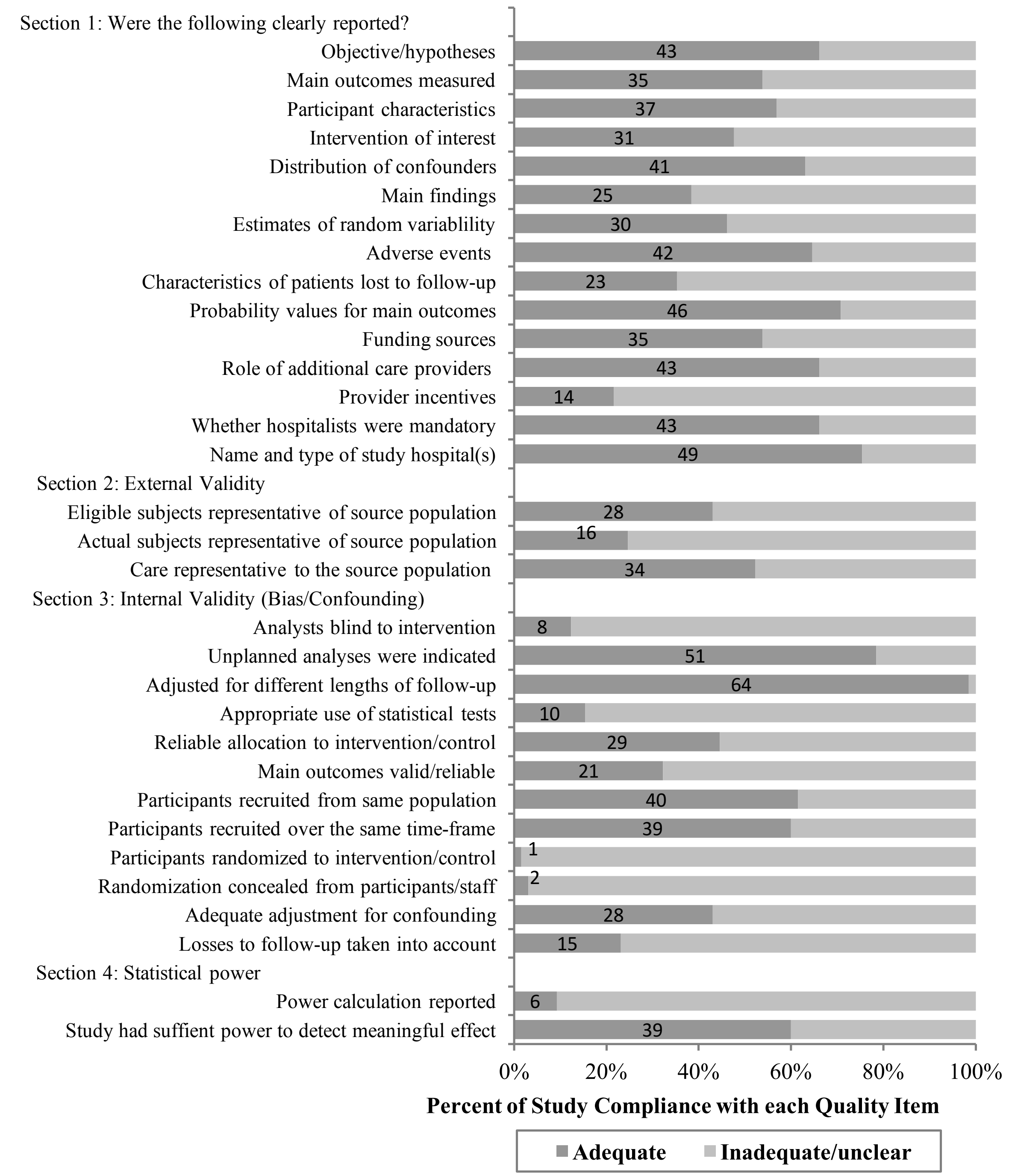
2.4.3 *Methodological critique*

Despite more than a decade of research on hospitalist performance and several calls to improve the rigor of study design, reporting, and analyses [33,101,112,116], the methodological quality of comparative evaluations remains poor. The median quality score of the studies that we reviewed was 15 of a possible score of 32 (range, 5 to 26; see **Table 2.1** and **Table 2.3**), suggesting that more than half of all hospitalist evaluations published to date raise concerns regarding their reliability, validity, or transparency in reporting. The number and percentage of reviewed articles complying with each of the items included in our quality checklist are displayed in **Figure 2.5**.

The quality of reporting and disclosure of information relevant to hospitalist interventions remain a concern in many publications; however, we highlight this as a promising area for methodological improvement. Thirty-four percent of all articles failed to state a clear objective of their evaluation in the introductory paragraphs (n = 22), and forty-three percent did not describe their sample and/or source populations or state patient inclusion or exclusion criteria (n = 30). More than half of reviewed articles did not describe the intervention and comparative care in enough detail to determine how many physicians actually delivered care to the patient sample and how this might have differed from care provided to the source population (n = 34). Only 22% of study authors included a statement on whether physicians were provided incentives to enhance their quality or efficiency (n = 14), and 34% of study authors did not indicate whether hospitalist care was mandatory for their patients (n = 22). These two issues are of particular concern, as their disclosure is necessary for interpreting the validity of any performance variations demonstrated across providers.

More than half of all studies also contained serious methodological errors, many of which could have been easily corrected. Twenty-six evaluations (40%) used insufficient sample sizes to demonstrate a clinically meaningful effect, and thirty-five (54%) appeared to use the wrong denominators when calculating incidence and risk for treatment outcomes

Figure 2.5 Methodological critique of study reporting, validity, and statistical power (n = 65).



* Data in the stacks represent the number of articles with adequate compliance on each of the 32 methodological questions

(that is, readmission or follow-up rates calculated among all admissions as opposed to those who survived until discharge). Fifteen studies (23%) made no attempt to adjust findings for potential confounding or bias, and another twenty-two studies (34%) used partially adjusted models that excluded one or more known confounders, such as patient age, sex, and/or insurance status; case mix; and the severity of the patient's condition. Finally, while 51% of studies used analyses that adjusted for some confounding factors in multivariable models (n = 30), only 15% used the appropriate hierarchical or clustered methods necessary for linking physician characteristics to patient outcomes in studies of provider performance. All of these issues decrease the internal validity of hospitalist evaluations, making it difficult for readers, clinicians, and policy analysts to assess the extent to which improvements in performance outcomes can be attributed to hospitalist care as opposed to unmeasured or unadjusted confounding variables.

Restricting studies to those conducted since the publication of Coffman and Rundall's systematic review [(33)] demonstrated no improvement in methodological quality over time (n = 33; median quality score = 14; range, 5 to 22). Calculating each article's percentage rating (study score ÷ 32), articles with poor quality ratings (between 0% and 49%; n = 35) typically had missing descriptions of source populations, inclusion and exclusion criteria, and the number of hospitalist and comparative care providers, all of which limit the external validity and representativeness of potentially important findings. The majority of poor quality studies also failed to disclose numerators or denominators for their outcome data (78%) and estimates of random variability (75%) for one or more main indicators, making it impossible for readers to assess the accuracy of the authors' analyses and conclusions. In contrast, articles with high quality ratings (>70%; n = 6) were transparent in their reporting, used randomized or quasi-randomized designs (67%), and made extensive attempts to account for selection bias and known sources of confounding (100%), all of which translated to high internal and external validity. It should be noted that because of the nature of inpatient care, it would be difficult for any study evaluation to obtain a perfect quality score, as concealment of allocation, even after randomization, is rarely feasible.

To assess the sensitivity of our conclusions to the methodological quality of the literature, we examined performance outcomes for those studies that received adequate or high quality ratings (percentage rating ≥ 60%; *n* = 14). The findings appear to be consistent with our earlier conclusions, suggesting improved efficiency by hospitalist providers (86%) with no subsequent improvements in processes (67%) or clinical outcomes of care (71%). Of the three studies which showed better [24,172] or worse [138] performance by hospitalists in these areas, two of the findings were from unadjusted analyses [24,138]. In contrast, while poor quality articles (*n* = 35; 77%) were equally likely to report gains in efficiency, they were also more likely to report improvements in the processes (54%) and outcomes of care (30%), the majority of which were unadjusted (70%) and likely driven by confounding.

2.5 Discussion

In this systematic review, we assessed the relationship between hospitalist physicians and the quality of inpatient care delivery. Forty-six of the sixty-five reviewed articles demonstrated that hospitalists delivered a higher quality of care to their patients compared to traditional inpatient physicians, and only seven studies indicated worse quality under the care of hospitalists. Superior outcomes were demonstrated across all care settings, regardless of study design, hospital type, patient eligibility, or physician practice structures. Stratifying these findings according to the area of quality examined showed improvements in operating efficiency among hospitalists (43 of 59 evaluations); however, there were few significant differences between physicians on process measures (15 of 26 evaluations) or clinical outcomes (33 of 52 evaluations). Taken together, our review of the current evidence suggests that hospitalists provide a level of clinical care that is comparable to that of their colleagues; however, their enhanced on-site availability and additional time spent on service suggests that the hospitalists' primary value likely comes from their ability to provide the same quality of clinical care in shorter periods of time, as evidenced by reductions in patients' average length of hospital stay reported in selected studies. Decreases in operating costs appear to be achieved largely by an increase in patient processing as opposed to reductions in the type and intensity of services provided. While there is no evidence to suggest that hospitalists provide a higher quality of clinical care, improvements in efficiency do not appear to come at the expense of clinical outcomes or patient and family satisfaction.

Despite these promising findings, many of the included studies had important methodological limitations, which decrease our confidence that findings reflect an accurate indication of hospitalist performance. Small sample sizes and inadequate statistical power were an issue in many studies, making it difficult to comment on whether hospitalists can decrease the incidence of rare outcomes such as in-hospital mortality or readmissions. The nonrandom allocation of patients frequently resulted in selection bias to preferred physician structures, where important covariates such as patient age, sex, ethnicity, insurance status, and preexisting comorbidities were often excluded from statistical models. Together, these factors resulted in poorly matched comparison groups and unadjusted biases. Finally, the statistical analyses used in selected studies were rarely conducted appropriately. Clinical indicators were frequently estimated among populations that were not actually at risk for the outcomes of interest, and inferences about quality were made at the level of providers without accounting for the clustering of patients within physicians. Furthermore, these methodological issues persist despite numerous calls urging researchers to enhance the rigor and reporting of the care provided by hospitalists compared with that offered by other healthcare providers.

Our findings are consistent with those reported in previous systematic reviews by Coffman and Rundall [33] and Landrigan *et al*. [111] suggesting improved performance by hospitalists based on the indicators of operating efficiency with no significant differences in patient outcomes between providers. These findings stand in contrast to those of Peterson's recent review [31], which found improvements in some process and outcome measures in addition to efficiency gains. It is worth noting that articles judged to be of 'poor' quality were excluded from Peterson's review, which may explain some of the deviations in our conclusions. When we attempted to replicate a version of Peterson's approach by excluding articles with quality scores below 50% (n = 35), we found little evidence to support processes or outcome improvements by hospitalists; however, 40% (n = 13) of the evaluations included in Peterson's review were found to have low quality scores in our review using the modified Downs and Black checklist [132].

In this systematic review, we propose a modified version of Donabedian's [98] framework as a simple conceptual map for understanding and synthesizing hospitalist performance, recognizing that an organization's structures, processes, and outcomes are interrelated and influence one another. By organizing these relationships into categories, researchers can logically predict and test relationships between constructs of interest and, in doing so, facilitate progression in the field of hospital medicine and quality initiatives. Structural differences between physician models should correlate with changes in the processes of care delivery, which in turn help drive improvements in operating efficiency and clinical outcomes. The results summarized in this review are important, as they suggest that the identification, labelling, and comparing of physicians as either 'hospitalists', 'traditional academic attending physicians', or 'community-based' providers is not sensitive enough to adequately differentiate the key structural characteristics which define hospitalists as distinct from other inpatient physicians and subsequently drive improvements in patient-level outcomes. The list of structural characteristics included in our conceptual model **(Figure 2.1)** quickly makes it apparent that inpatient physicians have access to many of the same resources and supports, regardless of job title, training, or time spent on service. By restricting all organizational aspects of a practice model to a single explanatory dummy variable as the vast majority of hospitalist evaluations have done, we do see evidence of improved performance in operating efficiency; however, we do not have a clear picture of where or how these efficiency gains occur and why we do not see similar improvement in related areas of quality (mainly processes and outcome measures).

Recognizing that hospitalists are now firmly entrenched within a large proportion of North American hospitals, if we wish to improve the quality of inpatient care delivery and introduce funding models that reward providers and/or institutions on the basis of their performance, further descriptive research labelling, categorizing, and analyzing physicians according to their practice structures alone is unlikely to advance the research field in a way that will help inform organizational decision-making or health policy. Future research should instead shift toward developing better conceptual and theoretical models that identify and measure specific structural differences between physician practices, organizational issues that affect hospitalist groups, and the process mechanisms whereby hospitalist-based physicians have an increased opportunity to intervene.

On the basis of the findings of this review, we suggest that one of the key structural characteristics driving efficiency improvements among hospitalists is likely the increased time spent attending on the inpatient service and its subsequent impact on inpatient volume. Hundreds of articles published over the past three decades have shown that processes utilized and outcomes of care achieved are better among healthcare providers who perform them more frequently [(17,185)]. These volume-outcome associations have been demonstrated across a wide range of study designs, patient populations, health delivery models, and outcomes examined, and they persist despite extensive adjustment for organizational differences between institutions. While the categorical classification of hospitalists implies a volume-outcome relationship, only three studies included in this review specifically examined case volume at the provider level as an explanatory variable of quality outcomes [(25,158,160)]. Many hospitalists choose to practice part-time. As such, the annual volume and experience of a part-time hospitalist may actually approach that of some comparative providers, potentially washing out any improvements in quality that may be driven by volume as opposed to the portion of a physician's practice which is dedicated to inpatient care delivery, a common approach used to define hospitalists. This effect was demonstrated by Lindenauer *et al*. [(158)], who found that hospital length of stay and costs varied by <0.10 days and $15, respectively, among providers in models that were not adjusted for physicians' annual case volume.

By examining the quality of general inpatient care as a function of a physician's annual case volume, we can also extend the application of this literature to other healthcare models around the world which have instituted parallel inpatient practices without necessarily establishing formalized hospitalist programs. For example, inpatient care delivery in Australia, New Zealand, the United Kingdom, Singapore, and several other former British colonies is similar to the North American hospitalist model in that primary care is handed over to a separate system of specialists and consultants (most often general internists and/or general surgeons) once a patient is admitted. Like the hospitalist, the specialist then 'owns' the patient for the duration of hospitalization, providing the majority of their clinical services within the hospital setting. In this manner, several structural characteristics of the hospitalist and specialist models overlap: both have high annual inpatient volume, which theoretically enhances clinical expertise and improves patient outcomes, and both operate in a routine environment where familiarity with staff, services, and technological resources support efficient practice. There are, however, a few key differences. Hospitalists tend to practice using a team-based approach where patients, call hours, and vacation time are rotated according to prearranged contracts, while specialists still tend to operate individually, negotiating their work hours directly with the hospital administration. Furthermore, inpatient specialists frequently hold higher levels of medical certification than many North American hospitalists, especially in Canada, where more than 90% of hospitalists hold only a general medical license and no formalized training in hospital medicine [10]. Finally, there is the issue of incentives. Financial and other incentives for improving quality and efficiency are more common for hospitalists in the United States, while inpatient care in other countries is traditionally publicly funded. As a result, the need for these providers to modify their performance is frequently generated by negative pressure to reduce inefficiencies, potentially offsetting any intrinsic motivation to provide better care.

Interestingly, none of the hospitalist evaluations published to date have examined process indicators relating to the timeliness of care delivery, which would theoretically drive efficiency gains within our conceptual framework. In addition, transitions of care and communication patterns among hospitalists, patients, and their primary care physicians remain virtually unexplored and are important areas for further work. While computationally complex, this review highlights the need for multilevel, multisite studies which integrate the organizational effects of hospitals with more complete and informative data on the structure of hospitalist programs when undertaking evaluations of provider performance. Superior statistical models need to be used that control for patient, physician, and hospital-level confounding to understand whether higher inpatient quality reflects better hospital staffing and/or administration, organizational cultures that support hospitalist groups, or true improvements in the processes of care delivery by hospitalist physicians. Finally, the general quality of reporting in published studies can be improved by stating source populations, any inclusion versus exclusion criteria, patient and physician sample sizes within each comparison arm, and the number of patients lost to follow-up or excluded because of missing data. Disclosure of any performance incentives and funding sources, as well as the role of additional healthcare providers, should also be encouraged.

2.5.1 *Strengths and weaknesses*

To our knowledge, this is the most comprehensive review of hospitalist performance conducted to date. While formal registration of the review was not undertaken, extensive attempts were made to prevent review-level bias, and the design, population, research questions, and literature search methods were all specified *a priori* according to the Participants, Interventions, Comparisons and Outcomes, or PICO, method [(186)] as well as the PRISMA guidelines [(133)]. We included studies of all methodological quality levels, with no restrictions on publication language, inpatient populations, physician practice structures, or outcomes examined. In addition, this is the first systematic review to assess the methodological quality of the hospitalist literature in which an objective checklist was employed that has been validated for use in both experimental and observational research [(132)]. We tested the sensitivity of our findings to methodological quality, demonstrating that our conclusions are supported in both high and low quality studies, but highlighted that poor quality studies were more likely to report better performance among hospitalists, a result which may have been driven largely by confounding. Finally, we have developed and presented a conceptual framework for synthesizing and evaluating hospitalist performance. By situating our conclusions within this underlying framework, we were able to identify several gaps in the evidence where hospitalist performance appeared to deviate from its theoretical foundation. We have highlighted key areas of interest that hospitalist researchers may wish to explore in the coming years.

Despite these strengths, several weaknesses in our review should be noted. Given the heterogeneity of designs and outcomes examined among studies, we were unable to conduct formal meta-analyses or generate summary estimates of risk for any of the outcome measures. While meta-analysis would be powerful for estimating the overall impact of hospitalists on the effectiveness and efficiency of inpatient care delivery, the validity of this approach rests largely on the quality of reporting in the original studies, and 53% of the reviewed studies did not report enough information to compute standard effect sizes and/or margins of error. The pooling of results is also considered inappropriate when unadjusted biases are suspected. Despite this limitation, decreases in the length of stay and the cost of care were demonstrated across all practice settings and patient populations, strongly suggesting that hospitalists do improve the efficiency of care delivery. Assessing the methodological quality of individual studies is widely accepted as good practice in systematic reviews of randomized, controlled trials; however, the use of quality assessment tools to appraise observational studies is less established. We used a validated and reliable checklist that has demonstrated high internal consistency and good test-retest and interrater reliability for both randomized and nonrandomized studies [(132)]. Nonetheless, each study is unique, and we recognize that a quality checklist may not include all items that are relevant for a particular topic and may include some items that are irrelevant, which can result in the misclassification of a study's quality. We attempted to minimize this risk by modifying the original Downs and Black checklist [(132)] to include several items specific to reporting within hospitalist comparisons and to remove one question that was not applicable to these designs. One author (HLW) extracted data from the selected publications which could introduce errors in our analyses; however, in those instances where required information was unclear, input was sought and consensus was reached between both authors. Finally, the majority of studies included in this review did not adjust for important confounders of quality such as patient age, sex, insurance status, comorbidities, and hospital and physician clustering. Recognizing that risk adjustment can have a profound impact on individual study results, any conclusions drawn from a systematic review of hospitalists' performance may change substantially, depending on the type of risk adjustment employed and on inclusion versus exclusion criteria. The trends identified in this review should be verified and reevaluated in the coming years as the methodological quality of new evaluations continues to improve.

2.6 Conclusion

Despite methodological limitations that decrease the quality of the published literature on hospitalist performance, common themes emerged from this review. Hospitalists are efficient providers of inpatient care as observed by reductions in patients' average length of stay and total hospital costs; however, the clinical quality of hospitalist care is comparable to that provided by their colleagues. Opportunities for further research include an expanded focus on the specific structures of care that differentiate hospitalists from other inpatient physicians as well as on the development of better conceptual and statistical models that identify and measure the pathways of care that these structural differences are thought to influence.

2.7 Afterword: has publication had an impact?

The literature on hospitalist performance has continued to proliferate since publication of the systematic review in 2011. With consistent evidence of efficiency gains over time, hospitalists have become firmly embedded in the North American culture of acute care provision. Subsequently a shift in the scope of research has occurred; there is less need for comparisons gauging hospitalists against other inpatient providers and instead, increasing interest on monitoring, measuring, improving and optimizing internal performance. The majority of recent publications have explored hospitalist-only performance before-and-after focused training initiatives, with the majority of interventions aimed at improving the processes of care delivery, adherence with clinical practice guideline and interpersonal communication [(187-194)]. Several more articles have focused on systems-level performance, assessing whether publically reported outcomes are improved among institutions with higher hospitalist presence [(77,195-198)]. Most recently the relationship between hospitalist workload and patient safety has become an area of interest [(76,199)]. The premise to these articles suggest that in order to compensate for declining institutional revenues, hospitalists are facing mounting pressure from their administrations to increase their productivity, which could undermine the quality and safety of care.

At the time of writing (October 2015) the systematic review had received over 8,500 downloads[1] and 40 subsequent citations. While these metrics suggest interest and acceptance of the topic amongst the hospitalist community, I wanted to assess whether publication of the review correlated with any improvement in the quality of evaluations disseminated since. Extending the review's search strategy to papers published between January 2011 and October 2014 **(pg. 38)**, 17 additional papers were identified that met the original selection criteria for inclusion (see **Table 2.4** for a summary of articles published since 2011).

New to the literature are the first international comparisons evaluating outcomes of hospitalist care in Singapore [(200)] and Taiwan [(201)] relative to a traditional academic ward team, and one Canadian study evaluating both family and internal medicine hospitalist care in a non-teaching community hospital [(37)]. Recent publications appeared to concentrate on a greater diversity of patient populations and hospitalist structures. All of the pediatric and geriatric studies were restricted to specialty populations (*n* = 4) consisting of: infants with bronchiolitis [(202)], medically complex children undergoing spinal fusion [(203)], seniors hospitalized for stroke [(204)], and elderly nursing home residents with advanced dementia [(205)]. Additional investigations focused on adults with chronic liver disease [(206)], sickle cell anemia [(207)], stroke [(208,209)] and pregnant women [(210)]. The majority of articles still evaluated quality of care among patients cared for by general practitioners (*n* = 11; 65%); however, two studies evaluated the use of neurohospitalists [(208,209)] (12%), one examined a hospital-based laborist model [(210)] (6%) and three assessed outcomes among generalist hospitalists compared to subspecialty attendings [(203,206,207)] (18%). Two papers assessed outcomes of hospitalists co-managing their patients' care with specialist teams [(203,206)] (12%). A descriptive summary of the 17 new articles can be found in **Table 2.5** and a synthesis of main outcomes is displayed in **Figure 2.6.**

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[1] Metric track only accesses on BioMed Central – the publishing journal's web pages; total article hits are underestimated.

Table 2.4 Summary of articles evaluating hospitalist performance (n = 17)[a]

Source	Design	Hospital type	Study population	Sample	Comparison	Quality score	Hospitalist performance: Processes of care	Hospitalist performance: Operating efficiency	Hospitalist performance: Patient outcomes
Alexandraki *et al.* (211)	RC	Teaching	All adults admitted to GMS	23,081	F vs. TWS F vs. C	20		↓,* −,*	↑,* −,*
Bhatt *et al.* (208)	B/A	Community	Adults admitted with ischemic stroke who were eligible and received tPA within 4.5 hours of arrival	107	F vs. C	24	↑,*	−,*	−,*
Chavey *et al.* (212)	RC	Teaching (367 sites)	All adult admissions excluding pregnancy	152,026	Mixed practice types	11		↓,ǂ	↑,ǂ
Chin *et al.* (213)	RC	Teaching	All patients admitted to GMS	21,025	A vs. TWS F vs. TWS	25		- ↓	- ↑
Desai *et al.* (206)	B/A	Teaching	Adults admitted with chronic liver disease with diagnosed spontaneous bacterial peritonitis	56	F[b,c] vs. TWS and consulting hepatology	15	↑,*	−,*	−,*
Freeman *et al.* (209)	RC	Community	Patients admitted with ischemic stroke	533	F vs. C	13	↑,*	↑,*	
Hock Lee *et al.* (200)	RC	Teaching	Adult inpatients	3,493	A vs. TWS	18		↑	−
Howrey *et al.* (204)	RC	Mixed	Seniors aged 66+ on Medicare and hospitalized for acute ischemic stroke	10,884	Mixed practice types	19		↑	↓
Iriye *et al.* (210)	B/A	Community	Nulliparous pregnant women with a singleton, vertex, live fetus at term	6,206	F laborist vs. C P laborist vs. C	21			↑ −
Kuo *et al.* (73)	RC	Mixed (454 sites)	5% sample of Medicare patients with a primary care provider	58,125	Mixed hospitalist practices vs. C	23		↑	↓

McCulloh *et al.* (202)	RC	Pediatric teaching (2 sites)	Pediatric patients 0-2 years discharged with bronchiolitis	713	A vs. C	14	↑,*	−,*	−,*,ǂ
Rappaport *et al.* (203)	B/A	Pediatric teaching	Medically complex pediatric patients who underwent spinal fusion surgery	167	F [b,c] vs. orthopedic ward service	17	↑,*	↓,*	−,*
Seiler *et al.* (21)	RC	Mixed teaching (n=1) and community (n=2)	Adult inpatients	8,295	Mixed hospitalist practices vs. C	17			↓
Shah *et al.* (207)	RC	Unknown	Adults with sickle cell anemia hospitalized for vaso occlusive crisis	298	F vs. hematologist	5	↑,*	↑,*	−,*
Shu *et al.* (201)	PC	Teaching	Adults admitted from ED	810	F [c] vs. TWS	28		↑	−
Teno *et al.* (205)	RC	Mixed	Nursing home residents with advanced dementia receiving Medicare and hospitalized with urinary tract infection, sepsis, pneumonia, or dehydration	32,763	Mixed practice types	15	↑		
Yousefi *et al.* (100)	RC	Community	Adult admissions to GMS, excluding surgical, obstetrical and psychiatric admissions.	21,521	F vs. C	20		↑	↑

[a] PC, prospective cohort; RC, retrospective cohort; B/A, before versus after; GMS, general medical service; P, private hospitalist attending physician; F, nonacademic faculty hospitalist attending physician; A, academic hospitalist attending physician; C, community-based physician; TWS, traditional academic attending physicians, assisted by residents, fellows and students.

[b] Hospitalists were comanaging their patients' care with comparison healthcare providers.

[c] Use of physician's assistants, nurse practitioners and/or discharge planners in the provision of care.

↑ indicates improved performance by hospitalists; − indicates no difference in performance between providers.↓ indicates worse performance by hospitalists; ǂ indicates that a *P* value or confidence interval was not provided, so results may or may not be statistically significant; *indicates that results are unadjusted.

Table 2.5 Descriptive characteristics of 17 comparative evaluations published since 2011 on hospitalist performance[a]

Study characteristics	**Studies, *n* (%)**[a]
Country of research	
Canada	1 (5.9)
United States	16 (94.1)
Research design	
Prospective cohort	1 (5.9)
Retrospective cohort	12 (70.6)
Before and after	4 (23.5)
Patient eligibility	
Adult patients only	11 (64.7)
Pregnant females	1 (5.9)
Pediatric patients only	2 (11.8)
Older adult patients only (age ≥ 65 years)	2 (11.8)
Medicare/Medicaid enrolment	2 (11.8)
Diagnostic/disease eligibility	
Bronchiolitis	1 (5.9)
Chronic liver disease	1 (5.9)
Community-acquired or bacterial pneumonia	1 (5.9)
Dehydration	1 (5.9)
Dementia	1 (5.9)
Hematology	1 (5.9)
Orthopedic and other surgical procedures	1 (5.9)
Sepsis	1 (5.9)
Singleton pregnancy (at term)	1 (5.9)
Stroke	3 (17.6)
Urinary tract infection	1 (5.9)
Hospital type	
Teaching hospital	11 (64.7)
Community hospital	8 (47.1)

Location of care	
General medical service	14 (82.4)
Orthopedic service	1 (5.9)
Pediatric service	2 (11.8)
Hospitalist practice structure	
Private hospitalists	1 (5.9)
Nonacademic faculty hospitalists	11 (64.7)
Academic hospitalist attending physicians	3 (17.6)
Mix/unknown practice structures	4 (23.5)
Comparative practice structure	
Community-based physicians	9 (52.9)
Traditional academic attending physicians	6 (35.3)
Mix/unknown practice structures	3 (17.6)
Study participants (*n* = 17)	
Median	4,850
Mean	20,006
Range	56 to 152,026
Hospitalist physicians (*n* = 9)	
Median	20
Mean	25.1
Range	1 to 59
Nonhospitalist physicians (*n* = 7)	
Mean	60.6
Median	15
Range	2 to 288
Number of outcomes studied	
Median	4
Mean	5.05
Range	1 to 19
Study quality score (maximum = 32)	
Median	18
Mean	17.9
Range	5 to 28

Significant improvement by hospitalists on ≥1 quality indicator, *n* (%)	
No improvement or worse performance	1 (5.8)
Better quality on ≥1 indicator	15 (88.2)
Unknown/significance not reported	1 (5.8)

[a] Number of articles may not sum to 17 as several studies compared more than one hospital type, eligibility diagnoses and/or physician structure.

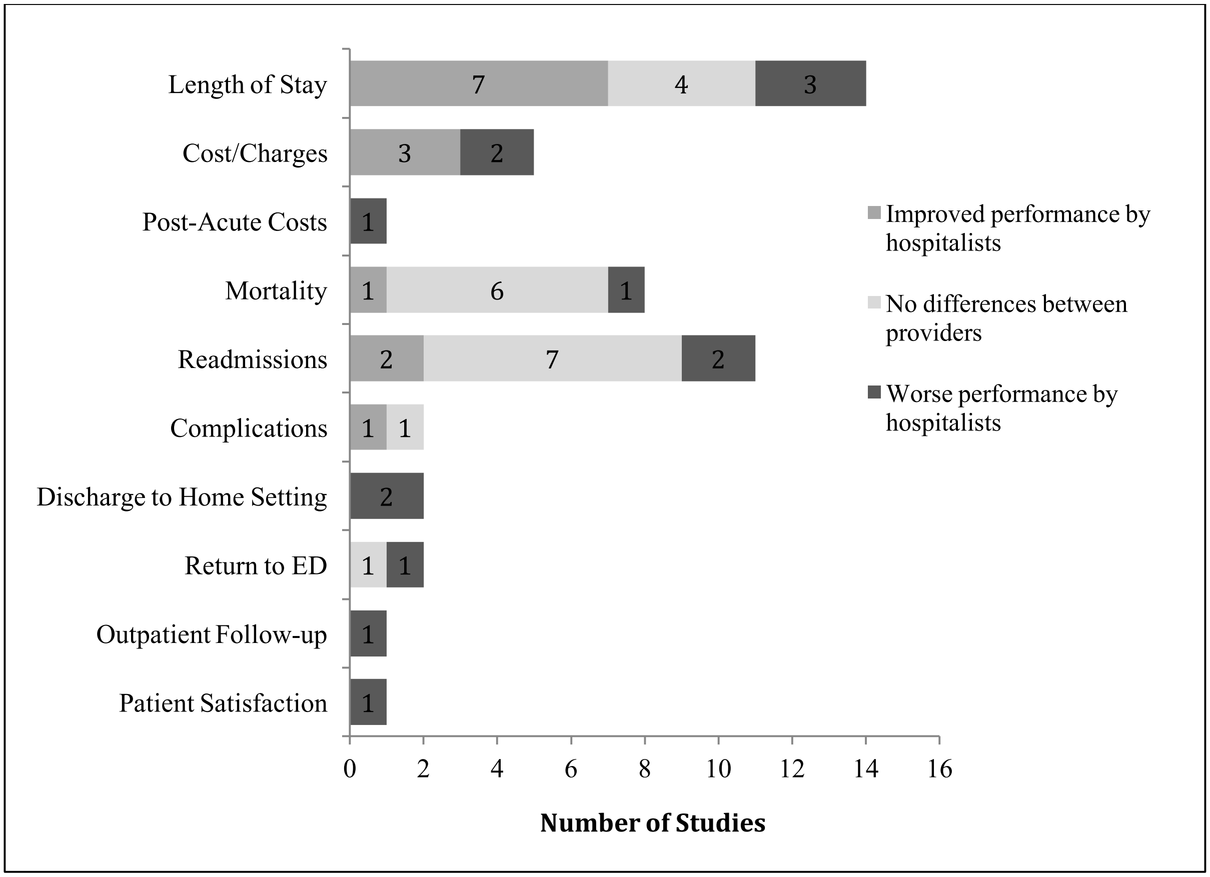
Fifteen of the 17 new papers reviewed demonstrated improved quality under hospitalist care on at least one indicator (88%). One study indicated worse outcomes for patients managed by hospitalists (21) and another suggested worse performance; however, the authors failed to report the statistical significance of their results (212). Overall, the findings of these papers echo those reported in the systematic review: that hospitalists improve the efficiency of inpatient care delivery without adversely affecting acute clinical outcomes. Nevertheless, trade-offs to hospitalist care are beginning to emerge from post-acute data, suggesting that patients managed by hospitalists may have higher medical utilization and associated costs once they are discharged (73,74).

Seven evaluations examined process indicators of quality. Indicators included diagnostic and procedural utilization, adherence to evidence-based practice guidelines and ICU transfers. Adherence with recommended treatment guidelines did not differ between hospitalists and subspecialists managing patients with stroke (208,209), liver disease (206), bronchiolitis (202), and sickle cell disease (207). Neurohospitalists - neurologists practicing full-time within the hospital setting with no outpatient responsibilities - did achieve shorter door-to-needle times and higher compliance rates for administering tPA within 60 minutes of arrival compared with community and locum neurologists treating eligible patients hospitalized with ischemic stroke (208). In addition, general hospitalists co-managing the post-surgical care of pediatric patients reduced the number of days their patients received parenteral feeds as well as the average number of laboratory investigations (203). Finally, one author found that the rates of feeding tube insertions were lowest among hospitalist attendings managing the care of geriatric patients with advanced dementia, an invasive procedure generally inconsistent with the aims of comfort care [205]. None of the studies reported differences in ICU transfers.

Fourteen articles examined the efficiency of care delivery between hospitalists and their colleagues. Seven of the fourteen articles that examined average or median length of stay found that patients managed by hospitalists had significantly shorter hospital stays compared to those who received traditional care (50%). Four evaluations found no significant differences in length of stay between providers (24%) and three reported longer lengths of stay with hospitalists (18%). Among the three authors to report longer lengths of stay, one failed to report the statistical significance of their findings [212], one reported results based on unadjusted analyses [211], and one found longer lengths of stay and higher costs for academic hospitalists with teaching responsibilities compared to a traditional ward service; however, efficiency improved with nonteaching, staff hospitalists [213].

Of the four articles to examine hospital costs or charges, three showed small but significant reductions in the average or median cost of care under the hospitalist model (75%). Aside from the academic hospitalist evaluation just described [213], the only other study to report higher costs did not adjust their analyses for sources of bias or confounding [203]. A novel study published in 2011 by Kuo *et al.,* investigated cost-shifting from acute to post-acute settings under the hospitalist model [73]. Kuo found that while length of stay and costs were reduced among patients receiving hospitalist care, patients were less likely to be discharged home and more likely to have repeat emergency department visits and readmissions, leading to higher medical utilization costs after discharge [73]. Patients also had fewer follow-up visits with their primary care provider [73]. In the Canadian study conducted by Yousefi *et al.,* hospitalists trained in internal medicine had lower lengths of stay while family medicine hospitalists performed similarly to traditional office-based family physicians [100]. Both hospitalist groups demonstrated lower rates of in-hospital morality and readmission [100].

Figure 2.6 Summary of new findings regarding hospitalist performance, the efficiency of inpatient care and outcomes of treatment



Sixteen papers examined the relationship between hospitalist care and clinical outcomes of treatment. The majority of studies found no significant differences in clinical outcomes between hospitalists and their colleagues (n = 10; 56%). Only four of the 16 papers reported improved outcomes by hospitalists (25%) and one of these did not report the statistical significant of their findings [(212)]. In a study investigating the use of in-hospital vs. on-call laborists, Iriye and colleagues reported a 27% decline in cesarean deliveries with laborist presence in term nulliparious women presenting with a singleton birth [(210)]. Chin *et al.,* found a decline in 30-day readmissions for staff hospitalists compared to the traditional academic teaching service, but readmissions were comparable between academic hospitalists and the teaching team [213]. Chavey and colleagues also reported small reductions in 7 and 30-day readmissions by hospitalists compared to family physicians alongside a 45% increase in hospital mortality [212]. Statistical significance could not be determined for either outcome [212]. Finally, one study investigated patient satisfaction, finding that satisfaction scores were significantly lower under hospitalist care compared to care provided by the patients' usual provider or another physician from the provider's call group [214].

The median quality score of the 17 new papers was 18 out of a possible score of 32 (range: 5 to 28), representing a 20% increase in the median score from the original systematic review. Five of the new evaluations cited the systematic review within their texts (29%). The median quality score of citing papers was 20 (range: 15-25; difference: +33%). Overall, the quality of reporting and the disclosure of information relevant to hospitalist interventions have improved. Seventy-six percent of articles described their source and sample populations and provided a numerical rundown of all exclusions (n = 13; difference: +34%). Seventy-six percent presented a descriptive list of potential confounding variables (n = 13; difference: +21%) and seventy-one percent provided estimates of variability for all main outcomes measures (n = 12; difference: +52%). Investigations involving a single site of care (n = 11) demonstrated marked improvement in the disclosure of information relative to physician care. Seventy-three percent of single-site investigations reported the number of hospitalist attendings (n = 8), 82% disclosed the location and type of hospital where the intervention took pace (n = 9) and 64% described the role of additional allied health professionals in the role of care provision (n = 7). There is however still room to improve the quality of reporting in multi-site investigations. Only one of the six multi-site studies disclosed the number of hospitalist and comparative practitioners who cared for their sample populations (17%) [214] and none provided a descriptive list of the physician populations or hospitals included in their investigations. While two of the six papers provided enough information to allow the reader to assess whether the care of hospitalists was mandatory (33%) [73,214], none could comment on the role of financial incentives to influence or motivate provider performance. Disclosing the number of care providers and presenting a description of their characteristics is essential for assessing whether and how outcomes may differ due to demographic differences between providers as opposed to variations in their processes of care delivery.

Overall, the methodological quality of investigations is also starting to improve. Only two of the 17 evaluations used insufficient sample sizes to detect significant effects in one or more outcome measures of interest (12%; difference + 47%). Sixty-five percent of evaluations used multivariate models to assess all outcomes (n = 11; difference +27%). The majority of these authors considered the distribution of their data when selecting their models (i.e.: length of stay) and all adjusted for a comprehensive list of known confounders that included demographics, case-mix, diagnosis (where relevant), illness severity and ICU transfers. Among authors that used multivariate models, 36% used hierarchical or clustered methods to account for physician and hospital characteristics and their influence on patient-level outcomes. Despite these improvements, six of the 17 new articles not use any form of risk adjustment (35%) and two failed to report P-values or variance for their results (12%). These fundamental skills of analysis and reporting continue to lower the reliability and plague the validity of hospitalist literature.

3 Defining hospitalist physicians using clinical practice data: a systems-level pilot study of Ontario physicians

3.1 Abstract

Background: Hospitalists have become dominant providers of inpatient care in many North American hospitals. Despite the global growth of hospital medicine, no objective method has been proposed for defining the hospitalist discipline and delineating among inpatient practices on the basis of physicians' clinical volumes. We propose a functional method of identifying hospital-based physicians using aggregated measures of inpatient volume and apply this method to a retrospective, population-based cohort to describe the growth of the hospitalist movement, as well as the prevalence and practice characteristics of hospital generalists working in one Canadian province.

Methods: We used human resource databases and financial insurance claims to identify all active fee-for-service physicians working in Ontario, Canada, between fiscal year 1996/1997 and fiscal year 2010/2011. We constructed three measures of inpatient volume from the insurance claims to reflect the time that physicians spent delivering inpatient care in each fiscal year. We then examined how inpatient volumes have changed for Ontario physicians over time and described the prevalence of full-time and part-time hospital generalists working in acute care hospitals in fiscal year 2010/2011.

Results: Our analyses showed a significant increase since fiscal year 2000/2001 in the number of high-volume hospital-based family physicians practicing in Ontario ($P < 0.001$) and associated decreases in the numbers of high-volume internists and specialists ($P = 0.03$; where high volume was defined as ≥ 2,000 inpatient services/year). We estimated that 620 full-time and 520 part-time hospital physicians were working in Ontario hospitals in 2010/2011, accounting for 4.5% of the active physician workforce ($n = 25{,}434$).

Hospital generalists, consisting of 207 family physicians and 130 general internists, were prevalent in all geographic regions and hospital types and collectively delivered 10% of all inpatient evaluation and care coordination for Ontario residents who had been admitted to hospital.

Discussion: These analyses confirmed a substantial increase in the prevalence of general hospitalists in Ontario from 1996 to 2011. Systems-level analyses of clinical practice data represent a practical and valid method for defining and identifying hospital-based physicians.

Citation

White HL, Stukel TA, Wodchis WP, Glazier RH. Defining hospitalist physicians using clinical practice data: a systems-level pilot study of Ontario physicians. *Open Medicine.* 2013; 7(3): e74-84.

3.2 Introduction

Since the first hospitalist programs were established in the late 1990s, the hospitalist movement has grown rapidly in terms of the number of physicians specializing in hospital medicine, the proportion of inpatients cared for by hospital-based physicians, and the number of hospitals employing formal hospitalist groups (12,70,215-217). Although several studies have reported on the demographic characteristics, prevalence, and outcomes of care of US hospitalists (12,70,216,218,219), fundamental debate continues within the medical community as to what hospitalists are, how they should be defined, and what (if anything) distinguishes them from other hospital-based specialists.

The Society of Hospital Medicine has defined a hospitalist as *"a physician who specializes in the practice of hospital medicine,"* which is in turn defined as *"a medical specialty dedicated to the delivery of comprehensive medical care to hospitalized patients"*(9). While these definitions identify the hospitalist's professional focus, they offer little guidance on what characteristics differentiate the clinical hospitalist from other practitioners. As a consequence, the term "hospitalist" has become colloquialized and is now commonly used to refer to a general internist or family physician who works in a hospital. However, there are exceptions to this general rule, and some hospitalists are now specializing, with new terms like "neurohospitalist," "surgical hospitalist," and "OB-GYN hospitalist" (aka "laborist") becoming increasingly commonplace (69).

Two approaches have traditionally been applied when identifying hospitalists in comparative evaluations. The first uses voluntary surveys of institutional staff or professional society membership to estimate hospitalist prevalence. With this approach, the responding physician self-identifies as a hospitalist. This method, while straightforward in design, is impractical and imprecise for researchers and policy-makers. Lacking a formal definition of the clinical hospitalist practice, any physician can choose to call himself or herself a hospitalist. Low response rates for such surveys have made it difficult to assess the population prevalence of hospital-based physicians, and the clinical workloads of practitioners are seldom explored. Furthermore, few countries offer certification or training in hospital medicine and as a result, administrative databases rarely include physician-specialty codes that categorize physicians as hospitalists.

The second approach uses a functional definition, categorizing hospitalists by the amount of inpatient care provided. Most often a threshold is established whereby hospitalists are identified and classified on the basis of a certain proportion of each physician's practice being generated from the care of hospital inpatients (e.g., ≥ 90%). These definitions are more restrictive, limiting the category of hospitalists to direct providers of care. The associated methods however are also problematic. Few authors have discussed the validity of proportional metrics, assessing whether the denominators used in their analyses have captured minimum volumes indicative of active practice (e.g., a physician with 90% inpatient practice may be classified as a hospitalist, even if he or she saw only 5 patients in the timeframe under investigation). Similarly, few, if any, authors have acknowledged the variability that exists between practice styles, adopting thresholds that can accommodate both full-time and part-time practitioners. As a result, high-volume part-time hospitalists who fall below the proportional thresholds are categorized in the comparison group alongside low-volume community providers, which can mute the effects of a hospitalist model of concentrated care.

Hospital medicine sits at a pivotal intersection for the way inpatient care is funded and delivered across the globe. With several North American, European, Asian, and Australasian governing bodies introducing activity-based funding models that reward hospitals for improved productivity and/or penalize those with lower than expected outcomes, hospital physicians and their institutions must become accountable for the quality of care and services they deliver. If the eventual goal in hospital medicine is to monitor and improve quality and performance, a standardized, systems-level method is needed for defining the clinical hospitalist, independent of self-identification.

Canadian hospitalists emerged alongside their US counterparts after cutbacks to physician reimbursement in the mid-1990s sparked an exodus of primary care practitioners from the hospital setting [(14,58,215,220)]. Canada is unique within the hospitalist movement in that the majority of this country's hospitalists are trained as general practitioners or family physicians (GP/FPs) as opposed to specialists [(10,215,216)]. The hospitalist career path is attractive to some GP/FPs, as it provides an opportunity to practice higher-acuity medicine while earning a competitive compensation exceeding that of an office-based practice. However, hospital medicine is not recognized as a distinct area of focused practice. There are no certification or training guidelines for Canadian hospitalists, and no method outside of self-identification exists of distinguishing hospital-based from office-based practitioners [220]. As a result, the population prevalence of Canadian hospitalists is largely unknown and almost certainly under-reported, which makes hospital medicine an ideal setting to pilot the application of a functional volume framework.

In this article, we propose a novel method of defining hospital-based physicians that uses the clinical volume of inpatient care combined with additional practice data to measure a physician's involvement in the provision of hospital care. We then apply this method at the systems level to describe the growth of the hospitalist movement, as well as the prevalence and characteristics of hospital physicians working in Ontario, Canada, over a 15-year timeframe.

3.3 Methods

3.3.1 *Study population*

We constructed a retrospective population-based sample consisting of all clinically active physicians who practiced in the province of Ontario, Canada, between April 1, 1996 and March 31, 2011 (fiscal 1996/1997 to fiscal 2010/2011) and who submitted claims for professional fees to the Ontario Health Insurance Plan (OHIP), a publicly funded plan that covers the cost of basic health care, including hospital care, to all permanent residents of the province. The cohort was identified using the Institute for Clinical Evaluative Sciences' Physician Database, a human resources database containing validated demographic, certification, and practice characteristics for all physicians licensed in the province since 1992. Active physicians were defined yearly according to guidelines developed by the Ontario Physician Human Resources Data Centre, which include maintaining an active license with the College of Physicians and Surgeons of Ontario; being 25 to 85 years of age with a practice located within the province; having an OHIP billing number with active insurance claims; not being engaged in postgraduate studies; and not being identified as retired or inactive because of disability, leave, sabbatical, or other reason.[221] Physicians were allowed to enter and leave the cohort throughout the 15-year observation window; however, once a physician was deemed active in a given fiscal year, it was assumed that he or she remained active throughout the fiscal period.

3.3.2 *Outcome measures*

For each year, we extracted physicians' demographic, training, and practice characteristics from the ICES Physician Database. Each physician's medical specialty was determined by combining data on both certified and functional specialties, where certified specialty captured the most recent certification information on file and functional specialty reflected the services that the physician actually billed for in his or her practice, derived from aggregated OHIP billings and validated through periodic telephone follow-up with random physician samples. In cases of discrepancy, the physician was assigned to the medical specialty recorded most often in his or her OHIP claims for the particular year, on the assumption that a physician would not be allowed to bill under a specialty code unless licensed to do so. Pediatric surgeons and psychiatrists were combined with the corresponding adult practitioners, and diagnostic radiology, nuclear medicine, and all laboratory specialties were considered together (as "diagnostics").

Physicians' demographics were then linked to their OHIP billings through a unique encrypted identifier to determine the annual number of patient evaluation-and-management (E&M) claims billed in relation to the location of care delivery (inpatient setting, emergency department, office, long-term care facility, or the patient's home). An E&M claim was defined as any clinical visit, consultation, assessment, reassessment, death pronouncement, case conference, counselling (patient, family, or group) or psychotherapy session billed to OHIP for an Ontario resident. E&M claims were used as a proxy indicator of the time that physicians spent in direct clinical care and case management. From the data, three measures of physicians' annual inpatient workloads were tabulated: (1) the total number of E&M

claims billed for inpatient care, (2) the proportion of total OHIP claims generated from the care of hospital inpatients (inpatient claims/total claims), and (3) the total number of calendar days with OHIP billings for inpatient care. Because the primary role of the hospitalist is to provide direct clinical care and care coordination, procedure volumes were not explored.

The number of unique inpatients seen by each physician and the proportion of inpatients with whom physicians had a previous medical relationship (defined as patients for whom the physician had billed at least one E&M claim within 24 months before the date of admission) were determined for the most recent fiscal year (2010/2011). Characteristics of the hospitals where physicians billed the majority of their inpatient services were also extracted from the Ontario Hospital Reporting System, a database maintained by the Canadian Institute for Health Information containing annual statistical information on all acute care hospitals operating in the province.

3.3.3 *Definition of hospital-based physicians*

In **Table 3.1** we propose a conceptual framework that uses annual inpatient volumes and additional practice data to define and delineate hospital-based physicians. We began with a functional definition validated by Kuo *et al.*, [(70)] identifying all active physicians in each fiscal year who had a minimum total volume of 100 E&M claims and for whom at least 80% of total claims were generated from the care of hospital inpatients. We then plotted the frequency distribution of active physicians by year and medical specialty according to the following four variables: (1) total number of inpatient claims billed, (2) proportion of total claims generated from the care of hospital inpatients, (3) the relationship between total claims volume and the proportion of claims billed for inpatient care, and (4) the relationship between inpatient claims volume and the proportion of claims billed for inpatient care. In examining variables 3 and 4, two concerns became apparent with the functional definition proposed by Kuo *et al.,* [(70)]: first, total claims volume was not a specific metric, which meant that too many low-volume physicians were categorized as hospitalists (false positives); and second, the definition did not discriminate between full-time and part-time practitioners. Part-time practitioners with moderately high inpatient volumes practicing exclusively in the

Table 3.1 Conceptual framework for defining community and hospital-based physicians using information from administrative databases**.**

Aspect of framework	Comprehensive community practitioner	Mixed-practice physician	Part-time hospitalist	Full-time hospitalist
Description of practice	Physicians practice primarily within the community but provide occasional inpatient care. Physicians also provide long-term care, emergency, and/or home care services as appropriate.	Full-time practice is split between outpatient and inpatient care.	Majority of practice is inpatient evaluation and management, but physician works at a part-time equivalency. Inpatient practice may be general or specialty-based.	Majority of practice is inpatient evaluation and management on a full-time basis. Inpatient practice may be general or specialty-based.
Scope of inpatient practice	Hospital inpatients are enrolled in the physician's primary practice either individually or within a team; inpatients are generally low-risk medical and ALC patients.	Hospital inpatients often come from outside the physician's primary practice through rotating call; inpatients may be general, complex medical, and ALC patients.	Physicians typically have no previous relationship with hospital inpatients; inpatients are general, complex medical, and ALC patients; physicians are often involved in comanagement of specialty patients.	
Compensation mechanism	Fee-for-service billing to insurance plans; physicians have no direct financial relationship with hospitals.	Fee-for-service billing to insurance plans. Hospitals may "top up" physicians' fee-for-service billings.	Fee-for-service billings plus negotiated salary stipend or alternative funding plans; hospitals may pay a portion or all of the physicians' income from their operating budgets. Physicians often work as independent contractors to individual hospitals.	

Annual inpatient volume*	< 30% of clinical volume is hospital-based, and total annual volume indicates an active community practice (> 50% of total volume is generated from office, nursing home, or home care; total volume ≥ 100 services; inpatient volume ≥ 10 services).	30%–79% of total volume is hospital-based, and inpatient volumes reflect an active and substantial inpatient practice (≥ 500 inpatient services annually).	≥ 80% of total volume is hospital-based, but volumes reflect a part-time case load (500–1,999 inpatient services annually).	≥ 80% of total volume is hospital-based and volumes reflect a full-time case load (≥ 2,000 inpatient services annually).

Note: ALC = alternate level of care (patients waiting in hospital to be transferred to a complex continuing care or long-term care setting).

* Inpatient volumes can be left as continuous measures of a physician's hospital experience in regression models, eliminating the need for categorization.

hospital would be correctly classified as hospitalists, whereas physicians with equivalent inpatient volumes but whose practices were split between hospital and community (e.g., 70% inpatient, 30% long-term care) would incorrectly fall in the comparison group. We therefore updated the definition of Kuo *et al.,* [70], replacing total claims volume with inpatient claims volume and distinguishing full-time from part-time but strictly hospital-based physicians on the basis of their volume of inpatient care provision. We then proposed two novel classifications: mixed-practice physicians (physicians with average-to-high inpatient volumes whose clinical practice is split between inpatient and outpatient care) and comprehensive community practitioners (community-based physicians who provide a full range of medical services including hospital care; see **Appendix 3.1** for an evaluation of concordance between the two frameworks). The proposed thresholds were established by examining the distributions of the four variables listed above, looking for points at which consistent changes in physician density formed over time, indicated by an increasing frequency of high-volume practitioners and a consistent density of mid-volume practitioners (see **Appendices 3.2** and **3.3** for selected distributions).

3.3.4 *Statistical analysis*

After describing the characteristics of physicians who provided inpatient care in Ontario hospitals by year, we plotted the distribution of active physicians according to the annual number of inpatient claims billed by year and medical specialty. To confirm whether upward or downward trends in inpatient volumes were significant over time, the proportion of physicians achieving each billing level (i.e., $\geq$ 2,000 inpatient claims) in fiscal year t were entered into separate autoregressive [AR] models by specialty, with a lag set to 1. This model can be presented as $\text{logit}(\rho_t) = \alpha + \beta_1 \rho_{t-1} + e_t$, where ρ_t is the proportion of physicians in a given specialty achieving each billing threshold in fiscal year t, β_1 confirms the significance of volume changes over time, ρ_{t-1} is the proportion of physicians achieving the billing threshold in the previous year, and e_t is the error term. Autoregressive models were needed to adjust for the autocorrelation of residuals because the physicians' inpatient volume in a given year was found to be dependent on inpatient volume in the previous year. We then used the inpatient volumes billed in 2010/2011 to describe the recent population of hospital physicians according to the functional categories proposed in **Table 3.1,** excluding practitioners with low total billings (< 100 total OHIP claims/year) and low inpatient billings (< 10 inpatient claims/year). SAS software, version 9.2 (SAS Institute Inc., Cary, N.C.), was used for the analyses. Ethics approval was obtained from Sunnybrook Health Sciences Centre and from the Health Sciences Research Ethics Board at the University of Toronto.

3.4 Results

Descriptive characteristics of physicians providing inpatient care in Ontario hospitals are shown in **Table 3.2** for selected fiscal years. In 1996/1997, 76.7% of active physicians working in the province provided inpatient evaluation-and-management services (n = 15,275 of 19,922), and almost half of all inpatient physicians held certifications in family medicine (n = 7,418; 48.6%). Beginning in 1998, the proportion of active physicians providing inpatient services began to decline, and this trend has continued each fiscal year since. Although many specialties experienced an exodus of practitioners from provision of hospital care, the largest declines have occurred among GP/FPs (**Table 3.2; Figure 3.1A)**. In 1996/1997, nearly three-quarters of active GP/FPs provided some level of inpatient care to hospitalized patients, but by 2010, fewer than half continued to do so (71.0% v. 47.2%).

Figure 3.1 shows the distribution of GP/FPs, general internists, and internal medicine specialists according to the annual volume of inpatient claims billed over time. Since 1997/1998, the proportion of active GP/FPs without hospital privileges has increased from 28.7% to 52.8% and the proportion providing occasional hospital care or coverage (1-249 inpatient claims/year) has declined from 42.0 to 30.7% ($P < 0.001$; **Figure 3.1A**). In turn, GP/FPs with high annual hospital volumes (≥ 2,000 inpatient claims/year) filled the resulting gap in inpatient care provision, increasing in prevalence from 0.9% of active GP/FPs in 1996/1997 to 2.5% in 2010/2011, with growth beginning in 2000 ($P < 0.001$). Conversely, the percentages of high-volume general internists and specialists have decreased over time ($P = 0.03$; **Figures 3.1B, 3.1C)**, which may be indicative of lighter inpatient workloads or more balanced distributions between inpatient and outpatient practices.

Table 3.2 Characteristics of active physicians providing inpatient care in Ontario hospitals for selected fiscal years

	Fiscal year; no. (%)									
Characteristic	**1996/1997**		**2000/2001**		**2004/2005**		**2008/2009**		**2010/2011**	
Total no. of active physicians	19,922		20,368		21,814		23,872		25,434	
No. providing inpatient care (% of active physicians)	15,275	(76.7)	14,914	(73.2)	15,020	(68.9)	15,949	(66.8)	16,820	(66.1)
Age, yr, mean (SD)	46.5	(11.2)	47.4	(10.9)	47.9	(10.8)	48.5	(11.0)	48.6	(11.2)
Time in practice, yr, mean (SD)	20.6	(11.4)	21.4	(11.2)	21.8	(11.2)	22.2	(11.5)	22.3	(11.8)
Sex										
Male	11,660	(76.3)	11,056	(74.1)	10,742	(71.5)	10,981	(68.9)	11,357	(67.5)
Female	3,615	(23.7)	3,858	(25.9)	4,278	(28.5)	4,968	(31.1)	5,463	(32.5)
Canadian medical graduate										
Yes	9,791	(64.1)	10,542	(70.7)	11,205	(74.6)	12,192	(76.4)	12,763	(75.9)
No	5,430	(35.5)	4,324	(29.0)	3,771	(25.1)	3,719	(23.3)	4,007	(23.8)
Unknown	54	(0.4)	48	(0.3)	44	(0.3)	38	(0.2)	50	(0.3)
Census metropolitan area of practice, by population										
≥ 1,250,000	6,426	(42.1)	6,166	(41.3)	6,360	(42.3)	6,671	(41.8)	7,030	(41.8)
500,000 – 1,249,999	2,594	(17.0)	2,535	(17.0)	2,565	(17.1)	2,757	(17.3)	2,939	(17.5)
100,000 – 499,999	3,782	(24.8)	3,688	(24.7)	3,497	(23.3)	4,011	(25.1)	4,232	(25.2)
9,000 – 99,999	1,465	(9.6)	1,480	(9.9)	1,494	(9.9)	1,468	(9.2)	1,558	(9.3)
< 9,000	1,002	(6.6)	1,034	(6.9)	1,104	(7.4)	1,042	(6.5)	1,050	(6.2)
Unknown	6	(<0.1)	11	(<0.1)	0	(0.0)	0	(0.0)	11	(<0.1)
Medical specialty										
Anesthesiology	722	(4.7)	761	(5.1)	871	(5.8)	1,048	(6.6)	1,130	(6.7)
Diagnostics†	502	(3.3)	508	(3.4)	579	(3.9)	628	(3.9)	728	(4.3)

General internal medicine	897	(5.9)	829	(5.6)	885	(5.9)	771	(4.8)	795	(4.7)
General practice/family medicine	7,418	(48.6)	6,751	(45.3)	6,174	(41.1)	5,894	(37.0)	5,970	(35.5)
Internal medicine specialties‡	1,791	(11.7)	1,950	(13.1)	2,171	(14.5)	2,715	(17.0)	2,975	(17.7)
Obstetrics and gynecology	558	(3.7)	563	(3.8)	581	(3.9)	641	(4.0)	668	(4.0)
Pediatrics§	626	(4.1)	673	(4.5)	728	(4.8)	850	(5.3)	936	(5.6)
Psychiatry	1,212	(7.9)	1,315	(8.8)	1,417	(9.4)	1,540	(9.7)	1,644	(9.8)
Surgery¶	1,549	(10.1)	1,564	(10.5)	1,614	(10.7)	1,862	(11.7)	1,974	(11.7)

* Except where indicated otherwise.

† Diagnostics includes diagnostic radiology, nuclear medicine, and all laboratory specialties.

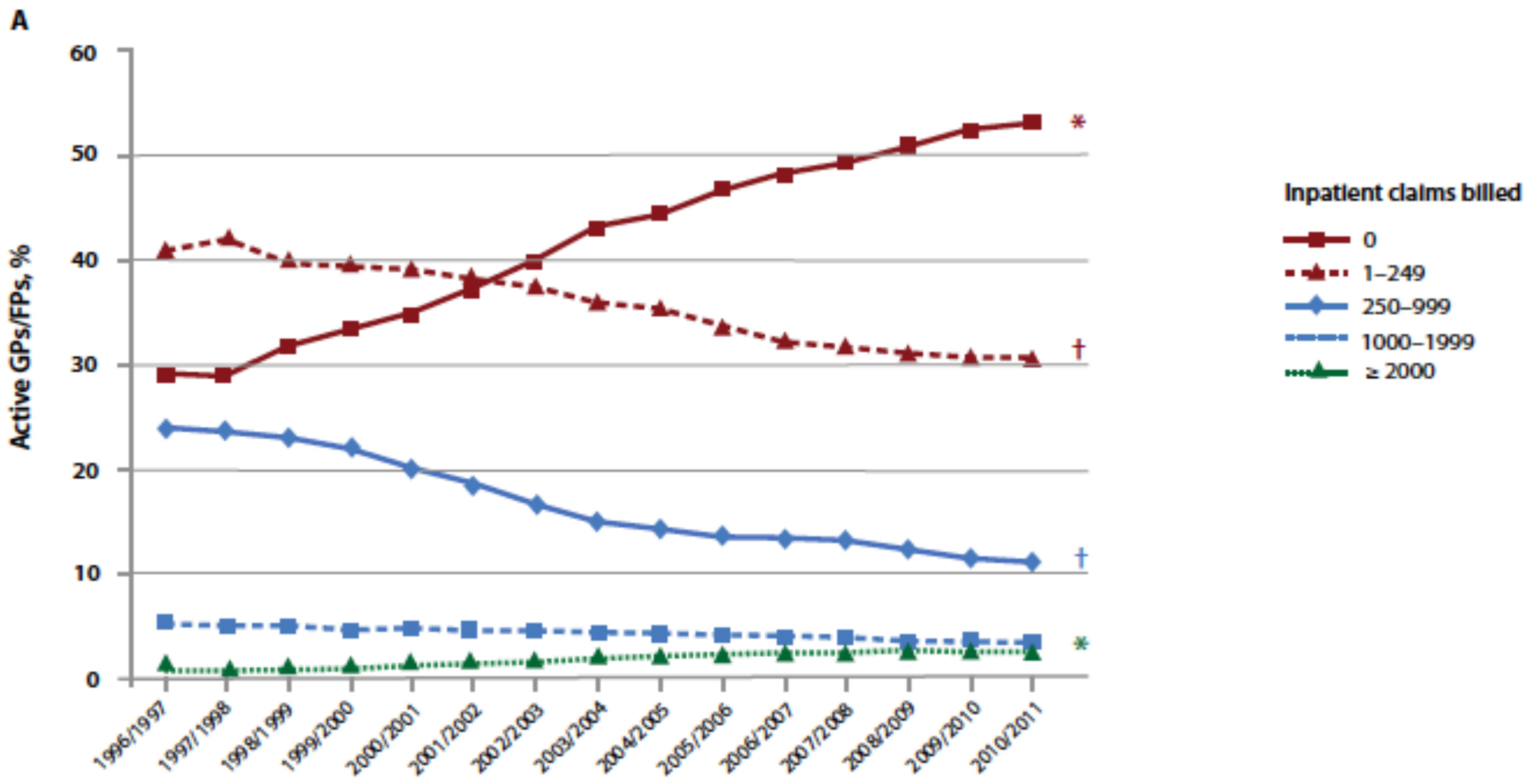
‡ Includes cardiology, clinical immunology, community and geriatric medicine, dermatology, endocrinology, gastroenterology, hematology, infectious diseases, medical genetics, medical oncology, nephrology, neurology, physical medicine and rehabilitation, radiation oncology, respirology, and rheumatology.

§ Includes general pediatrics and all pediatric internal medicine specialties.

¶ Includes all adult and pediatric surgeons licensed to practice by the Royal College of Physicians and Surgeons of Canada.

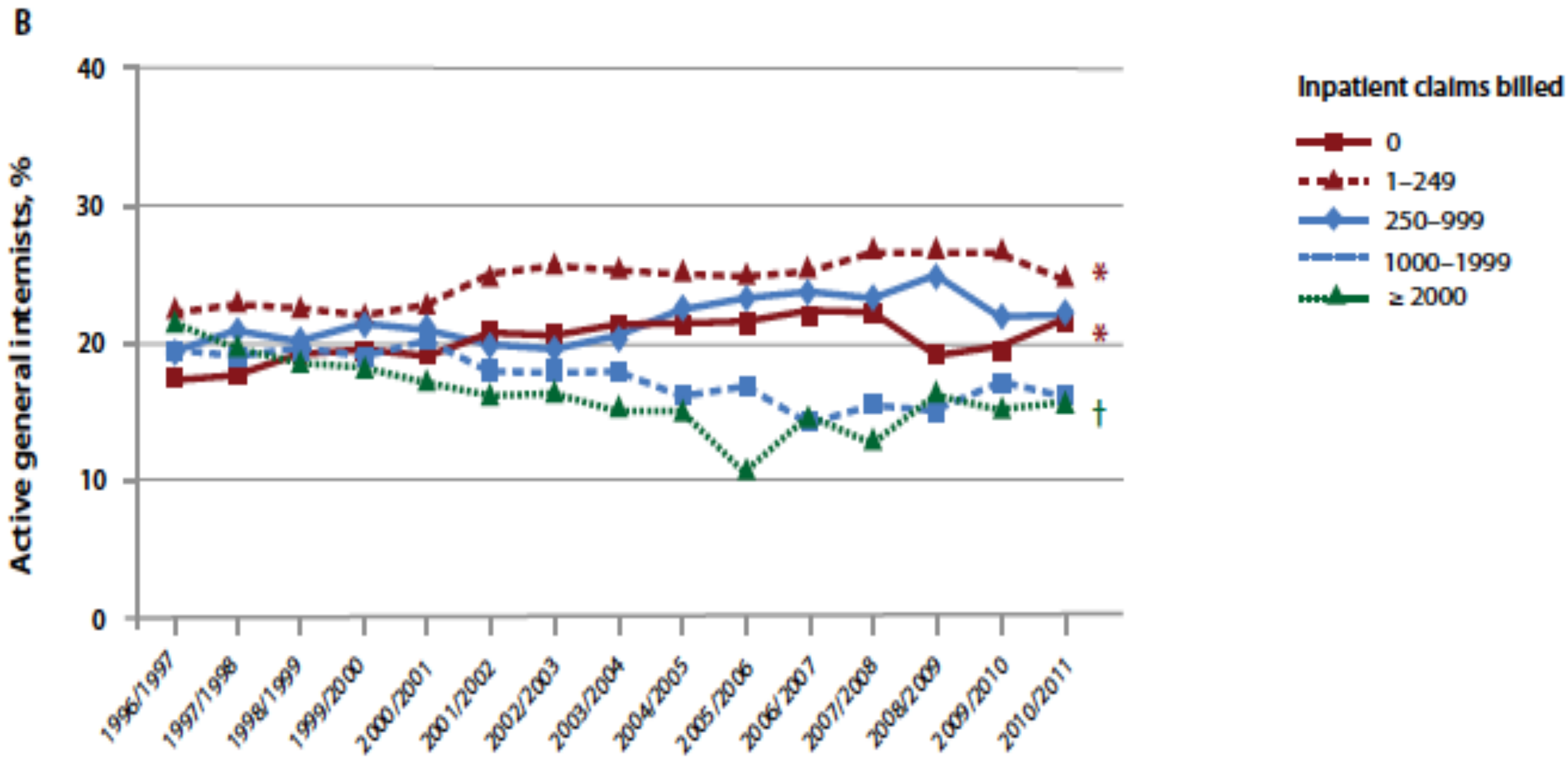
Figure 3.1 Distribution of active Ontario physicians, according to annual number of inpatient evaluation-and-management claims billed to the Ontario Health Insurance Plan (OHIP), fiscal year 1996/1997 to fiscal year 2010/2011: (A) general practitioners and family physicians, (B) general internists, and (C) internal medicine specialists.

3.1 [A] General/Family Practitioners



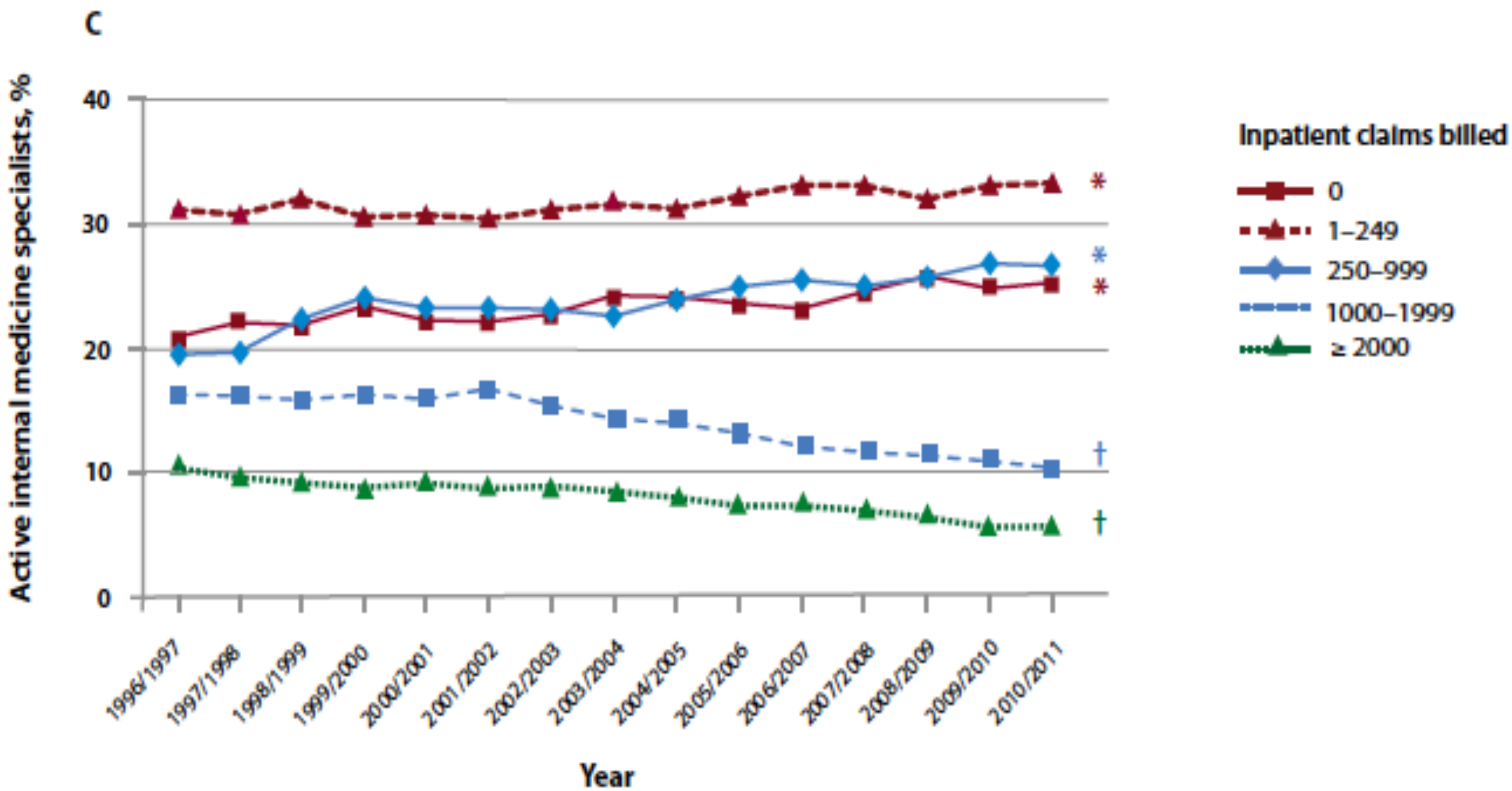
Significant increases (*) and significant decreases (†) in the proportion of physicians achieving each billing level over time, based on autoregressive models with a lag set to 1 ($P < 0.05$), are marked.

3.1[B] General Internists



Significant increases (*) and significant decreases (†) in the proportion of physicians achieving each billing level over time, based on autoregressive models with a lag set to 1 (*P* < 0.05), are marked.

3.1[C] Internal Medicine Specialists



Significant increases (*) and significant decreases (†) in the proportion of physicians achieving each billing level over time, based on autoregressive models with a lag set to 1 ($P < 0.05$), are marked.

Despite large declines in the number of GP/FPs who provide hospital care as a regular component of their clinical practice over time, the total volume of inpatient services delivered by these practitioners across the province has dropped only minimally, accounting for 32.1% of total provincial inpatient E&M claims in 1996/1997, just under 30% in the period from 2000/2001 to 2004/2005, and 28.4% in 2008/2009 (**Appendix 3.4**). The median inpatient volumes billed to OHIP by physicians are summarized in **Appendix 3.5.** Linking the workload data in **Appendices 3.4, 3.5** to descriptive data in **Table 3.2** and **Figure 3.1A** we can see that while the total volume of services delivered by GP/FPs across the province remained steady year after year, the total number of GP/FPs providing inpatient care declined. In order to maintain this overall consistent volume of care, fewer GP/FPs had to have provided more services as a collective. For the average volume of service to increase and the median to decrease, more workload would have had to be carried by the GP/FPs to the right of the median, suggesting that rising inpatient caseloads pertained only to high-volume practitioners and GP/FP hospitalists.

Figure 3.2 shows the recent distribution of inpatient care physicians by medical specialty and annual volume. Overlaid is the cumulative distribution of total inpatient E&M claims billed in Ontario to depict the relationship between workforce density and service volume. In 2010/2011, a total of 1,143 high-volume physicians (≥ 2,000 inpatient claims; 6.8% inpatient physician workforce) delivered 42% of all inpatient E&M services in the province of Ontario. Conversely, 8,600 low-volume physicians (< 250 claims; 51.1% of inpatient physician workforce) billed just 6% of provincial claims. Applying the clinical volume algorithms from **Table 3.1,** we estimated that 620 full-time and 520 part-time hospitalists were working in Ontario in fiscal year 2010/2011, of whom 548 (48.1%) were psychiatrists, 207 (18.2%) were GP/FPs, and 130 (11.4%) were general internists. The remaining physicians were internal medicine specialists (n = 105; 9.2%), anesthesiologists (n = 83; 7.3%), pediatricians (n = 43; 3.8%), and surgeons (n = 24; 2.1%). The majority of the 2,164 mixed-practice physicians were internal medicine specialists (n = 645; 29.8%), psychiatrists (n = 426; 19.7%), and surgeons (n = 303; 14.0%), while comprehensive community practitioners (n = 4,479) were primarily GP/FPs (n = 2,320; 51.8%).

Figure 3.2 Relationship between workforce density and service volume, represented as current distribution of inpatient physician workforce by medical specialty and annual inpatient volume, overlaid with the cumulative distribution of total inpatient evaluation-and-management (E&M) claims billed in Ontario, for fiscal year 2010/2011.

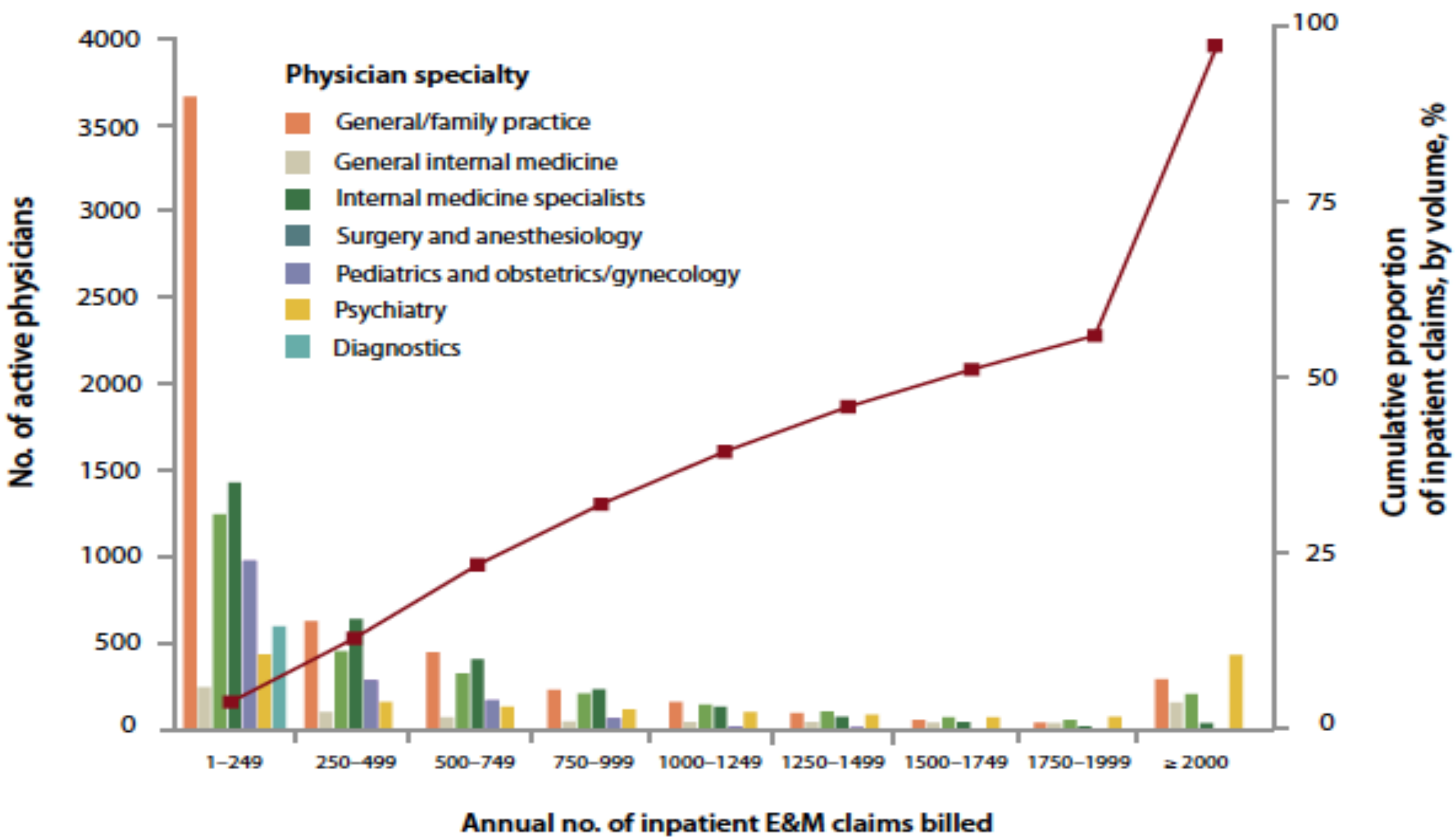


Table 3.3 presents recent demographic and practice characteristics of the hospitalist GP/FPs and general internists, herein referred to as "hospital generalists," with data for mixed-practice and comprehensive community practitioners provided for comparison. Full-time hospital generalists delivered 10% of total inpatient E&M services in 2010/2011, billing an average of 3,649 inpatient claims and accounting for 614 unique hospital inpatients and 220 calendar days worked in hospital. Using mean volumes, these metrics equate to an average clinical workload of 16.6 patient interactions and 2.8 new patients evaluated per workday, excluding non-billable reassessments and any additional outpatient services. Part-time hospital generalists evaluated an average of 11.0 inpatients and 2.6 new patients per hospital day worked, while mixed-practice physicians evaluated 11.6 inpatients and 2.3 new patients per day. All full-time hospital generalists worked a minimum of 100 calendar days in hospital, and all part-time practitioners (part-time hospitalists and mixed-practice physicians) exceeded 50 days. As expected, hospital generalists had limited previous medical relationships with their hospital inpatients, seeing an average of 10.8% of these patients within the 2 years before admission. On average, the comprehensive community generalists had seen more than half of their patients before admission to hospital (51.5%).

To test our definitional algorithm, we validated the list of institutions where full-time and part-time hospital generalists (classified according to **Table 3.1** and described in **Table 3.3**) billed the majority of inpatient services in 2010/2011 against 62 hospitals with and 101 hospitals without publicly disclosed hospitalist programs. The algorithm correctly identified 90% of hospitals known to employ hospitalists (specificity 98%, positive predictive value 97%). The six false negatives (100%) identified small community hospitals that had introduced hospitalist programs partway through the 2010/2011 fiscal year. The two false positives (100%) identified general hospitalists teaching at large, urban academic hospitals with general medicine teaching units but no formalized hospitalist program.

Table 3.3 Characteristics of comprehensive community, mixed-practice and hospitalist generalists, fiscal year 2010/2011.

Characteristic	Physician group; no. (%) of physicians*							
	Comprehensive community practitioners		Mixed-practice physicians		Part-time hospitalists		Full-time hospitalists	
Total no. of physicians	2,478		512		126		211	
Age, yr, mean (SD)	50.6	(11.2)	46.0	(11.1)	41.7	(9.2)	45.7	(10.2)
Time in practice, yr, mean (SD)	23.9	(11.8)	19.4	(11.8)	15.0	(9.7)	18.5	(10.8)
Sex								
Male	1,670	(67.4)	325	(63.5)	76	(60.3)	117	(55.5)
Female	808	(32.6)	187	(36.5)	50	(39.7)	94	(44.5)
Canadian medical graduate								
Yes	2,049	(82.7)	363	(70.9)	107	(84.9)	147	(69.7)
No	429	(17.3)	149	(29.1)	19	(15.1)	64	(30.3)
Medical specialty								
General practice/family medicine	2,320	(93.6)	280	(54.7)	62	(49.2)	145	(68.7)
General internal medicine	158	(6.4)	232	(45.3)	64	(50.8)	66	(31.3)
Metropolitan area of practice, by population								
≥ 1,250,000	639	(25.8)	208	(40.6)	42	(33.3)	87	(41.2)
500,000 to 1,249,999	240	(9.7)	80	(15.6)	33	(26.2)	26	(12.3)
100,000 to 499,999	529	(21.3)	147	(28.7)	39	(31.0)	80	(37.9)
9,000 to 99,999	471	(19.0)	60	(11.7)	11	(8.7)	18	(8.5)
< 9,000	599	(24.2)	17	(3.3)	< 5	(0.8)†	0	(0.0)

Hospital size, no. of acute care beds								
≥ 300	223	(9.0)	121	(23.6)	54	(42.9)	58	(27.5)
200–299	384	(15.5)	123	(24.0)	29	(23.0)	63	(29.9)
100–199	582	(23.5)	170	(33.2)	32	(25.4)	61	(28.9)
1–99	1,287	(51.9)	93	(18.2)	11	(8.7)	29	(13.7)
Unknown	< 5	(<0.1)†	5	(1.0)	0	(0.0)	0	(0.0)
Hospital location, residents/km^2								
Urban (> 400)	711	(28.7)	223	(43.6)	49	(38.9)	91	(43.1)
Mixed-urban (100–400)	474	(19.1)	127	(24.8)	42	(33.3)	59	(28.0)
Mixed-rural (20–99)	820	(33.1)	117	(22.9)	28	(22.2)	45	(21.3)
Rural (< 20)	471	(19.0)	43	(8.4)	7	(5.6)	16	(7.6)
Unknown	< 5	(0.1)†	< 5	(0.4)†	0	(0.0)	0	(0.0)
Hospital type								
Academic teaching hospital	406	(16.4)	172	(33.6)	72	(57.1)	79	(37.4)
Community hospital	2,072	(83.6)	340	(66.4)	54	(42.9)	132	(62.6)
Clinical workload								
Inpatient E&M claims billed, mean (SD)	409	(451)	2090	(1589)	1261	(444)	3649	(1962)
Unique hospital inpatients seen, mean (SD)	109	(101)	408	(309)	304	(161)	614	(291)
Calendar days billed for hospital care, mean (SD)	120	(92)	180	(80)	115	(49)	220	(49)
% hospital inpatients with previous medical relationship with physician, mean (SD)	51.5	(30.7)	20.0	(18.1)	11.3	(7.0)	10.8	(7.3)

Distribution of practice, %, mean (SD)								
Inpatient care	9.1	(7.9)	54.2	(15.5)	91.4	(5.9)	91.5	(5.9)
Office-based care	78.9	(17.4)	36.5	(19.4)	6.6	(5.5)	5.8	(4.8)
Emergency care	6.3	(11.2)	5.8	(11.7)	1.9	(3.5)	1.3	(2.9)
Long-term institutional care	4.7	(12.3)	3.3	(9.8)	0.2	(1.0)	1.4	(3.3)
Home-based care	0.9	(3.2)	0.3	(2.0)	0.0	(0.0)	0.0	(0.1)

Note: E&M = evaluation and management.
*Except where indicated otherwise.
†Counts < 5 have been suppressed.

3.5 Discussion

To our knowledge, this is the first study to propose a functional framework for defining and delineating physicians' inpatient practices on the basis of their clinical volume of inpatient care provision. Our definition of hospitalist practice aligns with the functional approach reintroduced by Kuo *et al.*, [37,66,70,106,141,156,222-224] but advances the methodology by adding a continuous measure of inpatient volume, which allowed us to differentiate providers by their daily clinical workloads and capture the diversity of practice models operating within the province. In presenting this framework, our intent is not to suggest that these thresholds are exact or concrete, but rather to provide both a descriptive and analytic structure that can accommodate the variety of practice styles and medical specialties that exist in hospital medicine. In doing so, we aim to move the methodology toward more objective and dynamic definitions of hospitalist practice, whereby clinical inpatient volumes can be analyzed as the primary predictor of physician practice and performance, accounting for additional provider characteristics, such as medical specialty and clinical experience, as desired. By examining the quality of general inpatient care as a function of a physician's annual inpatient volume, we can extend the application of the hospitalist literature to additional acute care delivery models around the world that have instituted parallel focused-inpatient practices without necessarily establishing formalized hospitalist programs. The volume metrics and descriptive variables used in this study are simple to derive and are often captured at the population level through insurance billings and/or service utilization databases.

This is also the first study to describe the prevalence and characteristics of Ontario hospitalists using systems-level data and to describe the emergence of hospital medicine and its impact on the provision of hospital care by other inpatient physicians. By examining changes in physician billing volumes over time, clinical practice data confirmed the introduction of GP/FP hospitalists to Ontario in the early 21st century and significant growth in the number of full-time hospital generalists practicing each fiscal year since. Our estimates for the current number of hospitalists in practice vastly exceed those reported by the Canadian Society of Hospital Medicine based on its voluntary membership survey (*n* = 110) [10], which confirms our premise that self-reporting as a hospitalist underestimates the functional prevalence of hospital-based practitioners. The demographic data observed amongst the general hospitalists identified in this study are consistent with those reported elsewhere in the Canadian hospitalist literature [10,215,216].

For ethical reasons we were unable to link de-identified administrative billings to a known cohort of hospitalist physicians to validate the inpatient volume thresholds proposed in our functional framework. This remains an important step in creating and refining a clinical definition of hospitalist practice. Despite this limitation, we were able to define and characterize a distinct cohort of general physicians who functionally devoted the majority of their practice to the care and management of hospital inpatients. We were able to validate our definitions at the institutional level with high precision and good sensitivity. Our definitions also had face validity, triangulated across the three clinical volume metrics and the clinical workload analysis presented in Table 3.3. In addition, we were able to describe trends in inpatient volume only among fee-for-service physicians, who account for about 90% of physicians working in Ontario. It is unlikely that this limitation affected our calculation of inpatient volumes or hospitalist estimates, as the majority of hospital services for general practitioners are still remunerated through fee-for-service billings, captured in the OHIP claims database. Alternative payment plans are used primarily to reimburse community-based physicians and were reported to be uncommon among hospitalists responding to the Canadian Society of Hospital Medicine survey (4.6%) [10]. Finally, this analysis focused exclusively on direct clinical care and case management; procedure volumes were not explored. This distinction resulted in some hospital-based specialties (surgery, anesthesiology, obstetrics and gynecology) having lower inpatient clinical volumes than might have been expected. In many instances, these subspecialty inpatients are increasingly managed or comanaged by hospitalists, which would reduce specialists' inpatient E&M claims to those immediately preceding or following a procedure.

When we replicated the functional hospitalist definition developed by Kuo *et al.,* [70] with 2010/2011 OHIP claims data using a minimum volume of 100 E&M claims and an 80% inpatient practice ratio, prevalence estimates of general hospitalist practitioners were overinflated by 17%, capturing 67 physicians with low inpatient volumes reflecting minimally active practices. More importantly, the Kuo definition ignored a large segment of mixed-practice generalists (*n* = 512) whose clinical volumes and workload appeared to parallel if not exceed those of part-time hospitalists **(Table 3.3).** In a comparative evaluation, these physicians would be classified into the reference category, muting any associations that might ultimately be driven by clinical volume or experience, a well-established determinant of outcomes in health care delivery.[225] To our knowledge, the systems-level relationship between clinical inpatient volume and outcomes of care has not been assessed for physicians practicing general hospital medicine.

Inpatient physicians are unified by the common goal of caring for hospital inpatients, and it is that professional focus which defines all practitioners, irrespective of medical specialty. As general and specialty hospitalists continue to grow in number across the globe, continuous metrics of clinical volume reflecting the dynamic continuum of inpatient practice and provider experience may be advantageous for defining, identifying, and monitoring hospital physicians and their performance. By using the definitional framework proposed in this study, researchers can begin to test structural differences between inpatient delivery models, exploring which aspects of physician care—clinical experience, medical training, or a combination of both—correlate with changes in the processes of care delivery that in turn help to drive improvements in operating efficiency and clinical outcomes.

4 Generalist inpatient volume and clinical outcomes of care: a systems-level performance evaluation of Ontario's hospital physicians

4.1 Abstract

Background: While physician volume is a well-established predictor of operative and procedural outcomes, little is known about whether a volume-outcome relationship exists amongst physicians practicing general hospital medicine.

Methods: We conducted a retrospective population-based cohort study of 55,484 patients aged 18 years of age or older who were hospitalized between fiscal 2009/2010 and fiscal 2010/2011 for congestive heart failure, pneumonia, chronic obstructive pulmonary disease or delirium at 151 hospitals in Ontario, Canada. We used multilevel regression to evaluate the relationship between the annual inpatient volume of attending generalists (family physicians and general internists) and 30-day mortality, 30-day readmissions and acute length of stay.

Results: At admission, patients' baseline health status was comparable across physician volume groups. A significant inverse relationship was found between inpatient volume, mortality and readmissions. For patients managed by an attending generalist in the highest (≥ 2,000 inpatient services/year) vs. lowest (< 500 services/year) volume categories, adjusted odds of 30-day mortality were 0.69 (95% CI: 0.59, 0.82) for congestive heart failure; 0.69 (95% CI: 0.60, 0.79) for pneumonia; 0.79 (95% CI: 0.67, 0.95) for chronic obstructive pulmonary disease; and 0.93 (95% CI: 0.79, 1.10) for delirium. Results for readmissions were similar. Acute lengths-of-stay were longer among high vs. low volume generalists by: 40% for congestive heart failure (95% CI: 33%, 48%); 33% for pneumonia (95% CI: 27%, 30%); 29% for chronic obstructive pulmonary disease (95% CI: 23%, 35%) and 28% for delirium (95% CI: 16%, 42%).

Conclusions: Higher inpatient clinical volume was associated with significantly lower 30-day mortality and readmissions and a longer acute length of stay. These findings may help to inform policy and economic discussions regarding the practice of hospital medicine in Ontario and elsewhere. Where high-volume inpatient practice is not feasible, alternative strategies for supporting community-based generalists in hospital care and quality improvement should be explored.

4.2 Introduction

The withdrawal of primary care physicians from inpatient clinical care and the subsequent emergence of hospital medicine represents one of the most notable and controversial changes in medical service delivery to occur in North America over the last two decades. The majority of research on hospitalists has demonstrated that concentrating inpatient care amongst a dedicated group of hospital providers can reduce lengths of stay and total hospital costs for patients compared to traditional models of practice where physicians' clinical activities are divided between inpatient and outpatient settings (76,219,226,227). However, less evidence has supported claims that hospitalists improve the clinical quality of care (33,76,219). Only 20% of studies examining mortality or readmissions have reported reductions associated with hospitalist care and fewer still have shown improvements in hospital complications, emergency department bounce-backs or follow-up post discharge (219).

Despite promising efficiency gains and ongoing interest in hospital medicine, many question the validity and relevance of previous hospitalist research to current inpatient practice for several reasons. First, the bulk of published literature on hospitalist outcomes are outdated and shadowed by methodological concerns: early evaluations were frequently underpowered to detect clinically meaningful differences in adverse outcomes and included diverse patient populations with minimal adjustment for disease severity. Second, most studies have consisted of single site evaluations, restricting analyses to a small number of self-identified hospitalist practitioners and comparing their patients to a known cohort of academic or community-based colleagues working within the same institution. Whether findings on hospitalist quality are more broadly generalizable across institutional settings, geographies and applicable to all inpatient practitioners is uncertain. Finally, while the performance of hospitalists have been studied extensively, little research has explored which structural characteristics differentiate hospital-based practitioners from other inpatient physicians or the relative importance of clinical volume for driving quality outcomes.

Physician volume is a well-established predictor of clinical outcomes with numerous systematic reviews concluding that more experienced, high-volume specialists produce better outcomes and higher quality care for their patients (225,228-231). The same relationship appears for hospital volume, with admission to higher-volume hospitals associated with lower short-term mortality and fewer readmissions [232-235]. To our knowledge, no one has investigated whether a volume-outcome relationship exists amongst physicians practicing general hospital medicine. Understanding the relationship between generalist volume and outcomes is critical for current inpatient practice, where institutional funding and physician reimbursement are increasing tied to performance targets and physicians face mounting pressure to improve the efficiency of acute care while simultaneously engaging in quality improvement.

We conducted a population-based cohort study to assess the relationship between annual inpatient volume and clinical outcomes of care in hospitalized patients managed by generalist physicians (family physicians and general internists) in Ontario, Canada. Our objective was to assess whether patients managed by high volume generalists had shorter lengths of stay, lower mortality and fewer readmissions compared with patients managed by lower-volume generalists.

4.3 Methods

4.3.1 *Study Population*

A retrospective cohort was established comprised of all Ontario residents aged 18 and older hospitalized with select conditions to acute-care hospitals in Ontario, Canada between April 1, 2009 and March 31, 2011. Patients were eligible if they were admitted with a first/index admission for congestive heart failure (CHF: n = 34,797), pneumonia (PNEU: n = 28,473), chronic obstructive pulmonary disease (COPD: n = 38,684), or delirium/confusion (DELIR: n = 7,195) as defined by the *International Classification of Diseases, 10th Revision* criteria (see **Table 4.1** for ICD-10 codes). These four conditions were selected as each have a moderate to high incidence of mortality/readmission, longer than average lengths of stay, are managed according to standard care protocols and are conditions that family physicians and general practitioners still manage in Canadian hospitals.

Table 4.1. ICD-10-CA diagnosis codes used to identify the study cohorts and condition-specific comorbidities.

Disease Cohorts	**ICD-10-CA Codes**
Admission Diagnosis or Diagnosis Most-Responsible for Length of Stay	
Chronic Obstructive Pulmonary Disease	J41-J44
Congestive Heart Failure	I50
Delirium	F05, R41.0
Pneumonia	J10.0, J11.0, J12-J18
Condition-Specific Comorbidities	
Chronic Obstructive Pulmonary Disease [236,237]	
Congestive Heart Failure	I50
Diabetes	E10-E14
Hypertension	I10, I11, I13, I15
Previous Myocardial Infarction	I21, I25.2
Renal Failure	N17-N19, R34, Z99.2
Congestive Heart Failure [238]	
Cancer	C00-C97
Cardiac Dysrhythmias	I44.0-I44.3, I45.6, I45.9, I46-I49, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0
Cardiac Valve Disease	I05-I08, I09.1, I09.8, I34-I39, Q22, Q23, Z95.2-.4
Cardiomegaly	I51.7
Cerebrovascular Disease	G45-G46, I60-I69
Cirrhotic Liver Disease	K70.3, K71.1
Chronic Obstructive Pulmonary Disease	J41-J44
Dementia	F00-F03, F06-F07, G30, G31.1
Hyponatraemia	E87.1
Hypotension	I95
Previous Myocardial Infarction	I21, I25.2
Renal Failure	N17-N19, R34, Z99.2

Pneumonia [239]	
Cancer	C00-C97
Cerebrovascular Disease	G45-G46, I60-I69
Congestive Heart Failure	I50
Dementia	F00-F03, F06-F07, G30, G31.1
Diabetes with Complications	E10-E14 excl. E10.9, E11.9, E12.9, E13.9, E14.9.
Hypotension	I95
Pleural Effusion	J90-J91
Liver Disease	K70-K77
Renal Failure	N17-N19, R34, Z99.2
Tachypnea	R06.0
Delirium [240,241]	
Cancer	C00-C97
Cognitive Impairment	F00-F03, F05.1, G30, G31.1
Drug Toxicity	T36-T48, T50-T51, T65
Infection/Septicemia	A02.1, A04.7, A22.7, A26.7, A32.7, A40-A41, A49.8, A49.9, R57.2 R65, U80.1, U81.0, T80.2
Pneumonia	J10.0, J11.0, J12-J18
Pre-existing Fracture	S12, S22, S32, S42, S52, S62, S72, S82, S92, T02, T10, T12

We used incident admissions to minimize patient-level differences in illness severity. Patients were excluded if they were admitted for the same condition within 12 months prior to the date of admission (*n* = 25,635; 23%). Patients were then assigned to the cohort corresponding to their earliest eligible admission. The episode of care began at the date of admission and ended at the final date of discharge, incorporating any transfers within or between institutions. To account for differences in admitting patterns in small remote hospitals, institutions with < 10 medical beds were excluded (16 hospitals, 9% of initial patient cohort). In addition, the patient's hospital stay had to be managed by an attending physician with a practicing specialty in family or general internal medicine (*n* = 55,792). Records with missing values were excluded (*n* = 308; <1%) leaving a final sample of 55,484 patients managed by 3,546 generalists in 151 hospitals.

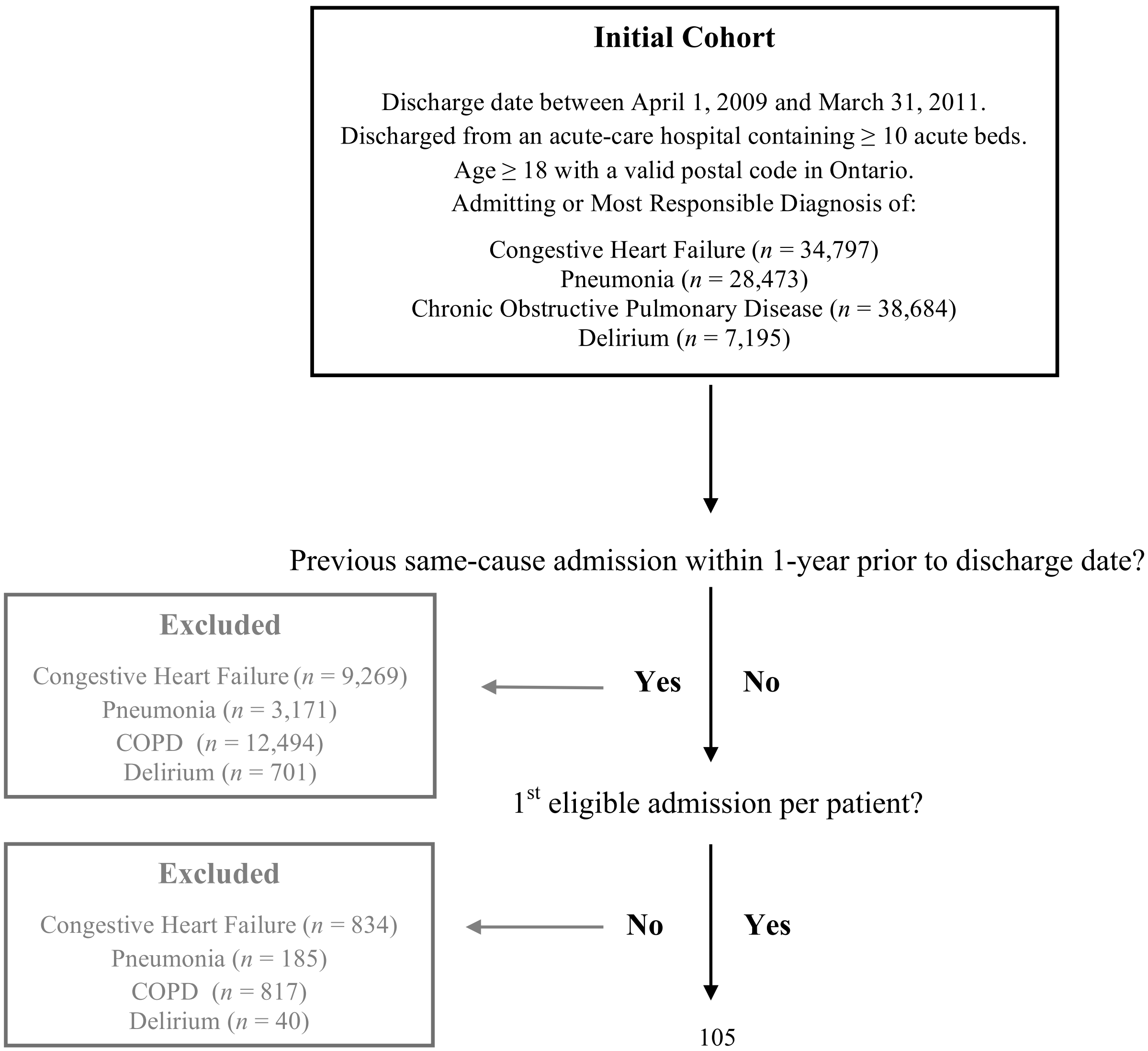
A flow diagram reporting all exclusions by cohort is displayed in **Figure 4.1.**

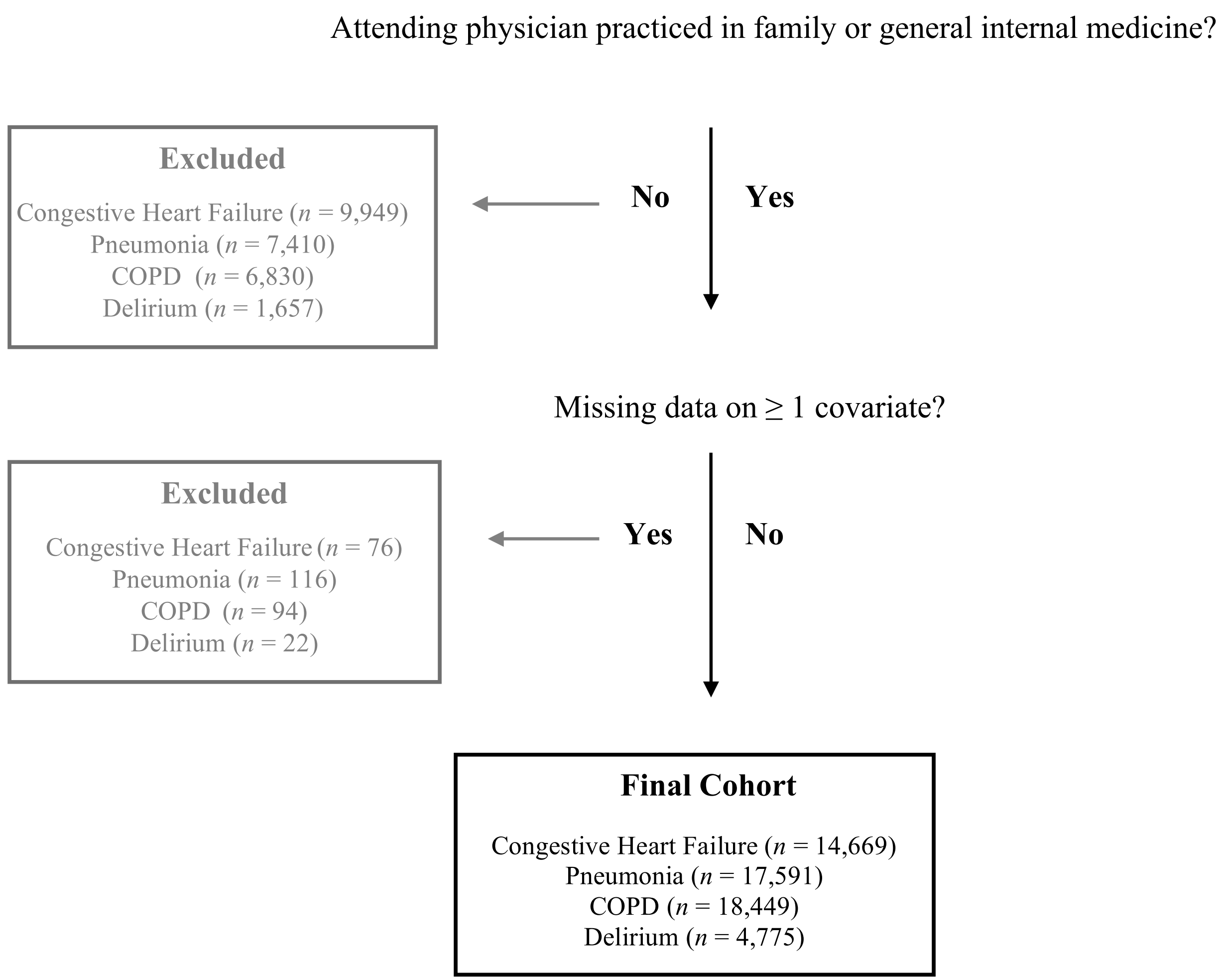
4.3.2 *Defining Physician Workload*

The primary exposure was the attending physician's annual inpatient clinical volume in the fiscal year corresponding with the index hospitalization, derived from administrative billing records. To calculate volume, we summed the total number of clinical evaluation-and-management claims each physician billed to Ontario's Health Insurance Plan (OHIP) for inpatient care in fiscal 2009/2010 and fiscal 2010/2011. OHIP is a publically funded plan that provides basic health care including hospital care to all permanent residents and captures fees for over 90% of all health care services delivered in the province. We defined an evaluation-and-management claim in previous work as any clinical visit, consultation, assessment, re-assessment, death pronouncement, case-conference, counseling or psychotherapy session billed to OHIP for a hospitalized resident [(242)]. It is used as a proxy measure of a physician's annual inpatient clinical load and hospital experience. Claims for procedural volumes and obstetrical services were excluded from the calculation of volume; however inpatient assessments of mental health and capacity were included.

To assign the attending physician of record, patients were allocated to the provider who billed the greatest number of evaluation-and-management claims for their care during the index episode. In the event of a tie, patients were allocated to the provider who billed the largest number of claims linked to a most-responsible physician - an enhanced set of fees billable only at certain times during hospitalization (date of admission/discharge) by the physician who self-identifies as being primarily responsible for the day-to-day care of an inpatient. In cases where an attending physician remained unallocated, the patient was arbitrarily assigned to the provider with the lowest random encrypted identification number (< 1%). The physician's medical specialty was then determined by combining data on both certified and functional specialty, where certified specialty captures the most recent certification information held while functional specialty reflects what the physician actually does in his/her clinical practice, derived from aggregated OHIP billings.

Figure 4.1: Flow diagram outlining cohort selection and exclusions.





Attending physician practiced in family or general internal medicine?
Excluded
Congestive Heart Failure (n = 9,949)
Pneumonia (n = 7,410)
COPD (n = 6,830)
Delirium (n = 1,657)
No
Yes
Missing data on ≥ 1 covariate?
Excluded
Congestive Heart Failure (n = 76)
Pneumonia (n = 116)
COPD (n = 94)
Delirium (n = 22)
Yes
No
Final Cohort
Congestive Heart Failure (n = 14,669)
Pneumonia (n = 17,591)
COPD (n = 18,449)
Delirium (n = 4,775)

Discrepancies were assigned to the functional specialty recorded most often in the physicians' OHIP claims for a given year. Patients managed by specialists were excluded (n = 28,546; 42%).

Annual clinical volume, expressed as the number of inpatient claims billed to OHIP per year, was first evaluated as a continuous variable. To simplify the presentation of results, we created three categories of inpatient volume: low (< 500 claims/year), medium (500-1,999 claims/year) and high (≥ 2,000 claims/year). Cutpoints were based on quintiles from the combined disease cohorts, however due to skewed distributions (large number of patients managed by a few high-volume physicians), quintiles 2 and 3 and quintiles 4 and 5 were combined to ensure the stability of sample sizes at the physician level. Cutpoints were established prior to examining outcomes data to avoid biasing volume-outcome associations.

4.3.3 *Outcome Measures*

Outcome measures included 30-day mortality, 30-day mortality or readmission and acute length of stay, each measured at the patient-level from the date of admission. Readmissions were analyzed as a combined outcome with mortality because the factors causing mortality were likely an exacerbation of those causing readmission such that the two events are rarely independent [243]. Combined outcomes are increasingly used in cohorts where inpatient mortality is high, leaving fewer patients at risk for readmission [244-246]. In addition, the patient's length of stay on an alternate level of care (ALC days) was excluded to ensure that physicians were evaluated only on aspects of efficiency they were likely to influence [247].

4.3.4 *Additional Data Elements*

All models were adjusted for patient, physician and hospital-level characteristics. Patient characteristics included age, sex, socioeconomic status, principal diagnosis and select comorbidities (see **Table 4.1** for list of validated disease-specific comorbidities and associated ICD-10 codes). Physician characteristics included the attendings' age, gender, years since graduation and medical specialty. The number of acute medical beds, teaching status, and geographic location were determined for each hospital.

4.3.5 *Data Sources*

Patient and physician records were linked using unique encrypted identifiers across multiple administrative databases containing systems-level information on all publicly funded hospital and physician services in the province. These included the Discharge Abstract Database (DAD) containing information on hospitalization dates, transfers, admitting diagnosis, diagnosis most responsible for length of stay, comorbidities present at admission, in-hospital deaths and the institution identifier; the OHIP Claims Database for physician billings corresponding to the index hospitalization; the Institute for Clinical Evaluative Sciences' Physician Database (IPDB), a human resources database containing validated demographic, certification and practice characteristics on all physicians licensed in the province since 1992; and the Registered Persons Database (RPDB) for residential postal code and death information. Residential postal codes were linked to neighbourhood-level household income quintiles using previously described methods [248]. Hospital characteristics were obtained from the Canadian Management Information System (MIS). A visual depiction of data linkages can be seen in **Appendix 4.1.**

4.3.6 *Statistical Analyses*

Since hospital practitioners are thought to treat sicker patients and thus more likely to encounter adverse clinical events, we developed a baseline patient severity score specific to each disease cohort, using logistic regression models to predict the patient's 30-day mortality risk at the time of admission incorporating all patient demographics, disease-specific comorbidities and Charlson comorbidities recorded in DAD as being present at the time of admission (C statistics: CHF = 0.74; PNEU = 0.77; COPD = 0.72; DELIR = 0.71) [231,243,249]. Risk-adjusted mortality rates, combined mortality/readmission rates and acute length of stay by volume category were then determined by dividing the observed outcomes by the expected estimates predicted from logistic (mortality/readmission) and linear (length of stay) regression after patient-level adjustment for demographics and baseline severity. These estimates can be interpreted as the outcomes that would be expected if the patient case-mix were identical across volume groups, independent of physician and hospital confounding.

To allow for the hierarchical nature of the data, multilevel models with 2-levels of clustering were fit to assess the relationship between generalist inpatient volume and clinical outcomes adjusting for the clustering of patients within physicians and physicians within hospitals. Random effects models were used, incorporating fixed effects at the first and second levels, and a random intercepts at the second and third levels. Models used the patient as the unit of the analysis and the attending's inpatient clinical volume in the fiscal year of admission as the primary exposure, controlling for patient age, sex and their interactions, predicted severity at admission, disease-specific comorbidities, neighbourhood income level, year of admission, physician characteristics, hospital location and academic affiliation. Hospitals' medical bed count was found to be correlated with both geography and academic affiliation and was subsequently excluded from regression models. Additional data elements assessing transfers of care, continuity of care, clinical history with the attending prior to admission, ICU stay during hospitalization, nursing ratios and administrative/support ratios were also assessed, found to be un-related to any of the outcome measures, and excluded from further analysis. Finally, iterative model building revealed that predicted severity at admission and physician specialty were the leading effect modifiers between workload and all outcome measures. Physician characteristics, hospital location and academic affiliation had minimal effects on outcome estimates, but were retained to improve overall model performance.

The four cohorts were analyzed separately, constructing disease-specific models for each of the three outcomes. Logit models were used to estimate the risk of mortality and readmission while loglinear models were used to estimate acute length of stay. Residuals from linear length-of-stay models were right-skewed; however untrimmed log transformation corrected the distributions. Estimates and standard errors from the multilevel disease-specific models were then pooled using a two-stage method to estimate the overall effect of generalist volume on clinical outcomes [250]. The pooling of estimates across cohorts using mixed-effects models takes into account inter-cohort heterogeneity as well as random error, generating more precise estimates of how volume overall relates to each outcome event [250].

To determine if there was a threshold effect for volume, the estimated probability of mortality, combined mortality/readmissions and acute length of stay (in days) were modeled and graphed incorporating a spline function (6 inflections were selected to maximize major and minor visual trends, occurring at 266, 665, 1185, 1950, 2856 and 4454 inpatient claims/year) adjusting for all patient, physician and hospital covariates. All multilevel regressions were performed using SAS GLIMMIX and SAS version 9.2 [251] was used for analysis. Ethics approval was obtained from Sunnybrook Health Sciences Centre and from the Research Ethics Board at the University of Toronto.

4.4 Results

The descriptive characteristics of patients are shown in **Table 4.2.** Demographics of patients were generally similar across physician volume categories; however, patients of high-volume generalists (≥ 2,000 inpatient claims/year) were older and more likely to live in lower-income neighbourhoods ($P < 0.001$) while patients of low-volume generalists (< 500 inpatient claims/year) were more likely to be admitted to smaller and rural hospitals ($P < 0.001$). Patients of high-volume generalists were slightly sicker at the time of admission (see **Table 4.2; Figure 4.2).** The descriptive characteristics of attending generalists can be found in **Appendix 4.2.** The majority of attendings fell in the low-volume category ($n = 2{,}002$). High-volume attendings were more likely to be internists ($P < 0.001$) and practice primarily in larger urban hospitals ($P < 0.001$). Using mean volumes, the average clinical workload for a low-volume generalist was 2.4 inpatient claims per day worked in hospital. Medium-volume generalists had an average of 5.1 inpatient claims per day while high-volume generalists had 13.8 claims. The intensity of visits per patient varied by physician volume, with low-volume generalists averaging 3.6 billed visits per hospitalized patient compared to 5.9 visits/patient among high-volume generalists.

Table 4.2. Patient-level characteristics, stratified by medical condition and physician inpatient volume. Ontario 2009-2011 (*n* = 55,484).

	Congestive Heart Failure				**Pneumonia**			
Variables	***Total***	***Low Volume****	***Medium Volume*****	***High Volume******	***Total***	***Low Volume****	***Medium Volume*****	***High Volume******
Sample Size†	14,669	1,987 (13.6)	6,595 (45.0)	6,087 (41.5)	17,591	2,783 (15.8)	7,464 (42.4)	7,344 (41.8)
Mean Age ± SD	79.1 (11.1)	78.9 (11.6)	78.8 (11.1)	79.1 (11.1)	72.6 (17.3)	74.4 (14.4)	72.2 (17.4)	73.3 (17.1)
Female Sex (%)	52.7	51.8	51.5	52.7	51.3	50.6	51.4	51.5
Neighbourhood Income Quintile (%)								
Q1 (lowest)	23.5	20.7	24.9	23.0	21.9	20.8	22.5	21.7
Q2	21.9	22.5	20.8	23.0	21.2	19.9	20.0	22.9
Q3	19.8	19.5	20.3	19.3	20.3	20.1	20.8	19.9
Q4	18.2	18.9	17.5	18.7	18.6	21.1	118.6	17.7
Q5 (highest)	16.6	18.4	16.6	16.0	18.0	18.1	18.2	17.8
Select Comorbidities Present at Admission (%)								
Cancer	1.3	0.9	1.3	1.3	2.7	2.9	3.0	2.4
Cerebrovascular Disease	0.4	0.3	0.3	0.4	0.5	0.3	0.5	0.6
Chronic Obstructive Pulmonary Disease	13.4	16.0	12.4	13.5	2.1	2.5	1.8	2.2
Congestive Heart Failure	---	---	---	---	10.7	10.7	9.4	11.6
Dementia	2.1	1.8	1.8	2.6	3.5	2.8	3.2	4.0
Diabetes with Complications	10.6	8.1	9.8	12.2	5.3	3.7	4.8	6.4
Liver Disease	0.8	0.5	0.7	1.0	0.6	0.5	0.6	0.6

Renal Failure	11.3	6.7	9.8	14.3	8.0	4.7	6.7	10.6
Peripheral Artery Disease	0.5	0.7	0.5	0.4	0.2	0.2	0.1	0.2
Previous Myocardial Infarction	4.0	3.9	4.3	3.7	1.7	1.4	1.5	1.9
Baseline Risk of 30-day Mortality ± SD	12.9 (7.2)	12.3 (6.8)	12.6 (7.0)	13.3 (7.4)	14.4 (9.8)	13.6 (9.2)	14.1 (9.7)	14.9 (10.0)
Physician Characteristics								
No. Attending Generalists (%)	2,576	989 (38.4)	1,188 (46.1)	399 (15.5)	2,859	1,205 (42.1)	1,263 (44.2)	391 (13.7)
Mean Age ± SD	47.3 (10.5)	46.7 (10.9)	48.4 (10.7)	46.2 (10.1)	46.5 (10.4)	46.4 (10.7)	47.8 (10.8)	45.2 (9.9)
Mean Years in Practice ± SD	20.5 (11.0)	19.6 (11.5)	21.9 (11.3)	19.4 (10.5)	19.6 (11.0)	19.3 (11.2)	21.1 (11.4)	18.4 (10.4)
Male Gender (%)	70.2	66.2	73.8	67.7	68.3	64.0	72.9	65.3
General/Family Physician (%)	61.1	84.8	65.4	48.8	66.0	89.4	71.2	51.7
Hospitalist (%) ‡	27.2	0.0	13.6	51.1	28.3	0.0	13.8	53.8
Hospital Characteristics								
Academic Hospital (%)	21.2	9.4	17.4	29.3	22.2	9.8	17.7	31.4
Hospital Location (residents/km$^{2;}$ %)								
Urban Hospital (> 400)	28.3	14.8	18.6	43.3	33.7	18.8	24.1	49.0
Mixed-urban (100-400)	23.0	20.9	18.2	29.0	21.0	17.5	16.5	26.9
Mixed-rural (20-99)	33.5	38.5	43.5	21.1	29.6	37.2	37.9	18.2
Rural (< 20)	15.1	25.9	19.8	6.5	15.7	26.4	21.4	5.9
No. Acute Medical Beds (%)								
≥ 300 beds	12.8	6.6	12.0	15.7	14.5	6.2	13.3	18.9
200-299 beds	17.0	9.4	10.3	26.8	18.3	10.2	11.2	28.7
100-199 beds	30.6	16.9	25.0	41.1	29.5	17.1	25.4	38.3
50-99 beds	20.8	23.0	25.9	14.5	16.8	19.2	20.8	11.9
1-49 beds	18.8	44.1	26.8	1.9	20.9	47.4	29.3	2.3

* Low volume: < 500 inpatient claims/year ** Medium volume: 500-1,999 inpatient clinical claims/year *** High volume: ≥ 2,000 inpatient clinical claims/year
† Means ± SDs are shown for continuous variables; frequencies (%) shown for categorical variables. Proportions may not add to 100% due to rounding.
‡ Hospitalists are defined from according to the functional algorithm in Chapter 3 as generalists with ≥ 80% of total OHIP billings attributable to inpatient evaluation-and-management claims with a minimum hospital workload of ≥ 500 inpatient medical claims billed/year.

Cont:

	Chronic Obstructive Pulmonary Disease				**Delirium**			
Variables	***Total***	***Low Volume****	***Medium Volume*****	***High Volume******	***Total***	***Low Volume****	***Medium Volume*****	***High Volume******
Sample Size†	18,449	2,805 (15.2)	8,640 (46.8)	7,004 (38.0)	4,775	584 (12.2)	1,980 (41.5)	2,211 (46.3)
Mean Age ± SD	73.9 (11.8)	73.5 (11.8)	73.7 (11.8)	74.3 (11.8)	77.9 (12.4)	76.6 (14.1)	77.0 (12.6)	79.0 (11.6)
Female Sex (%)	51.4	53.8	50.5	51.6	56.4	55.8	56.2	56.7
Neighbourhood Income Quintile (%)	27.2	24.7	27.2	28.2	23.4	20.6	25.4	22.3
Q1 (lowest)	22.0	21.6	21.9	22.3	20.5	21.8	19.2	21.3
Q2	19.2	19.1	19.5	19.0	19.4	18.5	18.9	19.4
Q3	17.4	19.4	17.4	16.5	19.2	19.5	18.1	19.2
Q4	14.2	15.2	14.1	13.9	17.8	19.7	18.3	17.8
Q5 (highest)	27.2	24.7	27.2	28.2	23.4	20.6	25.4	22.3
Select Comorbidities Present at Admission (%)								
Cancer	1.8	1.9	1.4	2.2	2.4	2.7	2.6	2.1
Cerebrovascular Disease	0.3	0.3	0.2	0.4	2.3	2.1	2.1	2.4
Chronic Obstructive Pulmonary Disease	---	---	---	---	2.4	3.6	1.8	2.6

Congestive Heart Failure	11.5	12.8	9.8	13.0	2.9	2.9	2.7	3.0)
Dementia	1.7	1.6	1.5	1.9	5.8	6.3	4.8	6.6
Diabetes with Complications	4.7	4.3	4.4	5.2	6.7	6.0	5.5	8.0
Liver Disease	0.3	0.3	0.2	0.4	1.1	1.0	1.0	1.3
Renal Failure	3.7	3.7	4.3	6.3	7.4	6.7	5.6	9.3
Peripheral Artery Disease	0.2	0.1	0.2	0.3	0.5	0.5	0.6	0.3
Previous Myocardial Infarction	1.4	1.1	1.1	1.9	0.7	1.5	0.4	0.8
Baseline Risk of 30-day Mortality ± SD	9.0 (6.3)	8.6 (6.1)	8.9 (6.1)	9.4 (6.7)	7.1 (4.2)	7.0 (4.5)	7.0 (4.2)	7.1 (4.2)
Physician Characteristics								
No. Attending Generalists (%)	2,745	1,118 (40.7)	1,238 (45.1)	389 (14.2)	1,657	431 (26.1)	880 (53.1)	346 (20.9)
Mean Age ± SD	47.4 (10.6)	46.6 (10.8)	48.4 (10.7)	46.6 (10.3)	46.8 (10.4)	45.9 (10.7)	47.6 (10.7)	46.3 (10.1)
Mean Years in Practice ± SD	20.5 (11.2)	19.4 (11.3)	21.7 (11.3)	19.5 (11.0)	20.0 (10.9)	18.7 (11.1)	20.8 (11.1)	19.5 (10.7)
Male Gender (%)	69.2	66.1	72.6	66.1	68.4	67.1	71.1	66.3
General/Family Physician (%)	72.0	91.0	76.4	59.1	66.4	91.8	71.5	55.2
Hospitalist (%)‡	26.2	0.0	12.3	53.9	33.5	0.0	17.5	56.7
Hospital Characteristics								
Academic Hospital (%)	16.7	8.4	14.0	23.3	28.4	14.9	26.0	34.1
Hospital Location (residents/km$^{2;}$ %)								
Urban Hospital (> 400)	20.3	11.1	13.1	32.8	33.1	16.6	25.9	43.8
Mixed-urban (100-400)	22.5	19.8	17.6	29.7	24.7	20.9	20.3	29.6
Mixed-rural (20-99)	39.2	41.4	46.2	29.8	30.1	39.2	36.4	22.1
Rural (< 20)	18.0	27.8	23.1	7.7	12.2	23.3	17.5	4.6

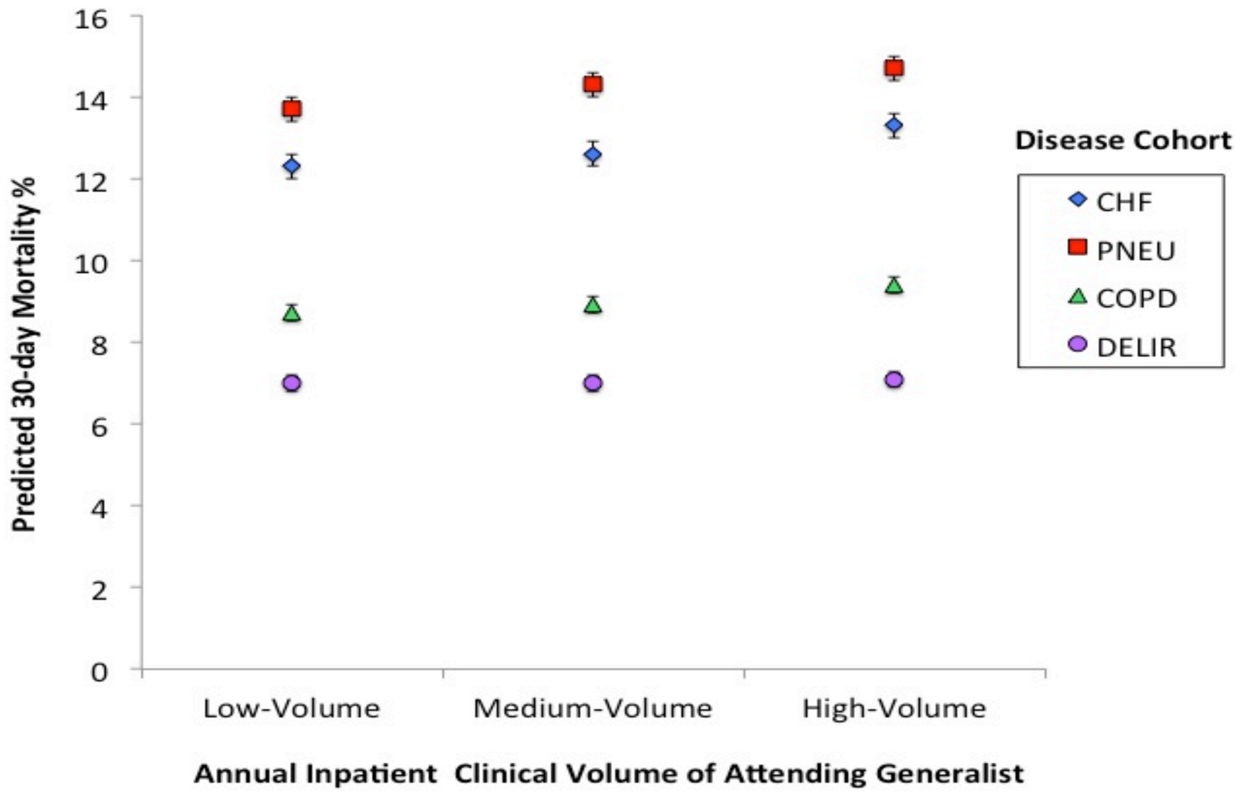
No. Acute Medical Beds (%)								
≥ 300 beds	10.9	5.9	9.5	14.7	18.7	10.3	18.2	21.4
200-299 beds	17.2	8.9	9.9	29.6	21.2	8.9	12.5	32.3
100-199 beds	27.2	14.9	24.3	35.7	30.2	20.0	28.8	34.0
50-99 beds	23.3	25.5	26.8	17.9	15.4	23.3	18.0	10.9
1-49 beds	21.5	44.9	29.5	2.1	14.5	37.5	22.5	1.3

* Low volume: < 500 inpatient claims/year ** Medium volume: 500-1,999 inpatient clinical claims/year *** High volume: ≥ 2,000 inpatient clinical claims/year

† Means ± SDs are shown for continuous variables; frequencies (%) shown for categorical variables. Proportions may not add to 100% due to rounding.

‡ Hospitalists are defined from according to the functional algorithm in Chapter 3 as generalists with ≥ 80% of total OHIP billings attributable to inpatient evaluation-and-management claims with a minimum hospital workload of ≥ 500 inpatient medical claims billed/year.

Figure 4.2 Baseline patient severity, measured as the average predicted 30-day mortality rate against physician inpatient claims volume category and 95% confidence intervals.



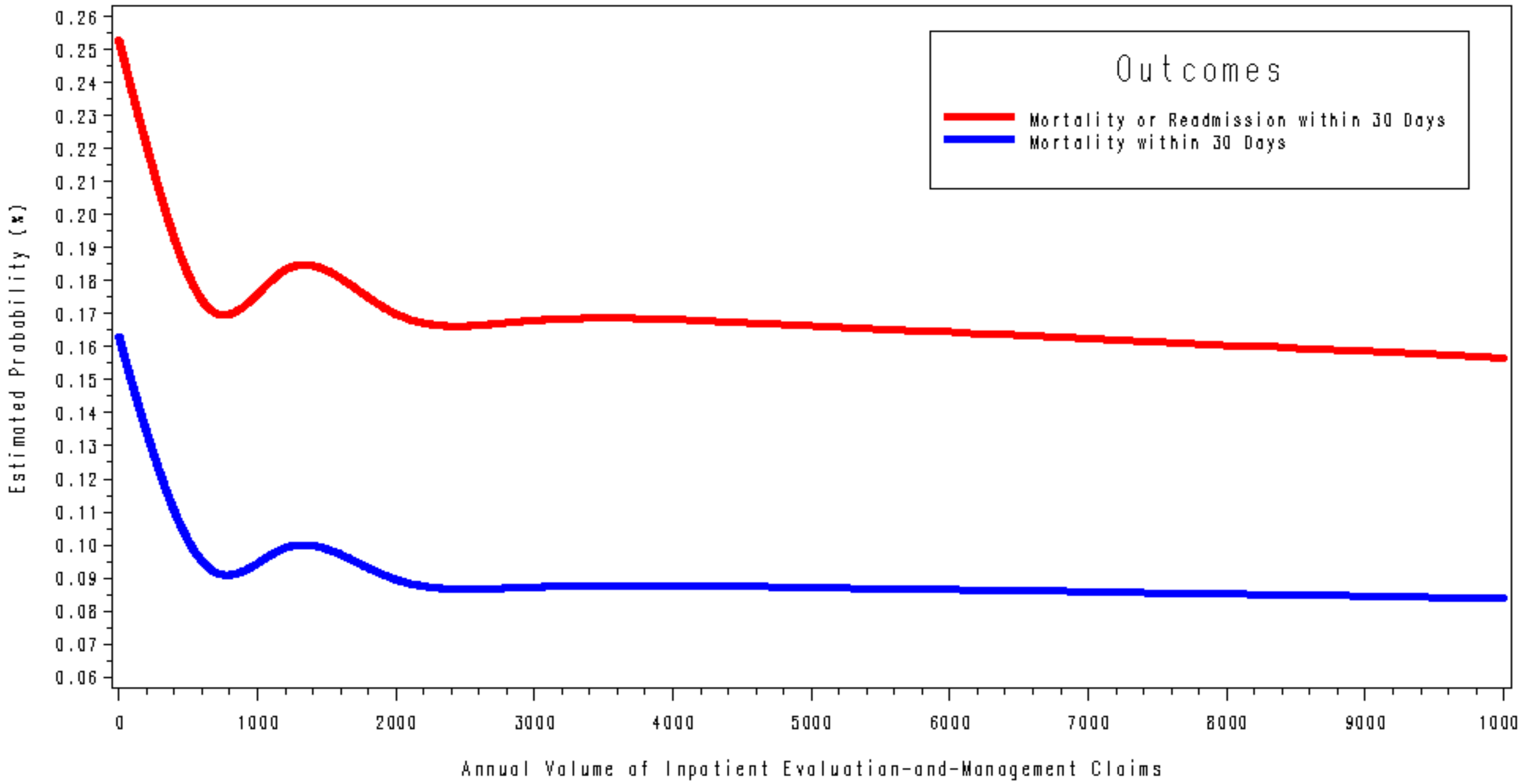
Annual volume ranges are: < 500 inpatient claims for low-volume, 500-1,999 inpatient claims for medium-volume, and ≥ 2,000 inpatient claims for the high-volume category. CHF indicates congestive heart failure; PNEU, pneumonia; COPD, chronic obstructive pulmonary disease; DELIR, delirium. Error bars indicate 95% confidence intervals.

An inverse relationship was observed between inpatient volume, mortality and readmissions (**Figure 4.3**). Among high-volume generalists, risk-adjusted mortality and combined mortality/readmission rates were lower for all disease cohorts (**Table 4.3);** however, acute length of stay increased with rising physician volume **(Figure 4.3B; Table 4.3)**. The fully adjusted spline functions illustrate non-linear relationships for each of the outcomes with the greatest declines in mortality and readmission risk occurring as the attending's clinical volume increased from 1 to 600 inpatient clinical claims/year. A threshold effect for all outcomes appeared as physicians exceeded 2,000 inpatient claims/year.

Results from risk-adjusted multilevel models by cohort are shown in **Figure 4.4 [A-C]** and listed in **Appendix 4.3**. The pooled risk of mortality in patients managed by high vs. low-volume generalists was 0.71 (95% CI: 0.52, 0.97) and the risk of combined mortality or readmission within 30-days was 0.77 (95% CI: 0.59, 1.02). Acute length of stay increased by 32% (RR: 1.12-1.56). To assess whether the relationships could be explained by the concentration of high-volume providers in urban, academic centres, we added hospital volume, computed as the mean number of cases admitted to each hospital per year over the study period, specific to each condition. Estimates from these models can be found in in **Table 4.4.** Finally, we re-ran all cohort models restricting the analysis to family physicians to examine whether findings could be explained by differences in medical training between family physicians and general internists. While margins of error widened due to reduced sample sizes at both the patient and physician levels, the overall significance and direction of outcomes remained the same (**Table 4.4)**.

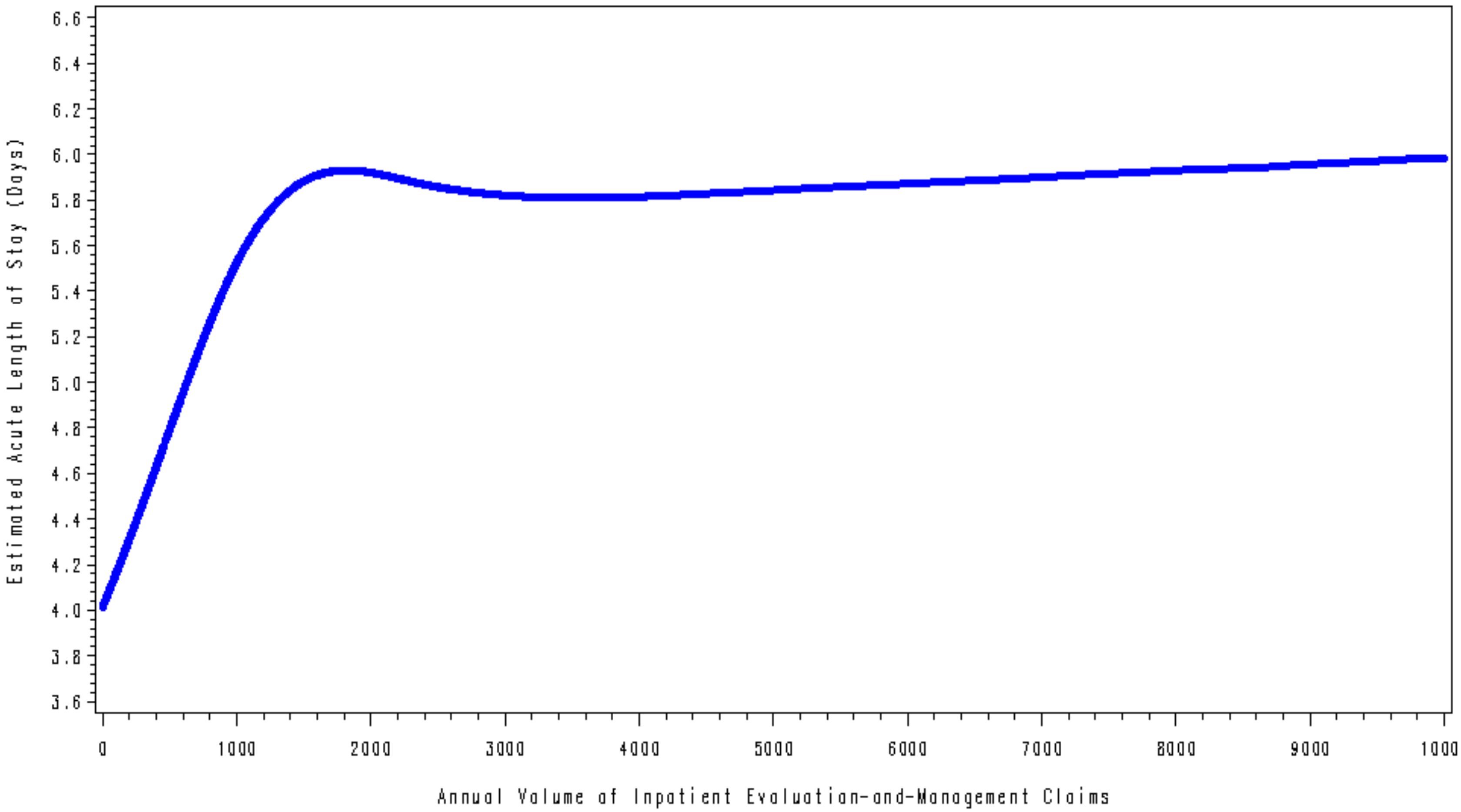
Figure 4.3. Relationship between annual inpatient claims volume by attending generalists and estimated[a] [A] probability of mortality, combined mortality or readmission and [B] acute length of stay. Ontario 2009-2011 (n = 55,484).

4.3 [A] 30-day mortality or readmission



[a] Estimates are predicted from risk-adjusted models incorporating a spline function (6 inflections: occurring at 266, 665, 1185, 1950, 2856 and 4454 inpatient claims/year) and all patient, physician and hospital covariates.

4.3 [B] Acute length of stay



[a] Estimates are predicted from risk-adjusted models incorporating a spline function (6 inflections: occurring at 266, 665, 1185, 1950, 2856 and 4454 inpatient claims/year) and all patient, physician and hospital covariates.

Table 4.3 Crude and adjusted† outcomes according to generalist inpatient claims volume (n=55,484).

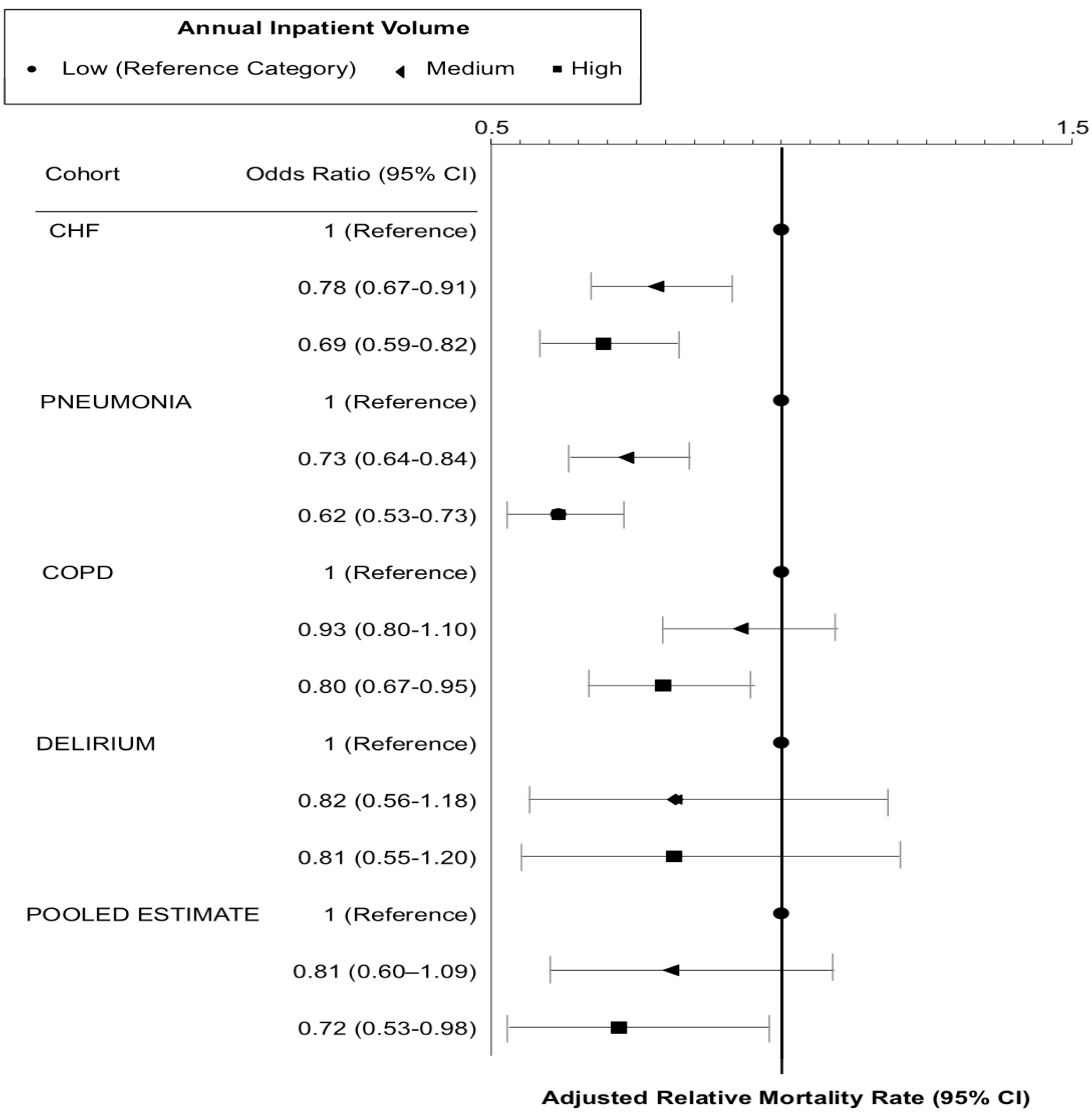
Outcomes of Care	Low-Volume (< 500 inpatient claims/year)	Medium-Volume (500-1,999 inpatient claims/year)	High-Volume (≥ 2,000 inpatient claims/year)
Congestive Heart Failure			
30-day crude mortality, %	15.5	13.0***	12.0***
30-day risk-adjusted mortality, %	16.1	13.2***	11.5***
30-day crude readmission or mortality, %	26.5	23.2***	22.3***
30-day risk-adjusted readmission or mortality, %	27.2	23.4***	21.9***
Crude acute length of stay, days	5.1	5.3 *	6.0***
Adjusted acute length of stay, days	5.0	5.6***	6.4***
Pneumonia			
30-day crude mortality, %	16.7	14.4***	13.5***
30-day risk-adjusted mortality, %	17.6	14.7***	13.0***
30-day crude readmission or mortality, %	22.9	20.1***	19.6***
30-day risk-adjusted readmission or mortality, %	23.8	20.3***	19.1***
Crude acute length of stay, days	4.4	4.6 *	5.1***
Adjusted acute length of stay, days	4.4	4.9***	5.4***
Chronic Obstructive Pulmonary Disease			
30-day crude mortality, %	9.3	9.3	8.7
30-day risk-adjusted mortality, %	9.8	9.4	8.4**
30-day crude readmission or mortality, %	16.6	17.4	17.3
30-day risk-adjusted readmission or mortality, %	17.1	17.6	17.0
Crude acute length of stay, days	4.7	4.8	5.2***
Adjusted acute length of stay, days	4.6	5.0**	5.4***
Delirium			
30-day crude mortality, %	8.7	7.1	6.6
30-day risk-adjusted mortality, %	8.8	7.1	6.6
30-day crude readmission or mortality, %	18.0	14.6	12.6***
30-day risk-adjusted readmission or mortality, %	17.8	14.5 *	12.8***
Crude acute length of stay, days	5.5	5.6	5.9***
Adjusted acute length of stay, days	5.5	5.8 *	6.2***

* $p<0.05$ ** $p<0.01$ *** $p<0.001$ compared with low-volume physicians.

† Rates are adjusted for patient demographics, predicted patient severity at admission and disease-specific comorbidities

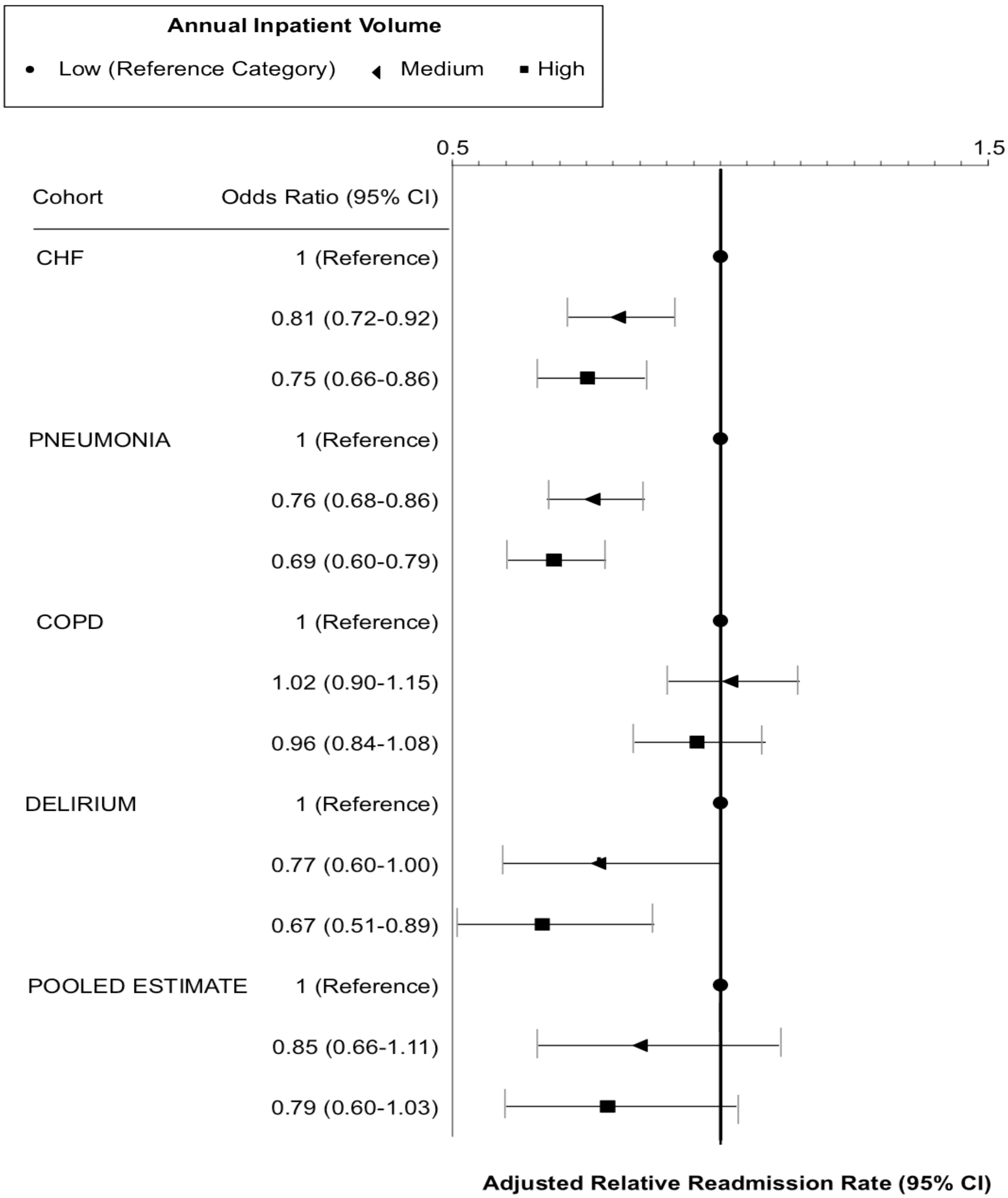
Figure 4.4 Multilevel regression models: adjusted[a] odds of [A] 30-day mortality, [B] 30-day mortality/readmission, and [C] percent change in acute length of stay for medium and high vs. low volume generalists. Ontario 2009-2011 (n = 55,484).

4.4 [A] 30-day mortality



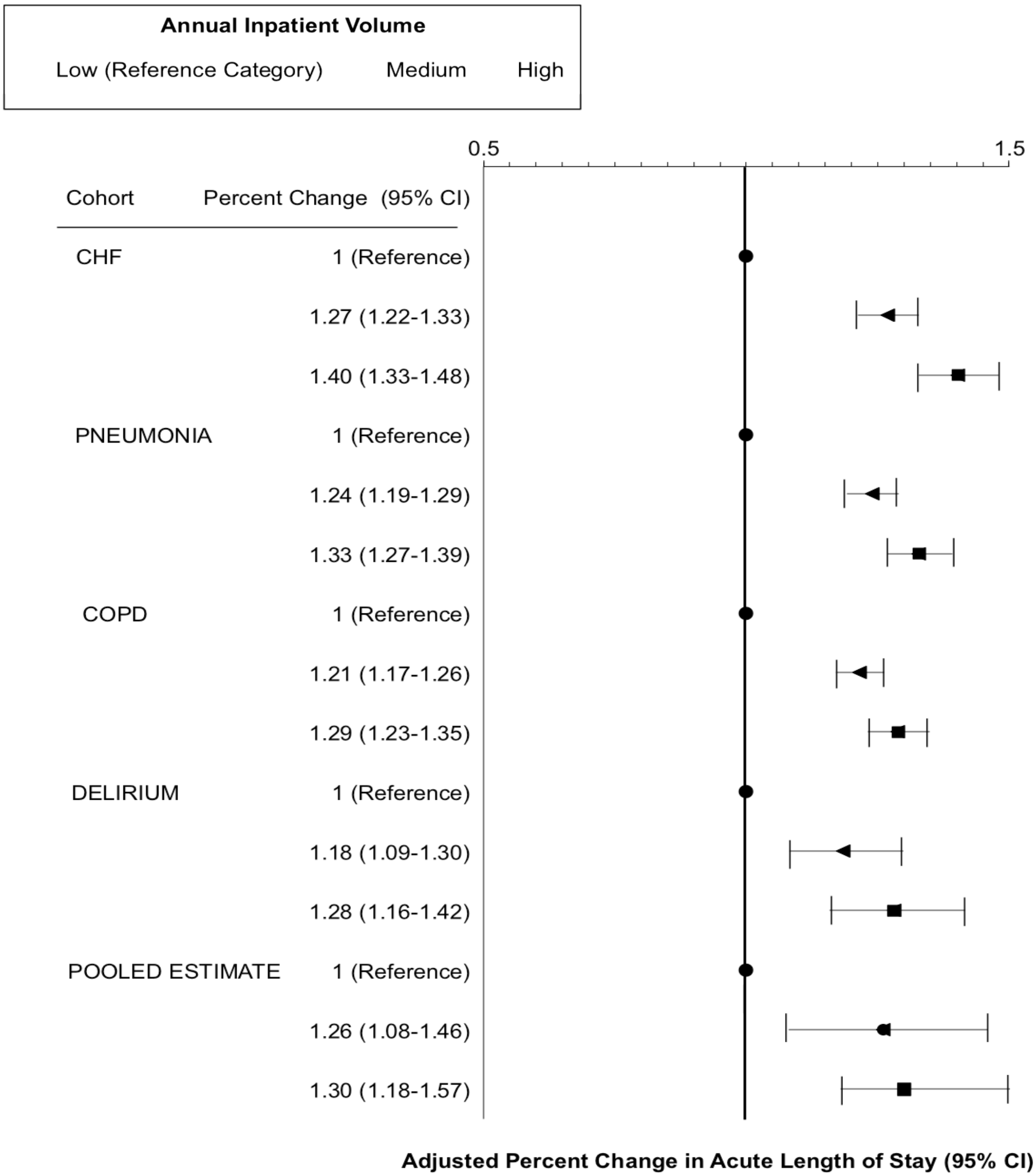
[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities (See **Table 4.1** for list of comorbidities), year of admission; physician characteristics, hospital location, academic affiliation and physician/hospital clustering.

4.4 [B] Combined 30-day mortality or readmission



[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities (See **Table 4.1** for list of comorbidities), year of admission, physician characteristics, hospital location, academic affiliation and physician/hospital clustering.

4.4 [C] Acute length of stay



[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities (See **Table 4.1** for list of comorbidities), year of admission, physician characteristics, hospital location, academic affiliation and physician/hospital clustering.

Table 4.4. Sensitivity analysis: regression estimates[a] for 30-day mortality, combined mortality/readmissions and acute length of stay adjusting for hospital volume; and among attending physicians trained in general/family medicine. Ontario, 2009-2011.

	Odds of Mortality		**Odds of Mortality or Readmission**		**Percent change, Acute Length of Stay**	
Cohort; Sensitivity Analyses	*Medium vs. low volume*	*High vs., low volume*	*Medium vs. low volume*	*High vs., low volume*	*Medium vs. low volume*	*High vs., low volume*
Congestive Heart Failure						
Full risk-adjusted model	0.78 (0.67, 0.91)	0.69 (0.59, 0.82)	0.81 (0.72, 0.92)	0.75 (0.66, 0.86)	1.27 (1.22, 1.33)	1.40 (1.33, 1.48)
Adding hospital volume	0.79 (0.67, 0.92)	0.70 (0.59, 0.84)	0.82 (0.72, 0.92)	0.77 (0.67, 0.88)	1.27 (1.21, 1.33)	1.40 (1.33, 1.48)
GP/FP attendings only	0.86 (0.72, 1.01)	0.67 (0.55, 0.82)	0.85 (0.74, 0.97)	0.77 (0.66, 0.90)	1.25 (0.19, 1.32)	1.40 (1.31, 1.50)
Pneumonia						
Full risk-adjusted model	0.73 (0.64, 0.84)	0.62 (0.53, 0.73)	0.76 (0.68, 0.86)	0.69 (0.60, 0.79)	1.24 (1.19, 1.29)	1.33 (1.27, 1.39)
Adding hospital volume	0.72 (0.63, 0.83)	0.59 (0.50, 0.70)	0.75 (0.67, 0.85)	0.67 (0.58, 0.76)	1.24 (1.19, 1.29)	1.33 (1.27, 1.39)
GP/FP attendings only	0.80 (0.68, 0.93)	0.76 (0.63, 0.91)	0.77 (0.66, 0.91)	0.82 (0.72, 0.94)	1.22 (1.17, 1.27)	1.33 (1.25, 1.40)
COPD						
Full risk-adjusted model	0.93 (0.80, 1.10)	0.79 (0.67, 0.95)	1.02 (0.90, 1.15)	0.96 (0.84, 1.08)	1.21 (1.17, 1.26)	1.29 (1.23, 1.35)
Adding hospital volume	0.91 (0.77, 1.07)	0.75 (0.62, 0.90)	1.00 (0.89, 1.13)	0.91 (0.80, 1.04)	1.21 (1.17, 1.26)	1.29 (1.23, 1.35)
GP/FP attendings only	0.97 (0.81, 1.15)	0.92 (0.75, 1.13)	1.04 (0.81, 1.19)	1.02 (0.89, 1.19)	1.20 (1.15, 1.25)	1.28 (1.21, 1.35)
Delirium						
Full risk-adjusted model	0.82 (0.56, 1.18)	0.81 (0.55, 1.20)	0.77 (0.60, 1.00)	0.67 (0.51, 0.89)	1.18 (1.09, 1.30)	1.28 (1.16, 1.42)
Adding hospital volume	0.82 (0.57, 1.19)	0.84 (0.56, 1.24)	0.80 (0.62, 1.02)	0.72 (0.55, 0.95)	1.18 (1.08, 1.30)	1.28 (1.15, 1.41)
GP/FP attendings only	0.92 (0.60, 1.41)	0.93 (0.59, 1.50)	0.79 (0.51, 1.07)	0.65 (0.38, 0.93)	1.15 (1.04, 1.27)	1.24 (1.10, 1.39)

[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities, year of admission, physician characteristics, hospital location, academic affiliation and physician/hospital clustering

* Low volume: < 500 inpatient claims/year ** Medium volume: 500-1,999 inpatient claims/year *** High volume: ≥ 2,000 inpatient claims/year

4.5 Discussion

This study demonstrated a strong inverse relationship between generalist inpatient volume and mortality/readmissions for patients hospitalized with four common medical conditions. Generalists with the highest annual volumes for inpatient clinical visits, consultations and assessments had the lowest 30-day mortality and readmission rates despite adjusting for a host of patient, physician and hospital characteristics. Nevertheless, patients managed by high-volume generalists had significantly longer lengths of stay of 28-40%, a difference that persisted across all cohorts despite controlling for severity of illness. In contrast, patients cared for by low-volume generalists had the shortest lengths of stay and the highest rates of mortality and readmission. Associations persisted when hospital volume was controlled for, and when analyses were restricted to family physicians, suggesting that workload-outcome associations are not driven by hospital location or clinical differences in training. Considered together, the study suggests that practice does improve performance for important quality outcomes at a trade-off to efficiency.

To our knowledge this was the first study to assess the relationship between physician volume and clinical outcomes for general, acute hospital medicine. It is also the first population-based assessment of Canadian hospitalist performance. Hospital medicine in Canada emerged in parallel with the United States after cutbacks to physician reimbursement in the mid 1990s sparked the exodus of primary care practitioners from hospital care provision [14,58,215,220]. Hospital generalists now deliver approximately 40% of all inpatient clinical evaluation and case management services for hospitalized residents in Ontario [242], However, unlike in the United States, many community-based GP/FPs still choose to provide some degree of hospital care to rostered patients [39], demonstrated by the variation of inpatient volumes observed in this study. Despite the high volume of inpatient services delivered by hospital generalists, no research has explored the quality or efficiency of inpatient care amongst Canadian hospitalists or how outcomes of hospital-based providers compare to those who concentrate primarily in community care.

Our findings suggested that outcomes in these cohorts were worst when managed by low-volume practitioners - physicians with <600 annual inpatient clinical claims/year. These low-volume generalists managed the care of just under 20% of sampled patients, yet accounted for over half of the physician population captured in the study. Mortality and readmissions improved with small increases in volume and appeared to plateau as physicians approached 2,000 inpatient services/year; equivalent to approximately 8 clinical interactions per workday[2]. These quality improvements are consistent in magnitude with those described by Yousefi and Chong [(100)], who reported lower morality and fewer readmissions among patients managed by GP/FP and general internal medicine hospitalists compared to traditional family practitioners working at one community hospital in Ontario. They also reconcile with the findings of Ross *et al.,* [(232)] and to the larger body of evidence on volume and outcomes, suggesting an inverse relationship between volume, short-term mortality and short-term readmissions at both the provider and hospital levels, with a threshold effect above which increased volume is no longer associated with quality improvements. While our findings on mortality and readmissions diverge from the American hospitalist literature that suggests similar quality outcomes under hospitalist care, the hospitalist literature compares a distinct model of hospital practitioners; it does not aim to capture or assess the system-wide provision of general acute care. The spline functions illustrate this difference, suggesting that practice and policy for Ontario will have the greatest impact where directed towards supporting lower-volume generalists to increase their hospital volumes and produce better outcomes. Similarly, the findings do not imply that a concentrated hospitalist model is the best or the only alternative for optimizing quality care for inpatients.

Our results for length of stay were consistent in both unadjusted and adjusted analyses, across disease cohorts, and across step-wise models, with little change in estimates occurring as patient severity, physician specialty and hospital characteristics including volume were

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[2] 250 workdays are assumed in a standard year: 5 workdays/week x 50 weeks/year. High-volume physicians in this study billed an average of 233 unique calendar days per year for inpatient clinical management.

added in succession. These findings are analogous to previous work where we found similar outcome improvements in mortality and readmissions and corresponding longer lengths of stay among higher-spending, high-volume urban hospitals [243]. These institutions tended to keep patients longer and had more nursing hours and specialist visits per patient - factors suggested to relate to better care [243]. They also mirror the findings of Yousefi and Chong, who reported lower mortality and readmission rates, but similar lengths of stay among Canadian GP/FP hospitalists compared to office-based practitioners [100]. While these findings juxtapose the literature on American hospitalists, efficiency metrics between the two countries may not be directly comparable. In 2011, U.S. hospitals operated more acute beds per population (2.7 vs. 1.8 per 1,000), had shorter average lengths of stays (5.4 vs. 7.7 days), and reported greater expenditures per hospital day ($3,030 vs. $1,751) in comparison to Canada [252-254]. Several explanations exist for these cost differentials: hospital operating and service costs are less expensive in Canada, diagnostic and pharmaceutical spending is lower, and a higher proportion of nursing hours are staffed by Registered Practical Nurses (RPNs) [255-257].

Despite this, further work is needed to understand the mechanisms underlying length-of-stay associations. Considered alongside the results for mortality and readmissions, acute lengths of stay may be appropriately longer, reflecting better patient care if high volume physicians are keeping patients longer to improve clinical stability, reduce the likelihood of readmission and/or optimize safe, coordinated transitions to post-acute care. Estimates could also be confounded by the decrease in short-term mortality observed among higher-volume generalists or by an increase in post-admission complication events, which could prolong hospital stays without necessarily resulting in higher mortality. It is also possible that longer stays represent caseload excess, where too few hospital physicians managing too many patients delays the time providers allocate for discharge and/or family care planning [76,199]. Finally, results may reflect polarity between public and private payer systems where Canadian physicians face different operational demands and rewards for monitoring and improving efficiency.

Our findings have three clear implications for policy. First, they suggest administrators may wish to explore physician-staffing policies and review whether hospital privileges could and should be restricted to physicians willing to maintain a minimum annual volume of acute service provision, ideally above the volume-mortality threshold. While this may seem infeasible for rural and/or remote hospitals where fewer physicians are available and willing to provide 24/7/365 hospital care, it may be possible to restrict access among very low-volume generalists in some settings. Second, these results may help inform policy and economic discussions regarding the presence of hospital generalists and the practice of hospital medicine in Ontario and elsewhere. Third, where high-volume practice is not feasible, alternative methods for supporting low-volume generalists in hospital care provision to produce better outcomes and implement standardized processes of care should be explored.

This study had several strengths. By constructing multiple homogenous cohorts we were able to minimize the impact of confounding by severity while assessing volume-outcome relationships within the contexts of each specific condition. The findings were consistent across disease cohorts, in pooled analyses, and to similar studies exploring relationships between hospital volumes and outcomes in the same diagnostic groups [232,243]. Pooling results from the risk-adjusted cohort models allowed us to estimate the average effect of generalist volume as accurately and precisely as possible, improving the generalizability of results. However in pooling the disease cohorts, variability around the point estimates increased, suggesting that by failing to evaluate physician performance within a disease-specific framework, clinically important effects can be diluted; particularly when diagnoses are included where adverse outcomes like mortality, occur infrequently.

Several limitations should be noted. Since our analysis relied solely on administrative data, some important risk factors and confounders are absent from the models. These include patient sociodemographics (ethnicity, individual income and lifestyle characteristics), clinical findings relating to the patient's disease state and process measures of care. While the findings might suggest inferences about causation, we do not know which components of the physician's care or style of practice led to better outcomes. It is however unlikely that the findings are the result of unmeasured differences in case-mix given that patients of high volume attendings had worse illness severity at admission. This investigation was also confounded by rurality. Many GP/FPs in Canada who continue to provide hospital care practice within rural settings. The practice of rural hospital medicine differs from urban centers in terms of the likelihood to admit such that severity tends to be lower in rural institutions. We attempted to control for these differences by removing small hospitals; adjusting for institution size, volume, geography and clustering; and predicted severity at the time of admission. While patient demographics confirmed that patients of high-volume generalists were primarily managed in urban institutions (42.0%), less than one-third were treated at academic centres (28.6%), over 40% were hospitalized in mixed urban-rural community hospitals, and adding hospital volume did not affect the observed relationships.

In summary, we found a significant inverse relationship between the annual volume of inpatient services delivered by generalist attendings and mortality/readmissions within Ontario hospitals. Increasing volume was associated with clinically significant reductions in 30-day mortality and readmissions at an increase in the acute length of stay. By examining the quality of hospital care as a function of a physicians' inpatient volume, we can capture the systems-level diversity of general practice and extend this literature to other countries that have instituted parallel focused inpatient practices without necessarily establishing formalized hospitalist programs.

4.6 Supplementary Analyses

Several additional analyses were explored as potential contributions to the analytic work presented in Chapter 4. These were trimmed from the above manuscript due to space constraints in the journals of interest; however, their methods are described below to provide evidence of analytic scope and depth.

Two additional disease cohorts were constructed comprised of eligible Ontario residents aged 18 and older hospitalized with a first/index admission for chest pain/angina (n = 35,548) and enteritis/colitis (n = 19,154; see **Appendix 4.4** for ICD-10 codes). These conditions were selected as they represented two of the leading diagnostic conditions for which family physicians still manage in hospital; however, both were dropped in the early stages of analysis after consensus was reached amongst core members to focus on a maximum of four conditions to manage the presentation of data and findings for publication. Patients in both cohorts were at low risk for experiencing the outcome events of interest and had relatively short acute stays. Their outcomes and associations with volume were never assessed. Once a decision was reached to drop these conditions, the four remaining cohorts were re-constructed to capture any patients eligible for inclusion in one of the remaining cohorts from a subsequent hospitalization. In particular, 174 individuals initially captured in the chest pain cohort were subsequently added to the heart failure cohort after experiencing an incident admission for heart failure within the two-year study time frame.

Two additional outcome measures were constructed, analyzed and deferred. In-hospital complications were examined to assess the degree to which providers were able to identify and respond to potentially avoidable adverse events during patients' hospitalization. These events are generally considered to arise by health care mismanagement as opposed to the patient's underlying disease state, and frequently lead to death, disability or prolonged hospital stays. Complications were defined as the development of one or more of the following comorbid conditions arising after admission: pressure ulcers; urinary tract infections; post-admission fractures; hospital-acquired pneumonia; shock or cardiac arrest; upper gastrointestinal bleeding; hospital-acquired sepsis; and deep venous thrombosis. Associated ICD-10 codes for these diagnoses can be found in **Appendix 4.4.** Outpatient follow-up visits within 30-days of discharge were also assessed to explore whether the likelihood of follow-up declined with increasing provider volumes. While follow-up is fundamentally under the control of the individual, it is the role of the attending to ensure follow-up is arranged and community supports put in place when patients transition from acute to post-acute care. Discharge abstracts were linked to the OHIP claims database using encrypted patient identifiers to determine whether one or more office visits to an outpatient practitioner occurred within 30-days of discharge from hospital (no vs. yes). Follow-up was assessed among patients who survived at least 30 days post-discharge to ensure the sample was at risk for the outcome.

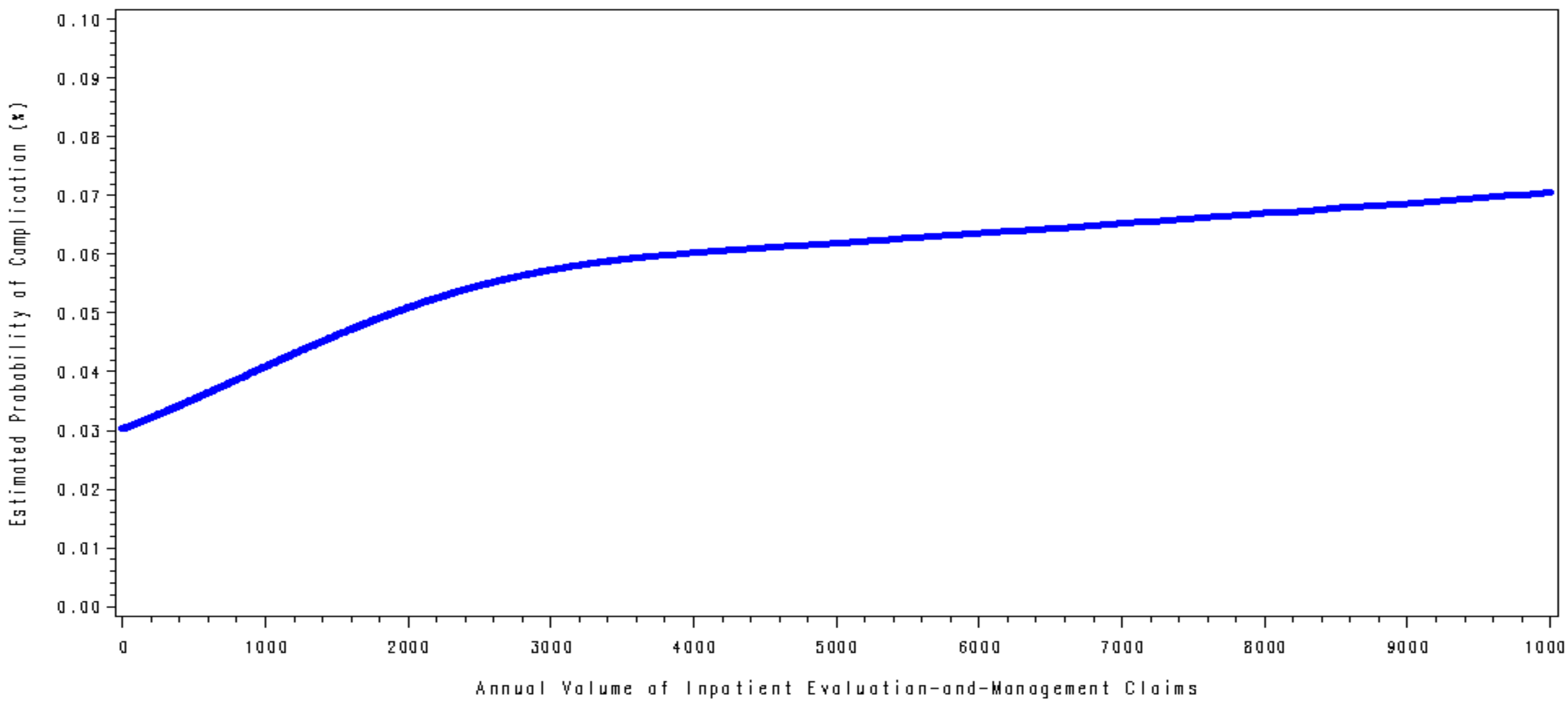
Disease-specific logistic regression models with 2-levels of clustering were fit for both outcomes according to the methods described on **pg. 119**, controlling for patient age, sex and their interactions, patient severity, disease-specific comorbidities, neighbourhood income level, year of admission, physician demographics, hospital geography and academic affiliation. Results were then pooled and graphed incorporating the spline function**.**

The relationship between clinical volume, post-admission complications and outpatient follow-up are displayed in **Figure 4.5** while model estimates can be found in **Figure 4.6**. The probability of experiencing a complication during hospitalization increased with rising volume; however, the incidence of complications was low with 3.5% of low-volume (n = 277), 4.3% of mid-volume (n = 1,050) and 6.1% of high-volume (n = 1,378) patients experiencing one or more outcome events. The majority of complications were minor in nature, consisting primarily of urinary tract infections and hospital-acquired pneumonia. The pooled risk of complication in patients managed by high vs. low-volume generalists was 1.57 (95% CI: 1.07, 2.32). In-hospital complications may have contributed to the longer lengths of stay observed among high-volume generalists. While follow-up rates improved with rising inpatient workload, no significant differences were observed between volume groups (Pooled OR: high vs. low 1.11, 95% CI: 0.85, 1.45; mid vs. low 1.00, 95% CI: 0.77, 1.28).

Lastly, after assessing volume as a continuous predictor of outcomes, I sought to test whether the findings remained consistent when physicians were re-analyzed by care model as 'hospitalists' using the functional algorithm proposed in **Table 3.1** [(242)]. Summing the attendings' total annual OHIP claims, physicians were assigned to one of the following functional practice categories: hospitalist (≥ 80% of total OHIP billings were derived from inpatient evaluation-and-management claims with a minimum volume of 500 inpatient clinical services/year) vs. non-hospitalist. Multilevel risk-adjusted models were re-run on all cohorts, replacing volume with the functional hospitalist category as the primary predictor. Results from these models can be found in **Table 4.5.** Hospitalists showed similar findings to those presented by volume; however the magnitude of point estimates were significantly reduced as a result of almost half the high-volume physicians being categorized into the non-hospitalist comparative group (*n* = 158; 47.2%). In Chapter 3, we saw that these high-volume generalists often had inpatient volumes that paralleled or even exceeded that of hospitalist practitioners, but because they practiced in additional outpatient settings, they did not meet the functional threshold needed to classify as a 'hospitalist'. Demonstrated in **Table 4.5**, this muted the underlying relationship between volume and outcomes and reduced statistical power. This finding reiterates that policies intending to improve physician performance should focus on supporting physicians to increase inpatient volumes; this is not necessarily achieved by unilateral utilization and adoption of hospitalists.

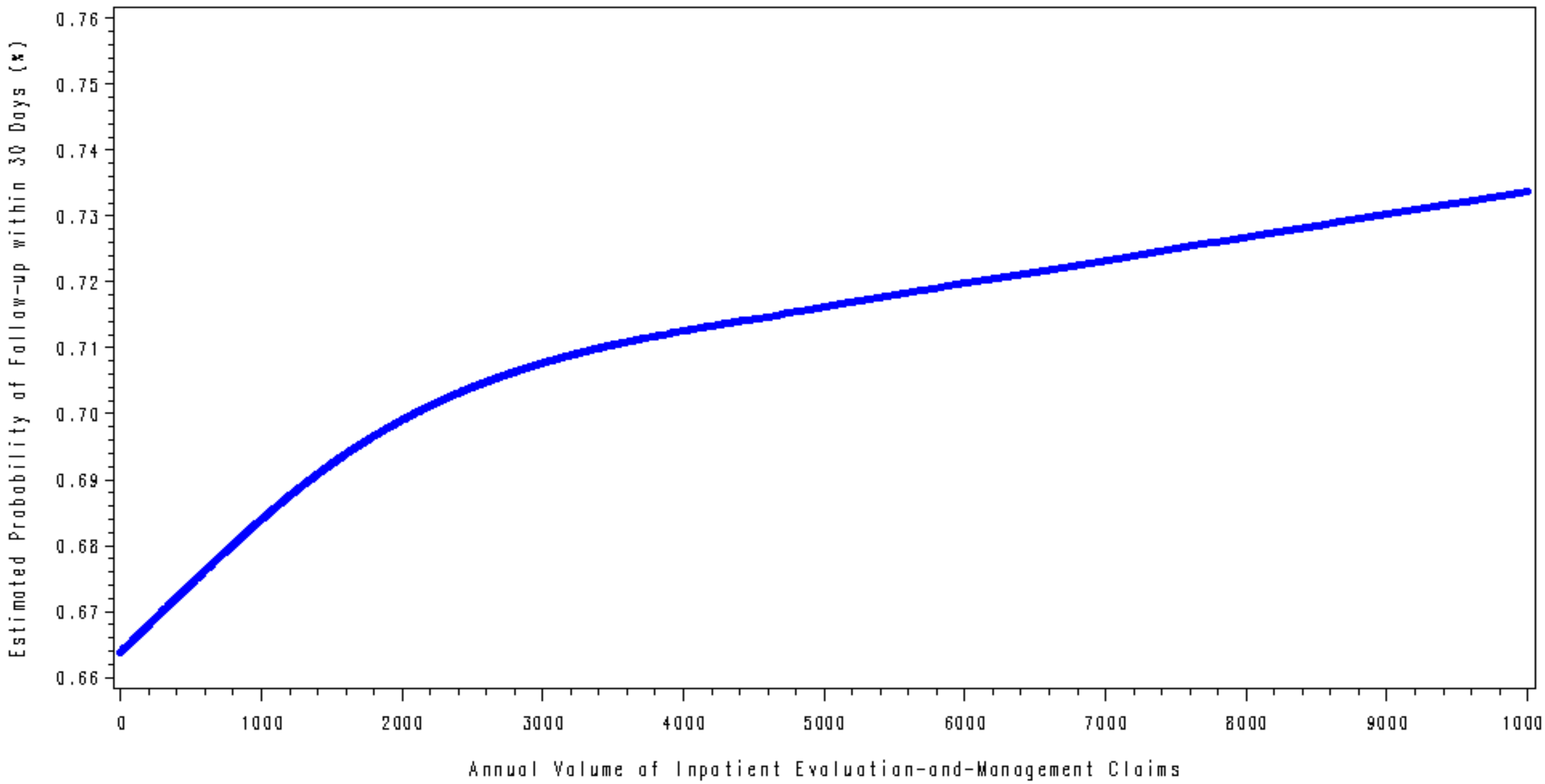
Figure 4.5. Relationship between annual inpatient claims volume by attending generalists and estimated[a] probability of [A] post-admission complication and [B] follow-up within 30-days of discharge. Ontario 2009-2011 (n = 55,484).

4.5 [A] Post-admission Complication



[a] Estimates are predicted from risk-adjusted models incorporating a spline function (6 inflections: occurring at 266, 665, 1185, 1950, 2856 and 4454 inpatient claims/year) and all patient, physician and hospital covariates.

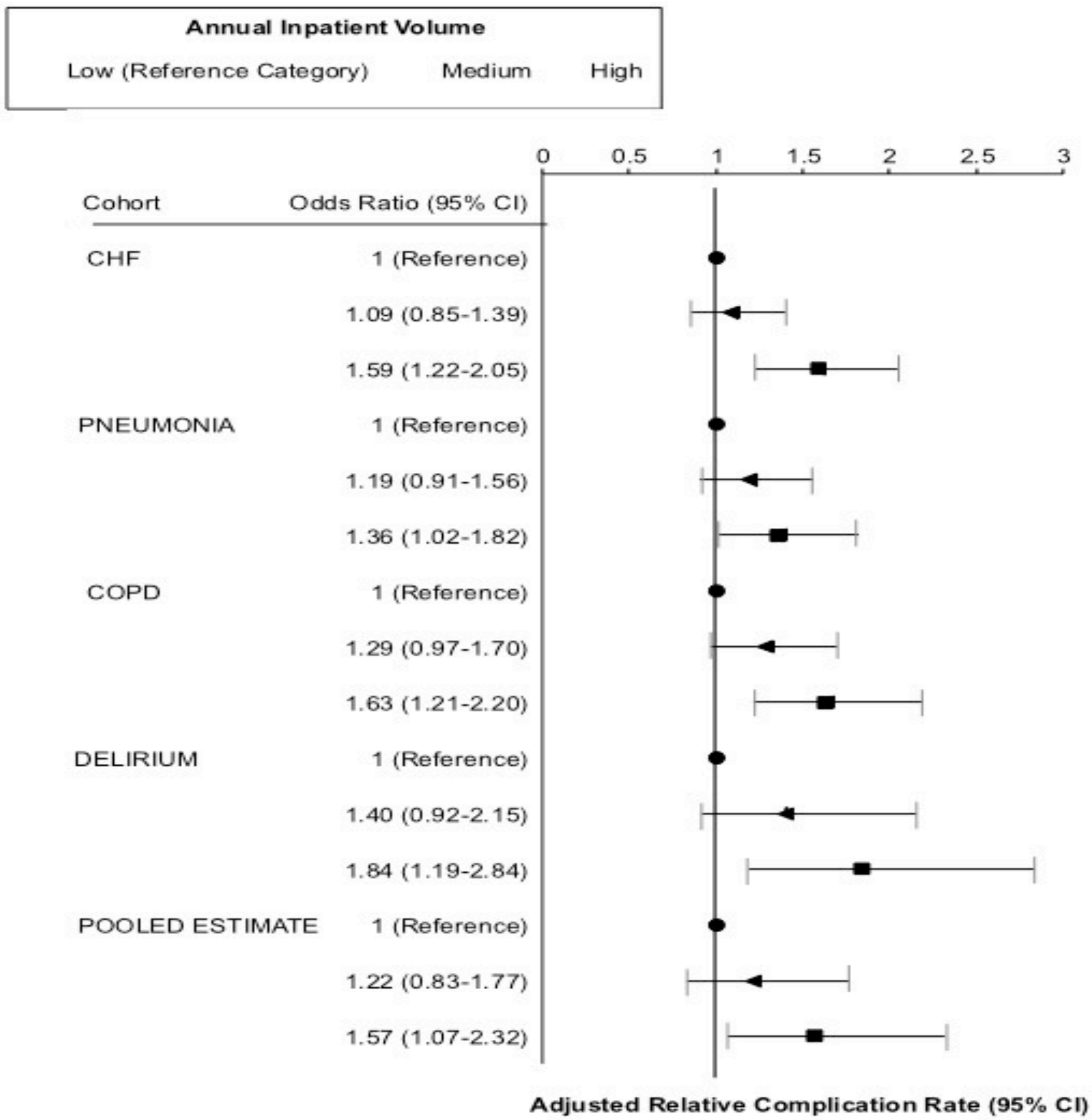
4.5 [B] Outpatient Follow-Up Within 30-days



[a] Estimates are predicted from risk-adjusted models incorporating a spline function (6 inflections: occurring at 266, 665, 1185, 1950, 2856 and 4454 inpatient claims/year) and all patient, physician and hospital covariates.

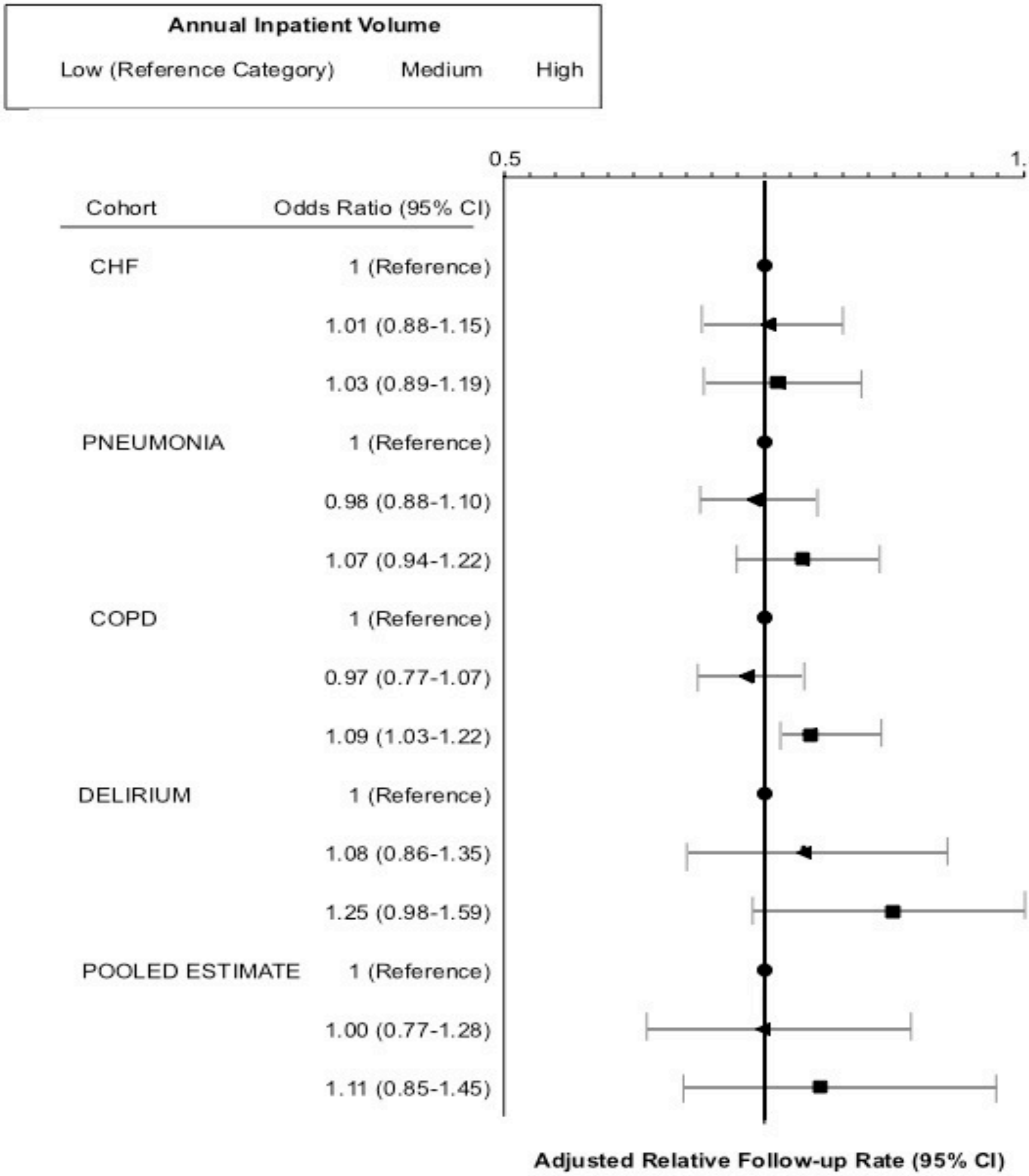
Figure 4.6 Multilevel regression models for additional outcomes: adjusted[a] odds of [A] post-admission complication and [B] follow-up within 30-days of discharge and for medium and high vs. low volume generalists. Ontario 2009-2011 (n = 55,484).

4.6 [A] Post-admission Complication



[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities (See **Table 4.1**. for list of comorbidities), year of admission, physician characteristics, hospital geography, academic affiliation and physician/hospital clustering

4.6 [B] Outpatient Follow-up within 30-days



[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities (See **Table 4.1** for list of comorbidities), year of admission, physician characteristics, hospital geography, academic affiliation and physician/hospital clustering.

Table 4.5 Sensitivity analysis: multilevel regression estimates[a] for 30-day mortality, readmissions and acute length of stay among hospitalist vs. non-hospitalist physicians. Ontario, 2009-2011 (*n* = 55,484).

Cohort; **Primary Predictor**	**Odds of Mortality**	**Odds of Mortality or Readmission**	**Percent change in Acute Length of Stay**
		Estimate (95% CI)	
Congestive Heart Failure			
High vs. Low Volume	0.69 (0.59, 0.82)	0.75 (0.66, 0.86)	1.40 (1.33, 1.48)
Hospitalist* vs. Nonhospitalist	0.79 (0.68, 0.90)	0.86 (0.77, 0.95)	1.13 (1.07, 1.18)
Pneumonia			
High vs. Low Volume	0.62 (0.53, 0.73)	0.69 (0.60, 0.79)	1.33 (1.27, 1.39)
Hospitalist* vs. Nonhospitalist	0.85 (0.75, 0.97)	0.86 (0.77, 0.96)	1.13 (1.08, 1.18)
COPD			
High vs. Low Volume	0.79 (0.67, 0.95)	0.96 (0.84, 1.08)	1.29 (1.23, 1.35)
Hospitalist* vs. Nonhospitalist	0.89 (0.73, 1.03)	0.99 (0.90, 1.09)	1.06 (1.02, 1.10)
Delirium			
High vs. Low Volume	0.81 (0.55, 1.20)	0.67 (0.51, 0.89)	1.28 (1.16, 1.42)
Hospitalist* vs. Nonhospitalist	0.91 (0.67, 1.15)	0.89 (0.69, 1.10)	1.04 (0.98, 1.12)

[a] Models are adjusted for patient demographics, predicted severity at admission, disease-specific comorbidities, year of admission, physician characteristics, hospital geography, academic affiliation and physician/hospital clustering.

* Hospitalists are defined using a functional algorithm generated in Chapter 3 as: generalists with ≥ 80% of total OHIP billings attributable to inpatient evaluation-and-management claims with a minimum hospital workload of ≥ 500 inpatient clinical claims billed/year.

5 Discussion

5.1 Review of overall findings

The data presented throughout this dissertation demonstrated clear trends that hospital physicians are increasingly prevalent in Ontario hospitals and deliver a sizable proportion of the province's inpatient medical care. Increased inpatient volumes among general/family practitioners and general internists were associated with lower mortality, fewer readmissions and longer lengths of stay for patients under their care. Given these findings, hospital generalists, including hospitalists, represent an important human resource sector in Canadian healthcare.

In Chapter 2, we synthesized the findings from 82 comparative evaluations to determine whether hospitalist physicians provide a higher quality of inpatient care relative to traditional delivery models where physicians maintain hospital privileges with concurrent outpatient practices. This literature demonstrated that hospitalists practicing in the United States improve the efficiency of inpatient care by reducing average lengths of stay and total hospital costs without adversely affecting patient outcomes. However, almost half of the evaluations had methodological concerns regarding the reliability and/or validity of data, including underpowered sample sizes, inappropriate use of statistical tests, and failing to adjust for established confounders. The findings from the systematic review were used to summarize the current state of evidence and interpret the analytic findings, as well as guide the identification of confounding variables used for risk-adjustment in Chapters 3 and 4.

Chapter 3 transitions the evidence on hospitalist quality into the Canadian context by exploring the growth of hospital medicine in Ontario and how the medical specialty of inpatient physicians have changed over time as hospitalists have taken on an increasing burden of general inpatient care. The results from this paper demonstrated that fewer Ontario physicians have elected to provide inpatient clinical services over the past 13 years and those who retained hospital privileges have generally decreased their inpatient workloads. As a result of declining volumes, a small number of hospital generalists emerged in Ontario hospitals, subsuming the gaps in care provision and taking on a larger burden of inpatient clinical service delivery each year since. This finding has important implications for hospital staffing and physician funding policies, suggesting that future work needs to explore how we can support both hospital and community-based practitioners within the acute care system. The volume algorithms used in Chapter 3 formed the methodological approach of the third and final paper suggesting how to define physician volume from administrative claims data. Scatterplots demonstrated that traditional algorithms used in the literature to define hospitalist by the proportion of their total service claims billed for hospital care could inaccurately label low-volume physicians as hospitalists, while simultaneously ignoring the impact of high-volume physicians working in mixed practice settings. The scatterplots also revealed that volume left as a continuous measure, could reflect and capture the diversity of general practice models operating within the province. By moving towards a continuous measure of physician experience with hospital care, we could capture the systems-level relationship between general inpatient volume and outcomes.

Chapter 4 ties the systematic review and descriptive papers together by assessing the relationship between annual inpatient volume and clinical outcomes of care in hospitalized patients managed by general/family physicians and general internists in Ontario. Adjusted for baseline differences in patient risk, physician demographics, hospital characteristics and physician/hospital clustering, increasing inpatient volume was associated with clinically meaningful reductions in mortality and readmission rates within 30-days of an index admission, and a longer acute length of stay. Outcomes in all cohorts were worst when managed by very low-volume generalists, and we demonstrated how the magnitude of this finding declined when hospitalists were re-analyzed by the proportional practice algorithm (**Table 4.5**), placing 158 high-volume generalists into the comparison group. The findings from this paper may help to inform policy and economic discussions regarding the presence of hospital generalists, the practice of hospital medicine, staffing supports for achieving desirable volumes of hospital care, and the role of community-based GP/FPs in hospital care provision in Ontario.

Considered together, these three papers represent the most comprehensive investigation of the prevalence of Canadian hospitalists and the performance of general practitioners in hospital care to date. Linking multiple administrative databases through the use of unique encrypted identifiers, we were able to: (1) identify the longitudinal population of active physicians practicing in Ontario and track their inpatient workloads to examine how patterns of hospital care provision have changed over time; (2) define a distinct cohort of hospital generalists and describe their current prevalence and practice characteristics; (3) link the physician cohort to a defined longitudinal cohort of hospitalized patients under their care to assess how outcomes varied as a function of physicians' annual inpatient clinical volumes; and (4) demonstrate how the magnitude of these outcomes changed when physicians were re-classified using a functional algorithm proposed to define and identify hospital practitioners by the proportion of practice spent on hospital provision as opposed to volume.

5.2 Contributions to the Literature: an Evolution of Findings

Since the first volume-outcome relationships in medical care were reported by Luft in 1979 [(258)], there has been persistent and sometimes heated debates about whether care should be concentrated to high-volume medical centers and/or high-volume practitioners. While the hospitalist literature has not traditionally been framed along the volume-outcome continuum, hospital medicine is, by design, a high-volume inpatient specialty. As such, efforts to assess provider volume as a contributor to quality in general acute medicine are gaining momentum.

In previous studies of hospitalist performance, researchers attempted to encapsulate three key structural characteristics of a hospital-based general practice into a single categorical exposure: (1) clinical expertise and experience managing common inpatient conditions; (2) enhanced on site availability; and (3) the volume of inpatient clinical services delivered. Seen through the systematic review, this method of defining and evaluating hospitalists by care model persisted in the literature for over a decade, comparing *'hospitalists'* to *'non-hospitalists'* on key indicators of effectiveness and efficiency. Studies produced consistent evidence that hospitalists could improve the efficiency of impatient care, albeit in American hospitals, by reducing the average length of stay and total hospital costs for patients; however, the early literature was plagued by methodological concerns. Findings were scrutinized as a result of inconsistent and vague definitions of hospitalist interventions, poor study designs, underpowered samples, missing descriptive data and inadequate risk-adjustment [33-35,219]. Intriguingly, researchers at the time could not explain why hospitalist care did not translate into improved clinical outcomes for patients. If our modeling of Donabedian's quality framework is correct, these three structural improvements to a concentrated model of high-volume care should promote good processes, and in turn drive better outcomes.

In 2009, Kuo and colleagues advanced the field of hospitalist research by proposing the use of administrative claims data for identifying hospital-based physicians in the absence of employment information [70]. Kuo's functional approach led to the first attempts at systems-levels research on hospitalist care. Utilizing Medicare claims, researchers now had access to large, nationally representative samples, and began investigating more diverse aspects of hospitalist care, including hospital-level variation in outcomes [71,75], longitudinal trends in performance [75], and post-acute utilization [73,74]. By removing the barrier of provider consent, biases relating to selection, reporting and funding declined, and a standardized method of defining the exposure emerged. Updating the systematic review post publication, these recent studies began to suggest a diverging pattern of findings. While hospitalists still showed efficiency gains, the magnitude of effects were declining. In addition, evidence suggested that costs under hospitalist care simply shifted from hospital to outpatient settings [73,74]. More specifically, while acute lengths of stay and inpatient costs declined, more patients were being discharged to inpatient rehabilitation, complex continuing care, and long-term care. Patients who were discharged home had fewer follow-up visits with their primary care physicians; more return trips to the emergency department; and higher readmissions back to hospital.

As discussed in Chapter 3, Kuo's method of identifying hospitalists has certain limitations. Kuo uses a 5% sample of Medicare data and defines hospitalists categorically as *"physicians in general internal medicine who had at least five evaluation-and-management billings in a given year and generated at least 90% of their total billings in the year from services to hospital inpatients"* [70]. Using this approach, a low-volume physician billing an annual volume of five total services could be classified as a hospitalist if all of their claims represented inpatient care. This physician would be classified and analysed alongside a colleague billing 1,800 inpatient claims out of 2,000 total services: both physicians generated $\geq$ 90% of their billings from hospital services, but one was substantially more active than another. Equally problematic, a third physician who achieves the same inpatient volume, billing 1,800 inpatient claims but 2,5000 total services, would get classified into the comparison, having generated only 72% of their billings from inpatient care. Two key issues are highlighted through this example: (1) Kuo's definition allows for low-volume, minimally active practitioners to be classified and analyzed as hospitalists so long as their claims exceed the proportional threshold; and (2) the proportional thresholds cannot accommodate or account for part-time and mixed-practice hospitalists, and the diversity of primary care models that are prevalent in Ontario's urban and rural communities, demonstrated in Chapters 3.While Kuo's method of utilizing claims data added objectivity to the literature, it still considers the exposure in binary terms: practitioners are hospitalists, or they are not. Low-volume practitioners can be analyzed in the intervention group; high-volume, practitioners can be placed into the controls, and the resulting effects on outcomes can be washed out or muted, as demonstrated in Chapter 4.

Chapters 3 and 4 build on Kuo's approach, using administrative claims data to identify and describe high-volume, hospital practitioners; but extend the literature to analyze trends and outcomes amongst the entire system of general physicians providing hospital care within the province. To my knowledge, the analytic paper proposed in Chapter 4 is the first study to assess the relationship between physician volume and clinical outcomes for general, acute hospital medicine. It is also the first population-based assessment of Canadian hospitalist performance. By assessing volume as a continuous predictor of outcomes we were able to demonstrate clear, clinically meaningful reductions in mortality and readmissions with rising physician volumes. More importantly, we were able to pinpoint outcome improvements to small increases in workload amongst very low-volume generalists. This finding suggests that practice and policy will have the greatest impact if strategies are directed towards supporting lower-volume generalists to increase the hospital volumes, and produce better outcomes. It also alludes to the possibility that assessing the exposure as a binary term may wash out any similar findings on quality within the hospitalist literature.

5.2.1 *Understanding Findings on Mortality and Readmissions*

By constructing multiple disease-specific cohorts, we were able to increase the likelihood of demonstrating a volume-outcome effect in this study by restricting conditions to those at highest risk for the events of interest. This minimized the impact of confounding by severity, establishing consistent, relatively homogeneous groupings of clinical conditions. This methodological difference is key to understanding why findings might vary from those found in the systematic review. The baseline risk of 30-day mortality was significantly greater for patients managed by high-volume physicians and estimates of effect for mortality and readmissions only became significant once this severity score was factored into risk adjustment.

Even then, the likelihood of an adverse outcome varied by cohort. Pooling estimates in the final models allowed us to approximate the average effect of volume on outcomes and improve the generalizability of the results. However, it also demonstrated how variability around the effects widened as heterogeneity from the individual conditions was introduced. By failing to evaluate physician performance within a disease-specific framework, clinically important effects can be diluted, particularly when diagnoses such as delirium are included, for which adverse outcomes are less likely to occur. Finally, when we re-ran the analysis classifying physicians using the functional proportion of practice algorithm [242], effect sizes were greatly reduced as a result of almost half the high-volume physicians being categorized into the 'non-hospitalist' comparison.

5.2.2 *Understanding Findings on Length of Stay*

The average length of stay for acute care in hospitals is often used as an indicator of efficiency. All other things being equal, a shorter stay will reduce the cost per discharge, shifting care to less expensive post-acute settings. However, shorter stays tend to be more service intensive and more costly per day. Too short a length of stay could also cause adverse effects on health outcomes, or reduce the comfort and recovery of the patient. If shorter stays lead to increased readmissions, the total cost per episode of illness may rise.

As discussed in Chapter 4, length of stay differences may not be comparable between Canada and the United States. Hospitals in the United States operate more acute beds per population and have more admissions and discharges per capita, putting their hospital spending as the most expensive one in world per discharge, despite having a shorter average lengths of stay [(252,259)]. Despite short stays, the United States underperforms compared to many high-income countries on several dimensions of hospital quality and safety [(259)]. According to the findings of this dissertation, lengths of stay were longer for patients managed by high-volume attendings. This finding was consistent in both unadjusted and adjusted analyses, across disease cohorts, and across step-wise models with little change in estimates occurring as patient severity, physician specialty and hospital characteristics including volume were added in succession. The findings are analogous to previous work where we found similar outcome improvements in mortality and readmissions and corresponding longer lengths of stay among higher-spending, high-volume urban hospitals [(243)]. They also mirror the findings of the only other evaluation published in the literature on Canadian hospitalist to date which found lower mortality and readmissions but similar lengths of stay among Canadian GP/FP hospitalists compared historically to office-based practitioners [(100).]

While this finding appears to diverge from the literature summarized in the systematic review (Chapter 2), there is no Canadian evidence to suggest whether or not efficiency gains are a realistic output of hospitalist care for Canada. Acute lengths of stay may be appropriately longer, reflecting better patient care if high volume physicians are keeping patients longer to improve clinical stability, reduce the likelihood of readmission and/or optimize safe, coordinated transitions to post-acute care. Post-admission complications described in the supplementary analyses may also have contributed to the longer lengths of stay observed among high-volume generalists. While the majority of complications were minor in nature, an increased incidence of the conditions coded (urinary tract infections; hospital-acquired pneumonia) would prolong hospital stays without necessarily resulting in higher mortality or readmission. It is also possible that longer lengths of stay reflect unmeasured differences in patient severity that persisted in the analysis despite adjustment for baseline mortality risk.

Finally longer stays may represent caseload excess, where too few hospital-based physicians managing too many patients delays the time providers allocate for discharge and/or family care planning [76,199]. This is a feasible scenario given the findings in Chapter 3 where we observed an increase in the average annual inpatient volumes billed by high-volume GP/FPs each fiscal year since 2000. In 2014, Elliott and colleagues published the findings of a retrospective cohort examining hospitalists' workloads as a continuous predictor of clinical outcomes, measured by billable encounters from the hospitalists' service records [76]. Contrary to previous hospitalist literature that has shown length of stay reductions under hospitalist care, Elliott found a non-linear relationship between workload and length of stay, demonstrating that as inpatient census rose, efficiency declined and costs increased [76]. Elliott proposed that as inpatient caseloads rise, time allocated to non-clinical tasks – documentation, communication, coordination of care, and discharge planning – declines. These tasks are critical to delivering efficient care, but are time intensive. If caseloads surpass the physicians' threshold for a manageable workload, physicians may prioritize clinical care and outcomes at the expense of hospital occupancy and case-management, slowly driving up length of stay [76].

5.3 Limitations

Several limitations of this research warrant discussion. The two analytic papers included in the dissertation relied solely on the use of administrative data. Administrative databases are appealing to researchers because they can be easily accessed and analyzed. Hospitalists are also a controversial area of health human resources and policy. At the time of proposal development, Ontario hospitalists were in discussion with the MOHLTC over the possibility of an alternative funding plan and as part of these negotiations, providers were asked to voluntarily disclose their OHIP billing numbers for 'analysis'. Fearing compensation clawbacks, the majority of providers were unwilling to disclose their identifiable information. Facing this circumstance, the use of administrative data allowed us to develop a method that could functionally classify hospital-based physicians in the absence of identifiable employment information. Their use also allowed us to track the prevalence, penetration and impact of hospitalists across the province at the systems-level. However, researchers and policy makers need to be aware of the limitations of using estimates of rates and risk derived from administrative records.

First, a growing number of Ontario physicians are remunerated through salary, capitation or blended reimbursement. While inpatient services are reliably captured through the OHIP claims database, outpatient services are occasionally diverted for physicians who are not required to submit shadow billings. These physicians will have no associated office-based claims in the OHIP database[3]. Lacking information on physicians' models of reimbursement, the workload variable reflecting the proportion of practice spent on inpatient care could be overinflated for physicians who work in both acute care institutions and in organizations excluded from shadow billing. Given this limitation, the proportion of practice metric (Chapter 3) should be used in combination with additional workload data and triangulated against linear volume to assess physicians' overall levels of billing activity. Similarly, the prevalence estimates and outcomes presented throughout the dissertation are only valid within the context of clinical evaluation and patient management. Findings might differ substantially if total service volumes including obstetrical care and procedural volumes are taken into account.

Second, the quality of administrative data presents an ongoing challenge to researchers. One of the most important limitations of this dissertation is that the validity of analyses is conditional on the quality and completeness of information captured in the administrative records. Accurate adjustment for variation in case mix and patient severity is essential for assessing provider performance and it is likely that key diagnostic data required for severity

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[3] The majority of physicians reimbursed through alternative funding plans are paid a 10% billing premium if they submit 'shadow billings' to OHIP to track care provision – meaning they submit non-reimbursable service claims as though they were billing fee-for-service. However, physicians working for community health centers are excluded from shadow billings. Physicians may choose not to submit claims for shadow billing premiums.

adjustment were under-captured in discharge abstracts. Canadian standards encourage the separation of pre-existing comorbidities from ones that develop post-admission (Diagnosis Type 1 vs. Type 3); however, the prevalence of pre-existing comorbidities were likely underestimated in our four disease cohorts **(Table 4.2),** leading to false-negative diagnostic errors. If present, these errors decrease the sensitivity, validity and utility of our predicted baseline severity index by limiting our ability to evaluate true differences in patient complexity between provider groups. Pre-existing comorbidities are not likely under-reported in DAD, rather they are more likely classified as secondary diagnoses (Diagnosis Type 2) - conditions that do not extend length of stay or require additional treatment beyond condition maintenance. Diagnostic coding may also be influenced by provider differences in documentation and charting. It is possible that high-volume physicians are more likely to document the existence of comorbidities in general as well as their influence on length of stay or treatment such that the likelihood of false-negatives would vary systematically by volume. Differential coding would bias the index towards fewer false-negatives and greater patient severity for high-volume attendings. Given the unknown extent and impact of false-negatives, use of the baseline patient severity index should be restricted beyond risk adjustment.

Third, several known risk factors and confounders of quality are not captured in administrative records and are thus absent from regression models These include additional characteristics of the physician's clinical practice structure (staffing/call model, compensation), process measures of care delivery, clinical/diagnostic findings relating to the patient's disease state and additional patient demographics (ethnicity, income and lifestyle-related characteristics). Variables included in risk-adjustment were intended to control for baseline differences in patients' risk of experiencing a poor outcome, identified at the time of admission, but it does not eliminate the likelihood that patients differed on other relevant but unmeasured characteristics. Residual confounding is likely and it is unknown to what extent the conclusions would change if additional information were to be included.

Finally, the analytic paper (Chapter 4) was restricted to two-years analyses of four common conditions. While findings suggest a relationship between provider inpatient volume and outcomes, it does not establish cause and effect and cannot be extrapolated to other areas of inpatient care. Administrative data is not current and significant delays exist between the time when data is collected and when they are available for third-party use. The outcomes analysed in these papers occurred three-to-four years ago and as a result, their relationship with volume may not be valid in the current context of hospital care provision. For physicians and hospital administrators to be successful in improving quality of care for Canadians, timely data needs to be accessible, on demand, and with the supports and expertise in place for users to make sense of it.

5.4 Suggestions for subsequent research

The three papers presented in this dissertation represent the beginnings of a body of research needed to understand the prevalence of Canadian hospitalists and the practice of hospital medicine. We have begun the process by identifying and describing the characteristics of hospital practitioners and exploring general clinical volume as a key structural predictor of quality in Ontario hospitals. Research must now turn to understanding the specific mechanisms through which high-volume generalists affect quality for patients under their care by isolating the practice characteristics and processes that differentiate them from their colleagues. This work needs to extend to program-level evaluations of the volume of hospital care, hospitalist and general medicine programs in select institutions to gain a better understanding of how the structure of programs along with their institutional, staffing and technological supports might influence quality. This can also identify challenges providers encounter when attempting to deliver high quality care to patients. Similarly, analyses should begin to assess relationships proposed in the theoretical framework, testing whether focused interventions within and among the constructs lead to targeted responses. Together, this research would provide physicians, administrators and policymakers with strategic information to develop and implement appropriate structural practices and care pathways to increase quality and reduce adverse events for hospitalized Ontarians.

Additionally, the analytic paper (Chapter 4) only sought to compare quality outcomes among physicians holding general medical certifications and was unable to account for the role that specialist consultations may have played in patient care and outcomes. Further work should explore whether specialist consultations vary systematically by generalist volume, whether the relationships to clinical volume also hold true for specialist physicians, and whether keeping volume constant, outcomes of care differ between hospital-based generalists and hospital-based specialists. Such work would aim to disentangle whether the mechanisms behind quality improvement are a function of expertise, volume or some combination of both. Furthermore, outcomes were only explored among cases where an attending physician of record could be assigned to the index separation. Several studies have suggested that quality of care is improved when patients are jointly managed by hospitalists and specialists [22,129,136,154,165,166,175,260], thus future work exploring hospitalist co-management in Ontario may also be of interest.

Follow-up studies using prospective cohorts and/or retrospective chart-review are warranted to investigate additional sources of patient-level confounding, and to evaluate the quality of comorbidity coding and the subsequent impact of false-negative/Type 2 diagnostic errors on severity/comorbidity calculations. Work is also needed to validate the volume categories proposed in Chapter 3 for identifying hospital-based providers against a known cohort of hospitalist practitioners.

Lastly, the definitive value of hospital medicine for Ontario likely rests on whether key stakeholders believe that the quality gained under the hospitalist model of care is worth the financial cost of supporting programs' existence. To assess this, a cost-effectiveness analysis of hospitalist care remains an important area of future research and a significant investigation in its own right. Case-costing will require accurate financial data on both hospitalist salaries and program operating expenses (where there exist), which for the moment, remain undisclosed.

6 Implications for Policy

6.1 Revisiting Theory

Each of the papers included in this dissertation rest on the proposed theoretical foundation that the effectiveness and efficiency of inpatient care is influenced by the formal structures and processes of care delivery as well as through patient and physicians' demographics, the patients' clinical complexity and available medical resources. As a conceptual model, Donabedian's structure-process-outcome framework has provided performance analysts with a tool to guide both the research and the development of effective improvement initiatives. However, a challenge with Donabedian's model includes the difficulty of estimating and negotiating relationships between each of the concepts and how they interact together to contribute to variation in outcomes. Recognizing that health is complex and multifaceted, our theoretical frameworks and subsequent analyses must increasingly aim to integrate multiple levels of risk including individual, provider, and community/population factors, assessing the relationships within and amongst each. For these efforts to be effective in improving the quality of care provided by physicians, performance evaluation must move from exploring single risk factors for quality to ones that accommodate the complex health systems in which patients receive treatment.

The conceptual model proposed in **Figure 2.1** to understand inpatient physician performance attempts to illustrate how certain structural issues inherent in inpatient care can affect processes and lead to better – or worse – health outcomes. The research presented in the final evaluative paper has begun this work, confirming physician volume as a key structural predictor of quality. Research must now turn to understanding the mechanisms through which high volume generalists decrease the risk of mortality and readmission for patients under their care by isolating the specific practice characteristics and processes that differentiate hospital-based practitioners from their lower volume colleagues. For example, controlling for the effects of volume, the majority of additional structural characteristics tested in the analytic paper (provider specialty, experience and practice characteristics; the hospital environment, annual hospital volume; level of nursing/support staff) had minimal influence on the three outcome measures of interest. Still, limitations in the availability of data precluded the investigation of several alternative proposed structural predictors including the use of case managers and discharge planners, call models, compensation mechanisms and the use of supportive technology. While a high-volume provider likely has more clinical expertise managing the common conditions seen among hospitalized patients (translating as a direct link to better outcomes), the way they deliver care might also be unique. Descriptive findings in both papers confirmed that high-volume physicians were more likely to practice in large, urban and academic institutions and previous research has shown that these institutions tend to have greater staffing and technological resources that support clinical practice [243,261]. If high-volume physicians and hospitalists use care aids such as wireless devices, in-room computers, automated order entry, clinical checklists and/or care management pathways as a routine part of case management and daily rounding, adverse events including complications, mortality and readmissions may decline. In addition, the physical clustering of patients on dedicated hospitalist units or floors may facilitate enhanced collaboration and communication with nurses, case-managers and allied health professionals based in that location. For now, explorations of these mechanisms lie outside the scope of this dissertation and are simply proposed for discussion. Further works needs to demonstrate whether such relationships exist and how they affect outcomes both positively and negatively. By testing relationships among the predictors and outcomes proposed in our conceptual model on a known cohort of hospital physicians, hospital medicine can move into the next stage of health systems performance – targeted improvement.

There is a pressing need in Canadian healthcare to improve the processes of acute care provision in order to reduce unnecessary utilization and spending, improve patient safety, optimize transitions and enhance patient experience. Given the growing prevalence of hospital generalists and the volume of clinical services they deliver, hospital generalists can have a pivotal impact on both processes and outcomes of care in Ontario, but the potential value of achieving these objectives will only be realized if all stakeholders, including physicians, hospital leaders and their funding bodies, actively participate in change efforts.

Such efforts might include but are not limited to: process improvement initiatives, the development and implementation of common care pathways, increased accountability, enhanced reporting and alternative payment arrangements, partly based on performance.

6.2 Patient Safety

A growing body of performance literature suggests that when patterns of care are widely divergent, clinical outcomes suffer and as a result, patient safety may be compromised [262-264]. One method of improving quality is to reduce variation in the way processes of care are implemented through the use of standardized practices and procedures. Standardization of practice can be defined as a set process by which health care services are delivered, chosen by a committee of key stakeholders, taking into account evidence-based results to ensure quality patient care while adhering to fiscal constraints [265]. Standardization of practice improves care by reducing unnecessary variation in provider performance and improving communication amongst hospital staff. When standardized processes are used, quality increases, variation decreases, and costs subsequently decline [266-268]. Standardization does not mean that a process becomes inflexible; physicians and staff must still use clinical judgment to vary their care based on the needs of patients when medically indicated; but it does provides structures that help ensure important steps or treatments do not get skipped. Examples of standardized practices include the development and use of decision-making protocols, clinical practice guidelines, checklists and common care pathways.

General medicine and hospitalist programs across the province are in the process of developing and implementing the use of standardized order sets and risk assessments for the management of several common inpatient conditions, including congestive heart failure, chronic obstructive pulmonary disease, stroke and sepsis. Standardized referral pathways are also being implemented for specialist, occupational/physical therapy and CCAC services. Finally, best-practice protocols are being established to aid in the prevention of hospital-acquired complications such as urinary tract infections, venous thromboembolism, hospital-acquired pneumonia and infection/sepsis and to improve patients' transitions from hospital to home and to other post-acute settings [269-271]. Each of these represents clinically actionable processes that will enhance patient safety and improve outcomes, accessible to all hospital providers, regardless of clinical volume. However, standardized processes are largely championed by established medicine programs and implemented in urban, academic hospitals attending to annual case volumes large enough to actualize, monitor, and evaluate focused interventions. As demonstrated in Chapter 4, strategies need to be developed for educating, supporting and mentoring lower volume, rural, and community-based generalists to apply similar processes in their institutions which may have fewer physician, human and administrative resources to champion change. One possibility might be to advocate for LHIN or province-wide roll-out of specific improvement initiatives to ensure that standardized practices in areas such as order sets, risk assessments, referrals and discharge processes - are developed and applied consistently and uniformly across governed agencies regardless of institution size and geographic location.

The Ontario Ministry of Health and Long Term Care continues with the roll-out of Quality-Based Procedures (QBPs) and associated funding under the Excellent Care for All Act (ECFAA). With these changes, hospital administrators and their providers will face greater incentives to provide high quality, efficient care. QBP funding uses an evidence-based framework to set prices for select procedures and patient conditions, taking into account the volume of services delivered, patient's clinical complexity and the quality of care delivered. The three key aims of the QBP model are to: standardize care; reduce practice variation; and encourage investment in patient safety and quality improvement. As frontline providers of clinical care, hospital practitioners will be instrumental in their institutions' achievement of funded QBPs. While each QBP has a coinciding clinical handbook to guide the implementation of best practices, standardized hospital care pathways, capacity planning, performance evaluation/target setting and the development of governing policy; current policy does not mandate that health care providers deliver care in accordance with the handbook recommendations As a result, individual institutions and subsequently front-line care workers are left to determine how they will achieve their required targets and associated funding. Efforts here need focus on strategies for supporting low-volume hospital generalists in hospital care provision, to produce better outcomes and implement standardized processes of care. Advancing the health care infrastructure for telemedicine, e-consultation, collaboration spaces, and virtual access to specialist, hospitalist and CCAC support may also aid in addressing the unique care needs of physicians working in rural and remote communities.

6.3 Hospital Staffing

If hospitals wish to achieve their quality improvement obligations, hospital physicians and their leadership teams need to engage in a shared quality agenda. For this to occur, hospital administrators need to see physicians as partners in both the delivery of clinical care and in quality improvement. Equally important, hospital physicians need to broaden their focus and begin seeing their role in the performance of the hospital as a system of care provision. Physicians need to develop a perspective of shared responsibility for the outcomes of all patients in the system, regardless of whether they were personally involved in their care.

Combined with a compensation model that rewarded effectiveness, efficiency and role diversity, hospital physicians would have an inherent motivation to become engaged with quality improvement initiatives. In the 2012 Drummond Report, the Commission on the Reform of Ontario's Public Services recommended that: *"Hospitalist physicians be used to co-ordinate care from admission to discharge"* (Recommendation 5-55) [(272)]. They further recommended that hospitalists and primary care providers *"work together to better co-ordinate patient's moves through the health care continuum"*, stating that the hospitalist's role was particularly crucial for patients with complex health needs where multiple specialists may be involved in care (5-55) [(272)]. In tandem, the Commission recommended that all physicians adopt blended compensation models where compensation be linked to positive health outcomes that are in turn linked to strategic targets in addition to the number of interventions performed (e.g.: fee-for-service; Recommendation 5-59) [(272)].

While Canadian hospitalists appear to be valued for their clinical contributions to acute medicine, the majority of hospitalist programs report ongoing challenges to their sustainability. In Ontario, the fee codes for inpatient care have traditionally undervalued the work performed by hospital practitioners and as a result, the majority of hospital medicine programs rely on their contracting institutions to subsidize financial shortfalls between recoverable insurance billings and their hospitalists' negotiated salaries. Absent from provinces' billing schedules are fees to compensate the non-clinical tasks equally critical to a hospital physicians' work, such as communication, care coordination, discharge planning, documentation, and participation in quality improvement initiatives. According to a work sampling study conducted on a typical hospitalist program operating in one Ontario hospital, only 17% of their hospitalists' time was observed providing direct "billable" clinical care [(273)]. Twenty-five percent of time was spent gathering information through the review of medical records, test results and diagnostic scans; 22% was spent communicating with other health care providers, physicians, patients and their families (either in person or through phone calls); and documentation of care (writing orders and prescriptions, filling out forms, chart documentation, dictation) took up 20% of the physicians' time [(273)]. Eight percent of time was spent on travel within the hospital between patient care locations and the remainder (9%) was allocated to personal time: handwashing, nutrition, computer/mobile use and nonclinical conversation [(273)]. Given these billing constraints, the fee-for-service payment arrangements currently used to compensate hospital care in Canada may act against the very benefits of hospital medicine by discouraging any further provision of care outside of what can be recovered. There are few incentives for physicians to examine or change their processes of care, to engage in quality improvement, or to increase collaboration and communication amongst colleagues to ease patients' transitions across care settings, even if infrastructure is improved.

Hospitalists spend the majority of their professional time in hospital settings and what goes on within these institutions directly affects how they perform their obligations to patients and the quality of their work-life balance [(87)]. As the gap between supply and demand grows, hospitalists take on increasing inpatient workloads as demonstrated in Chapter 3. According to a member survey conducted in 2007 by the Canadian Society of Hospital Medicine, the top challenges hospitalists reported within their practices included daily workload, the burden of evening and weekend work and a lack of support from administration [10]. That being said, Ontario hospitalists reported a high level of satisfaction with their careers, citing high acuity medicine, collaboration with colleagues and the multidisciplinary nature of care as rewarding aspects of their jobs [10]. Schedule design appeared to be highly correlated with satisfaction and burnout. Hospitalists working in smaller groups and institutions reported more clinical days worked per month and more billable encounters per workday compared to hospitalists employed in larger practices [10].

This feedback is important for staffing policy, provider satisfaction and minimizing attrition. Rural and remote hospitals face greater barriers to recruitment, with fewer physicians available and willing to provide 24/7/365 hospital care. Physicians in these areas tend to face longer work hours, a high-level of on-call responsibility, a lack or total absence of back-up and support from specialists and complementary/allied health professionals, and the need for additional clinical competencies to meet remote community needs such as obstetrics, anesthesiology, general surgery, neurology, and psychotherapy. Other challenges may include professional isolation and limited educational/cultural/recreational/social opportunities for themselves and their families. As a result, hospitalist programs may not be feasible in certain areas of the province. While findings from Chapter 4 suggested that low-volume inpatient practices should be minimized, they did not indicate that full-time hospitalist practice is the best replacement. Comprehensive practice, shared community call models, and part-time hospital care may all be viable alternatives if satisfaction, personal time and compensation can be supported. Compensation for physicians choosing alterative hospital practice models from that of a full-time hospitalist should be flexible and reflect the full spectrum of professional, clinical, non-clinical and personal factors inherent to acute medical practice. It should also guarantee protected time off, paid continuing medical education/skills training and locum tenens coverage.

6.4 Hospital and Related Policy

Lastly, formalized strategies and policies are needed to govern the training of hospital physicians and the core skills required to practice hospital medicine. Residents of family medicine in Canada presently complete a two-year training program that includes an average of three months in hospital internal medicine. Under this training structure, family residents looking to pursue a career as a hospitalist may not gain enough experience managing the diversity of clinical conditions and opportunities to develop relevant procedural skills [274]. For these physicians, standards for additional training in complex disease management, pain management, elder care and palliative care are warranted [274]. Two elective training programs exist in Canada, but both are located in Toronto. The University of Toronto and Sunnybrook Health Sciences Centre each offer one-year clinical fellowships in hospital medicine where fellows learn to manage acutely ill and complex patients in addition to acquiring skills in case management, medical consultation, interprofessional collaboration, safe transitions of care, discharge planning and participation in hospital administration/quality improvement. While likely beneficial, the limited geography of these programs is disadvantageous to the majority of the country's new practitioners.

Fundamental to the issue of hospitalist training may be an underlying, unspoken fear of human resources and physician supply. Is it possible that the development of further training programs or the formalization of standards could attract more family physicians who choose careers dedicated to hospital medicine? If so, fewer graduates would be available to offer primary care within the community. At some point, dialogue between the College of Family Physicians of Canada, the Royal College of Physicians and Surgeons of Canada, the Canadian Society of Hospital Medicine, provincial Ministries of Health, hospitals and hospitalists will be necessary to decide when and how training needs, certification, core competencies and scope of practice will be determined for future practitioners.

7 Conclusion

The withdrawal of primary care physicians from inpatient clinical care and the subsequent emergence of hospitalist medicine represent one of the largest changes to the delivery of physician services in Canada in the last two decades. While the structure of Canadian hospitalist programs are still evolving, the findings from this dissertation suggest high-volume generalists have a role to play in improving quality of care for hospitalized residents. The introduction of hospitalists brings a new set of challenges. We need to ensure that efforts are made to collect valid and accurate data on hospital practitioners, the practice models they operate within and the processes of care used to deliver services. We also need methods of monitoring their patient's outcomes and finding ways to share this data across the health care system. By isolating key predictors of outcomes, we can begin to develop and implement appropriate delivery models and process pathways that support high quality care for all residents of Ontario, regardless of where they live within the province. Finally, we need to find ways of supporting hospital physicians' value and engagement in quality improvement. This may include the exploration of accountability agreements, technology-enhanced care delivery, formalized training and mentorship initiatives, and alternative methods of compensation.

High-volume hospital generalists may improve the quality of inpatient care for hospitalized Canadians. But if hospital leaders work with all their provider groups to identify improvement goals and support one-another in pursuit of achieving them, health will be enhanced for the patients they serve.

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9 Appendices

Appendix 2.1 Individual study results on hospitalist performance.

2.1 [A] Process indicators of quality (*n* = 26)

Source	Type[a]	Sample[b]	Hospitalist Intervention	Comparison Group	Risk-Adjustment	Reported Results[c]
Abenhaim et al., [(99)]	RC	N = 2722 I = 1094 C = 1628	Faculty hospitalists (n = 7)	Traditional academic attendings with house staff		Subspecialty consultations decreased by 42%*ǂ
Auerbach et al., [(134)]	RC	N = 5308 I = 1615 C = 3693	Academic hospitalist attendings (n = 5) with house staff	Community-based physicians (n = 113) with house staff	Regression: demographics, case-mix, clinical data, year	No difference in subspecialty consultations
Auerbach & Pantilat [(135)]	RC	N = 148 I = 74 C = 74	Academic hospitalist attendings (n = 5) with house staff	Community-based physicians (n = 36) with house staff	Regression: demographics, severity, clinical data, physician clustering	Hospitalists were 3.5 x more likely to have documented a family meeting and 4.8 x more likely to have prescribed a long-acting benzodiazepine in the 48 hours prior to death; no difference in the likelihood of providing skin or oral care
Bell et al., [(137)]	QE	N = 1078 I = 371 C = 707	Mixed practice types	Community-based physicians & internal medicine subspecialists	Quasi-randomized based on physician's call cycle	No differences in communication patterns with outpatient physicians*
Bellet & Whitaker [(138)]	B/A	N = 1440 I = 813 C = 627	Pediatric hospitalist attendings (n = 10) with house staff	Traditional academic attendings (n = 31) & community-based physicians (n = 13)		No difference in subspecialty consultations*

Davis et al., [142]	RC	N = 2124 I = 211 C = 948	Private hospitalists (n = 2) assisted by a nurse manager	Community-based physicians (n = 17)		Hospitalists ordered 22%* fewer laboratory tests but 20%* more hematology services per patient; no differences in radiology*, EEG*, ECG* or antibiotic utilization*
Dwight et al., [84]	RC	N = 3807 I = 1274 C = 2533	Faculty pediatric hospitalists (n = 3)	Traditional academic attendings with house staff	Regression: demographics, comorbidity	No difference in subspecialty consultations
Freese et al., [62]	B/A		Private hospitalists (n = 2)	Community-based physicians (n = 73)		Subspecialty consultations decreased by 17%*ǂ; no differences in laboratory*ǂ or radiology*ǂ utilization
Go et al., [148]	QE	N = 450 I = 177 C = 273	Academic hospitalist attendings with house staff	Mixed practice types		No difference in ICU transfers*
Hackner et al., [149]	PC	N = 1637 I = 477 C = 1160	Academic hospitalist attendings (n = 10) with house staff	Community-based physicians (n = 73)		Subspecialty consultations decreased by 56%*; no differences in laboratory*, hematology*, OT/PT* utilization or ICU transfers*
Kearns et al., [152]	QE	N = 4455 I = 2238 C = 2217	Academic hospitalist attendings (n = 4) with house staff	Traditional academic attendings (n = 27) with house staff	Randomization	No difference in ICU transfers*
Khasgiwali et al., [153]	RC	N = 1916 I = 1173 C = 743	Academic hospitalist attendings (n = 5) and private hospitalists (n = 3)	Traditional academic attendings (n = 82) with house staff	Stratification by DRG	No differences in radiology utilization*
Lindenauer et al., [157]	RC	N = 326 I = 137 C = 189	Academic hospitalist attendings and private hospitalists (n = 20)	Community-based physicians (n = 65)	Regression: demographics	Hospitalists were 7% more likely to measure LVEF during admission; no differences in ACE-I/ARBs/ warfarin utilization or lifestyle counselling
Ogershok et al., [162]	B/A	N = 2177 I = 1099 C = 1078	Pediatric hospitalist attendings (n = 8) with house staff	Traditional academic attendings with house staff		Hospitalists ordered 29% fewer laboratory*, 33% fewer hematology* and 20% fewer radiology* tests per patient

Palmer et al., [24]	QE	N = 2464 I = 829 C = 1635	Academic hospitalist attendings (n = 3) with house staff and a nurse discharge planner	Traditional academic attendings (n = 27) with house staff	Quasi-randomization based on physician's call cycle	Hospitalists ordered fewer laboratory*, hematology* and radiology* tests per patient; no differences in the number of tests ordered between hospitalists and generalist attendings
Reddy et al., [168]	RC	N = 151 I = 73 C = 78	Academic hospitalist attendings with house staff	Mixed practice types	Regression: demographics, clinical data	No differences in laboratory, hematology or radiology utilization
Rifkin et al., [169]	RC	N = 455 I = 185 C = 270	Private hospitalists (n = 9)	Community-based physicians (n = 56)	Stratification by severity	Mean time from stability to switch to oral antibiotics decreased by 35%*; no differences in appropriateness of initial antibiotics use* or the number of infectious disease/pulmonary consultations*
Rifkin et al., [171]	RC	N = 158 I = 68 C = 90	Faculty hospitalists (n = 12)	Community-based physicians (n = 46)		Pts managed by hospitalists were 1.5x more likely to receive DVT prophylaxis* and 1.3x more likely to receive pneumococcal vaccination*; no differences in the % of pts receiving timely antibiotics*, blood cultures prior to antibiotic initiation* or smoking cessation counselling*
Roytman et al., [172]	RC	N = 342 I = 126 C = 216	Faculty hospitalists (n = 15)	Community-based physicians	Regression: demographics, severity, comorbidity	Hospitalists were more likely to use ACE-I/ARBs within 24 hours of admission, prescribe IV diuretics and obtain social work consults but less likely to prescribe beta-blockers, obtain serial chest radiographs or multiple specialty consults; no differences in ECG use, PT/dietician consultation or sodium/fluid restrictions
Schneider et al., [25]	QE	N = 1207 I = 495 C = 712	Academic hospitalist attendings (n = 43) with house staff	Traditional academic attendings (n = 171) with house staff	Regression: demographics, hospital site, comorbidity, physician experience	No differences in pneumococcal vaccination, pain control or communication with outpatient physicians

Sharma et al., [106]	RC	N = 21183	Mixed practice types	Mixed practice types	Regression: demographics; comorbidity, hospital teaching status	Pts managed by hospitalists were 57% more likely to stay in the ICU during their final hospitalization
Smith et al., [176]	RC	N = 45 I = 22 C = 23	Private critical care hospitalists with house staff	Community-based physicians with house staff	Regression: demographics, severity, clinical data	Hospitalists were 4 x more likely to order chest radiographs; no differences in ICU transfers, antibiotic, hematology, laboratory utilization or palliative care.
Somekh et al., [177]	RC	N = 750 I = 250 C = 500	Faculty hospitalist attendings (n = 8)	Community-based physicians and a cardiologist staffed chest-pain unit		Hospitalists ordered more stress MPIs*ǂ and 2-D echos*ǂ but fewer angiography* tests compared to community physicians; hospitalists ordered fewer stress MPIs* but more 2-D echos* and angiography tests*ǂ compared to cardiologists
Stein et al., [180]	RC	N = 237 I = 114 C = 123	Academic hospitalist attendings (n = 16) with house staff	Community-based physicians (n = 52) with house staff or practicing solo (n = 39)		No differences in ICU transfers*
Vasilevskis et al., [183]	RC	N = 372 I = 120 C = 252	Mixed practice types	Mixed practice types	Regression: comorbidity, clinical data, hospital clustering	No differences in frequency of cardiac testing, LVEF measures or ACE-I/ ARB/beta-blocker prescribing
Wachter et al., [184]	QE	N = 1623 I = 806 C = 817	Academic hospitalist attendings (n = 14) with house staff	Traditional academic attendings (n = 26) with house staff	Quasi-randomization based on physician's call cycle	No difference in subspecialty consultation rates*

[a] Study designs include randomized control trials (RCT), quasi-experimental designs (QE) time-series (TS), prospective cohorts (PC), retrospective cohorts (RC) before-after (B/A) and cross-sectional survey (CS)

[b] N = total sample size; I = hospitalist intervention same size; C = comparison sample size

[c] * Indicates that results are based on unadjusted analyses; ǂ indicates that a p-value or confident interval was not provided - results may or may not be statistically significant.

2.1 [B] Efficiency indicators of quality (*n* = 59)

Source	Type[a]	Sample[b]	Hospitalist Intervention	Comparison Group	Risk-Adjustment	Reported Results[c]
Abenhaim et al., [99]	RC	N = 2722 I = 1094 C = 1628	Faculty hospitalists (n = 7)	Traditional academic attendings with house staff		Median LOS decreased by 78%*ǂ *(patients assigned to hospitalists based on brief anticipated LOS)*
Auerbach et al., [134]	RC	N = 5308 I = 1615 C = 3693	Academic hospitalist attendings (n = 5) with house staff	Community-based physicians (n = 113) with house staff	Regression: demographics, case-mix, clinical data, year	Median LOS decreased by 33% Median costs reduced by 22%
Bekmezian et al., [16]	RC	N = 925 I = 109 C = 816	Faculty hospitalist (n = 1)	Traditional academic attendings with house staff	Regression-demographics, case-mix	Mean LOS decreased by 38% Mean costs reduced by 29%
Bellet & Whitaker [138]	B/A	N = 1440 I = 813 C = 627	Pediatric hospitalist attendings (n = 10) with house staff	Academic attendings (n = 31) & community-based physicians (n = 13)	Regression: demographics, case-mix, physician characteristics	Mean LOS decreased by 11% Mean costs reduced by 9%
Boyd et al., [139]	RC	N = 1009 I = 740 C = 269	Two private hospitalist teams (n = 4,5) both with house staff	Traditional academic attendings (n = 8) with house staff	Regression: demographics, severity	Mean LOS increased by 12% - 19% Mean costs increased by 10%
Carek et al., [140]	RC	N = 5453 I = 1648 C = 3805	Private hospitalists (n = 12)	Academic attendings with (n = 13) house staff and community-based physicians (n = 52)	Regression-demographics, severity (*hospitalists compared to teaching service only*)	Mean LOS increased by 18% compared to teaching service but decreased by 5%* compared to community physicians Mean costs increased by 28% and 10%*
Craig et al., [141]	RC		Private hospitalist-staffed facilities	Non-hospitalist facilities	Demographics	Mean LOS decreased by 11% - 17%ǂ Mean costs increased by 5% - 13%ǂ
Davis et al., [142]	RC	N = 2124 I = 443 C = 1681	Private hospitalists (n = 2) assisted by a nurse manager	Community-based physicians (n = 17)	Demographics, case-mix	Mean LOS decreased by 25% Mean costs reduced by 12%
Diamond et al., [30]	B/A	N = 3299 I = 1620 C = 1679	Academic hospitalist attendings with house staff	Community-based physicians with house staff		Mean LOS decreased by 27%* Median costs reduced by 16%*
Dwight et al., [84]	RC	N = 3807 I = 1274 C = 2533	Faculty pediatric hospitalists (n = 3)	Traditional academic attendings with house staff	Regression: demographics, comorbidity	Mean LOS decreased by 14%

Dynan et al., [144]	RC	N = 5543 I = 2383 C = 3160	Faculty hospitalists (n = 8) assisted by a nurse practitioner	Traditional academic attendings (n = 40) with house staff	Regression: demographics, case-mix, comorbidity	No difference in mean LOS Mean costs reduced by 15%
Everett et al., [145]	RC	N = 11750 I = 3133 C = 8617	Private hospitalists (n = 27)	Community-based physicians (n = 131)	Regression: demographics, case-mix, year	Mean LOS decreased by 16% Mean costs reduced by 8%
Everett et al., [146]	RC	N = 22792 I = 11565 C = 11227	Private hospitalists (n = 40)	Academic attendings (n = 10) with house staff and community-based physicians (n = 52)	Regression: demographics, case-mix, severity, year	Mean LOS and costs increased by 42% and 32% respectively compared to academic attendings; mean LOS and costs decreased by 14% and 8% respectively compared to community-based physicians
Freese et al., [62]	B/A		Private hospitalists (n = 2)	Community-based physicians (n = 73)		Mean LOS decreased by 0.64 days*ǂ Mean cost reduced by 25%*ǂ
Gittell et al., [147]	RC	N = 6686	Private hospitalists	Community-based physicians	Regression: demographics, severity, clinical data, physician clustering	Observed/expected LOS decreased by 36%; mean costs reduced by 6%
Go et al., [148]	QE	N = 450 I = 164 C = 259	Academic hospitalist attendings with house staff	Mixed practice types	Regression: demographics, severity, comorbidity, site, physician clustering	No difference in mean LOS Mean costs reduced by 17%
Gregory et al., [4]	B/A	N = 402 I = 93 C = 309	Faculty hospitalist (n = 1)	Traditional academic attendings with house staff		Mean LOS decreased by 37%* Mean costs reduced by 24%*
Hackner et al., [149]	PC	N = 1637 I = 477 C = 1160	Academic hospitalist attendings (n = 10) with house staff	Community-based physicians (n = 73)	Stratification by age and severity	Mean LOS and costs decreased by 16%*
Halasyamani et al., [150]	RC	N = 10595 I = 6136 C = 4459	Academic hospitalist attendings (n = 15) with house staff and private hospitalists (n = 18)	Community-based physicians (n = 63)	Regression: case-mix, physician clustering	Mean LOS and costs decreased by 20% and 10% respectively for academic hospitalists; mean LOS and costs decreased by 8% and 6% respectively for private hospitalists
Huddleston et al., [22]	RCT	N = 469 I = 232 C = 237	Faculty hospitalists (n = 3) comanaging with the orthopaedic team	Academic orthopaedic attendings (n =12) with surgical residents	Randomization with adjustment for surgery type	Mean LOS decreased by 9% No differences in mean costs

Kaboli et al., [151]	QE	N = 1706 I = 447 C = 1259	Academic hospitalist attendings (n = 3) with house staff	Traditional academic attendings (n = 34) with house staff	Regression: demographics, physician clustering	Mean LOS decreased by 16% Mean costs reduced by 10%
Kearns et al., [152]	QE	N = 4455 I = 2238 C = 2217	Academic hospitalist attendings (n = 4) with house staff	Traditional academic attendings (n = 27) with house staff	Regression: demographics, diagnosis	No differences in mean LOS or costs
Khasgiwali et al., [153]	RC	N = 1916 H = 1173 C = 743	Academic hospitalist attendings (n = 5) and private hospitalists (n = 3)	Traditional academic attendings (n = 82) with house staff	Stratification by DRG	No differences in mean LOS* or costs*
Krantz et al., [154]	B/A	N = 493 I = 265 C = 228	Private hospitalists (n = 6) comanaging with cardiologists	Academic cardiologist attending with house staff		Median LOS decreased by 55%* Time-to-admission decreased by 43%*
Kulaga et al., [155]	RC	N = 2707 I = 583 C = 2124	Academic hospitalist attendings (n = 2) with house staff	Community-based physicians with house staff	Stratification by DRG	Mean LOS decreased by 21%*ǂ Mean costs reduced by 18%ǂ*
Kuo et al., [156]	RC	N=314590 I = 91065 C=223525	Mixed practice types	Mixed practice types	Regression: demographics, case-mix, comorbidity, clinical data, hospital characteristics & clustering	Mean LOS decreased by 6%
Landrigan et al., [23]	TS	N = 7748 I = 3625 C = 3823	Academic hospitalist attendings with house staff and a nurse discharge planner	Community-based physicians	Time-series-temporal trend, case-mix	Mean LOS decreased by 12% Mean costs reduced by 16% after the introduction of hospitalists - no concurrent improvements in LOS or cost among comparison HMOs
Lindenauer et al., [157]	RC	N = 326 I = 137 C = 189	Academic hospitalist attendings and private hospitalists (n = 20)	Mixed practice types	Stratification by severity	Median LOS was equivalent or increased for pts with minor, moderate or severe illness and decreased for pts with major illness; no difference in median costs
Lindenauer et al., [158]	RC	N = 76926 I = 24772 C = 52154	Mixed practice types (n = 284)	Mixed practice types (n = 1964)	Regression: demographics, case-mix, physician volume, hospital characteristics; stratification by diagnosis	Mean LOS decreased by 12% compared to internists and family physicians; Mean costs reduced by 5% compared to internists but not different from family physicians

Maa et al., [159]	B/A		Academic surgical hospitalists (n = 3)	Traditional surgical attendings with house staff		Time-to-surgery decreased by 50%*
Meltzer et al., [160]	QE	N = 6511 I = 1613 C = 4898	Academic hospitalist attendings (n = 2) with house staff	Traditional academic attendings (n = 58) with house staff	Regression: demographics, case-mix, comorbidity, physician clustering	No differences in LOS or costs in year one; mean LOS and costs decreased by 11% and 9% resp. in year two
Molinari & Short. [161]	B/A	N = 1319 I = 903 C = 416	Private hospitalists (n = 5) with nurse case manager	Community-based physicians (n = 59) with nurse case manager	Regression: demographics	Observed/expected LOS was 74% more likely to fall within optimal guidelines
Ogershok et al., [162]	B/A	N = 2177 I = 1099 C = 1078	Academic pediatric hospitalist attendings (n = 8) with house staff	Pediatric academic attendings with house staff		No difference in mean LOS* Mean costs reduced by 13%*
Palacio et al., [163]	RC	N = 5923 I = 3699 C = 2224	Faculty hospitalists (n = 14)	Traditional academic attendings (n = 8) with house staff		Mean LOS decreased by 16%*
Palmer et al., [24]	QE	N = 2464 I = 829 C = 1635	Academic hospitalist attendings (n = 3) with house staff and a nurse discharge planner	Traditional academic attendings (n = 27) with house staff	Mixed effects ANOVA: demographics, case-mix, physician clustering *(cost only)*	Mean LOS decreased by 17%* compared to generalist and 28%* compared to subspecialty attendings; mean costs reduced by 29% compared to subspecialty but not different for generalist attendings
Parekh et al., [164]	RC	N = 2552 I = 913 C = 1639	Academic hospitalist attendings (n = 7) with house staff	Traditional academic attendings (n = 33) with house staff	Regression: demographics, case-mix	No differences in mean LOS or costs
Phy et al., [165]	B/A	N = 466 I = 230 C = 236	Faculty hospitalists (n = 12) comanaging with the orthopaedic team	Academic orthopaedic attendings with surgical residents	Regression: demographics, severity *(time-to-surgery only)*	Mean LOS decreased by 21%* Time-to-surgery reduced by 34%
Pinzuer et al., [166]	B/A	N = 140 I = 86 C = 54	Faculty hospitalists (n = 3) comanaging with the orthopaedic team	Academic orthopaedic surgeon (n = 1) with house staff	Regression-demographics, case-mix, comorbidity	Observed/expected LOS decreased by 20%‡; no difference in costs
Ravikumar et al., [167]	B/A	N = 9724 I = 1589 C = 3935	Faculty hospitalists comanaging with the surgical team	Traditional surgical attendings with house staff		Mean LOS decreased by 16%* for patients admitted to surgical ICU; 27%* for patients admitted to progressive care
Reddy et al., [168]	RC	N = 151 I = 73 C = 78	Academic hospitalist attendings with house staff	Mixed practice types	Regression: demographics, case-mix	No differences in mean LOS or costs

Rifkin et al., [169]	RC	N = 455 I = 185 C = 270	Private hospitalists (n = 9)	Community-based physicians (n = 56)	Regression: demographics, severity, clinical data	Mean LOS decreased by 14% Mean costs reduced by 13%
Rifkin et al., [170]	RC	N = 11388 I = 2027 C = 9361	Faculty hospitalists (n = 9)	Community-based physicians (n = 198)	Regression: demographics, case-mix, physician characteristics & clustering	No differences in the likelihood of having an above average LOS
Roy et al., [120]	RC	N = 118 I = 47 C = 71	Faculty hospitalists	Community-based physicians		No differences in median LOS* or costs*; % of pts receiving surgery within 24 hours of admission was 3 x higher* among hospitalists
Roytman et al., [172]	RC	N = 342 I = 126 C = 216	Faculty hospitalists (n = 15)	Community-based physicians	ANCOVA: demographics, comorbidity; stratification by severity	Mean LOS decreased by 0-40% Mean costs reduced by 14-28%
Salottolo et al., [173]	B/A	N = 500 I = 261 C = 239	Faculty hospitalists (n = 6)	Academic trauma physicians surgeons with house staff	Regression: demographics, clinical data	Mean LOS increased by 11%
Scheurer er al., [174]	RC	N = 11969 I = 1214 C = 10755	Mixed practice types (n = 53)	Mixed practice types (n = 1489)	Stratification by severity	Mean LOS decreased by 6-18%* for pts with moderate to severe illness but not different for pts with minor illness*; mean costs reduced by 10-26%* for pts with major and severe illness but not different for pts with minor/moderate illness
Schneider et al., [25]	QE	N = 1207 I = 495 C = 712	Academic hospitalist attendings (n = 43) with house staff	Traditional academic attendings (n = 171) with house staff	Regression: demographics, comorbidity, site, physician experience	No differences in mean LOS or costs
Simon et al., [175]	B/A	N = 759 I = 115 C = 644	Faculty hospitalist (n = 1) comanaging with the orthopaedic team	Academic orthopaedic team	Regression: demographics, clinical data, surgeon clustering	Mean LOS decreased by 26% (only 12% *of post-intervention pts were actually co-managed by the hospitalist)*
Sloan et al., [115]	B/A	N = 1409 I = 731 C = 679	Faculty hospitalist psychiatrists (n = 6) with physician assistants	Psychiatrists providing continuity-of-care (n = 6) with physician assistants		No significant difference in mean LOS*
Smith et al., [176]	RC	N = 45 I = 22 C = 23	Private critical care hospitalists with house staff	Community-based physicians with house staff	Regression: demographics, severity, clinical data	Mean LOS increased by 50% Mean costs increased by 80%

Somekh et al., [177]	RC	N = 750 I = 250 C = 500	Faculty hospitalists (n = 8)	Community-based physicians and a cardiologist staffed chest-pain unit	Regression: demographics, clinical data, comorbidity	Mean LOS increased by 11%ǂ compared community physicians and 278% compared to cardiologists
Southern et al., [178]	RC	N = 9037 I = 2913 C = 6124	Academic hospitalist attendings (n = 5) with house staff	Traditional academic attendings with house staff	Regression: demographics, case-mix, clinical data	Mean LOS decreased by 22%
Srivastava et al., [179,275]	B/A	N = 1970	Pediatric hospitalist attendings (n = 3) with house staff	Traditional academic attendings with house staff	Regression: demographics, severity	Mean LOS and costs decreased by 13% and 9% resp. for patients with asthma and by 11% and 8% resp. for patients with dehydration; no difference in mean LOS or costs for pts with viral illness
Stein et al., [180]	RC	N = 237 I = 114 C = 123	Academic hospitalist attendings (n = 16) with house staff	Community-based physicians (n = 52) with house staff or practicing solo (n = 39)		Mean LOS and costs decreased by 21%* and 26% resp. compared to community-based physicians; mean LOS and costs decreased by 17%* compared to solo physicians with no differences in cost
Tenner et al., [181]	B/A	N = 1211 I = 615 C = 596	Private pediatric hospitalists (n = 5)	Pediatric intensivist attendings with house staff	Regression: severity, clinical data	Mean LOS decreased by 21 hours
Tingle and Lambert [182]	RC	N = 529 I = 355 C = 174	Faculty hospitalists (n = 5)	Traditional academic attendings with house staff	ANOVA-severity	No differences in mean LOS or costs
Vasilevskis et al., [183]	RC	N = 372 I = 120 C = 252	Mixed practice types	Mixed practice types	Regression: comorbidity, clinical data, hospital clustering	No differences in mean LOS or costs
Wachter et al., [184]	QE	N = 1623 I = 806 C = 817	Academic hospitalist attendings (n = 14) with house staff	Traditional academic attendings (n = 26) with house staff	Regression: demographics, case-mix	Mean LOS decreased by 12% Mean costs reduced by 10%
Wells et al., [26]	PC	N = 181 I = 91 C = 90	Private hospitalists (n = 5)	Community-based physicians (n = 37)	ANCOVA: demographics	Mean LOS and costs decreased by 32% and 44% resp. for pts with asthma; no differences in LOS or costs for pts with bronchitis, gastroenteritis or pneumonia

[a] Study designs include randomized control trials (RCT), quasi-experimental designs (QE) time-series (TS), prospective cohorts (PC), retrospective cohorts (RC), before-after (B/A) and cross-sectional survey (CS)

[b] N = total sample size; I = hospitalist intervention same size; C = comparison sample size

[c] * Indicates that results are based on unadjusted analyses; ǂ indicates that a p-value or confident interval was not provided - results may or may not be statistically significant

2.1 [C] Clinical outcomes of treatment as indicators of quality (*n* = 51)

Source	Type[a]	Sample[b]	Hospitalist Intervention	Comparison Group	Risk-Adjustment	Reported Results[c]
Abenhaim et al., [99]	RC	N = 272 I = 1094 C = 1628	Faculty hospitalists (n = 7)	Traditional academic attendings with house staff		In-hospital mortality decreased by 92%*ǂ; 30-day readmissions reduced by 31%*ǂ; Complications decreased by 84%*ǂ - (*Hospitalist patients selected based on brief anticipated LOS)*
Auerbach et al., [134]	RC	N = 5308 I = 1615 C = 3693	Academic hospitalist attendings (n = 5) with house staff	Community-based physicians (n = 113) with house staff	Regression: demographics, case-mix, clinical data, year	Risk of in-hospital, 30-day & 60-day mortality decreased by 21-29%; No differences in 10-day readmissions
Auerbach & Pantilat [135]	RC	N = 148 I = 74 C = 74	Academic hospitalist attendings (n = 5) with house staff	Community-based physicians (n = 36) with house staff	Regression: demographics, severity, clinical data, physician clustering	Hospitalist pts were 2.7 x more likely to report being pain and anxiety free in the 48 hours prior to death
Batis et al., [136]	B/A	N = 466 I = 230 C = 236	Faculty hospitalists (n = 12) comanaging with the orthopaedic team	Surgical orthopaedic or general teaching service		No difference in 1-year survival rates*
Bekmezian et al., [16]	RC	N = 925 I = 109 C = 816	Faculty hospitalist (n = 1)	Traditional academic attendings with house staff		No difference in in-hospital morality*; 72 hr readmissions were 4.4 x higher*
Bellet & Whitaker [138]	B/A	N = 1440 I = 813 C = 627	Academic pediatric hospitalist attendings (n = 10) with house staff	Academic attendings (n = 31) & community-based physicians (n = 13)		10-day readmissions were 3 x higher* among hospitalists
Carek et al., [140]	RC	N = 5453 I = 1648 C = 3805	Private hospitalists (n = 12)	Mixed academic attendings (n = 13) with house staff and community-based physicians (n = 52)	Regression: demographics, severity (*hospitalists compared to teaching service only)*	No difference in 30-day readmissions
Craig et al., [141]	RC		Private hospitalist-staffed facilities	Non-hospitalist facilities	Demographics	No difference in 7-day readmissionsǂ
Davis et al., [142]	RC	N = 2124 I = 443 C = 1681	Private hospitalists (n = 2) with a nurse manager	Community-based physicians (n = 17)	Stratification by DRG	No differences in in-hospital mortality*, 30-day readmissions* or pt satisfaction*

Dhuper & Choksi [143]	B/A	N = 10966 I = 5508 C = 5458	Academic hospitalist attendings (n = 12.5 FTEs) with physician assistants	Traditional academic attendings (n = 44.5 FTEs) with house staff	Case-mix	In-hospital mortality reduced by 34%; No differences in 30-day readmissions*, adverse events* or pt satisfaction*
Diamond et al., [30]	B/A	N = 3299 I = 1620 C = 1679	Academic hospitalist attendings with house staff	Community-based physicians with house staff		No differences in in-hospital mortality*; 14/30-day readmissions reduced by 54%*
Dwight et al., [84]	RC	N = 3807 I = 1274 C = 2533	Faculty pediatric hospitalists (n = 3)	Traditional academic attendings with house staff	Regression: demographics, comorbidity	No differences in in-hospital mortality or 7-day readmissions
Dynan et al., [144]	RC	N = 5543 I = 2383 C = 3160	Faculty hospitalists (n = 8) with a nurse practitioner	Traditional academic attendings (n = 40) with house staff	Regression: demographics, case-mix	No differences in in-hospital mortality, 15-day or 30-day readmissions
Everett et al., [145]	RC	N = 11750 I = 3133 C = 8617	Private hospitalists (n = 27)	Community-based physicians (n = 131)	Regression: demographics, case-mix	No differences in in-hospital mortality or 30-day readmissions
Everett et al., [146]	RC	N = 22792 I = 11565 C = 11227	Private hospitalists (n = 40)	Mixed academic attendings (n = 10) with house staff and community-based physicians (n = 52)	Regression: demographics, case-mix	No differences in in-hospital mortality; 30-day readmissions reduced by 21% compared to academic attendings but not different from community-based physicians
Gittell et al., [147]	RC	N = 6686	Private hospitalists	Community-based physicians	Regression: demographics, severity, clinical data, physician clustering	No differences in in-hospital mortality or 7-day readmissions; 30-day readmissions reduced by 28%
Go et al., [148]	QE	N = 450 I = 164 C = 259	Academic hospitalist attendings with house staff	Academic attendings and community-based physicians, both with house staff	Regression: demographics, severity, comorbidity, site, physician clustering (*complications only)*	No differences in in-hospital mortality*; 30-day readmissions* or complications
Gregory et al., [4]	B/A	N = 402 I = 93 C = 309	Non-academic hospitalist (n = 1)	Traditional academic attendings with house staff		No difference in readmissions*
Hackner et al., [149]	PC	N = 1637 I = 477 C = 1160	Academic hospitalist attendings (n = 10) with house staff	Community-based physicians (n = 73)		No differences in in-hospital mortality*, 14-day* or 30-day readmissions*

Halasyamani et al., [150]	RC	N = 10595 I = 6136 C = 4459	Academic hospitalist attendings (n = 15) with house staff and private hospitalists (n = 18)	Community-based physicians (n = 63)	Regression: case-mix. physician clustering	No differences in in-hospital mortality, 30-day mortality or readmissions
Huddleston et al., [22]	RCT	N = 469 I = 232 C = 237	Faculty hospitalists (n = 3) comanaging with the orthopaedic team	Academic orthopaedic attendings with surgical residents (n =12)	Randomization	Minor complications decreased by 32%; 24% more patients were discharged without any complications; no difference in pt satisfaction
Kaboli et al., [151]	QE	N = 1706 I = 447 C = 1259	Academic hospitalist attendings (n = 3) with house staff	Traditional academic attendings (n = 34) with house staff	Regression: demographics, physician clustering (*mortality only)*	No differences in in-hospital mortality or 30-day readmissions*
Kearns et al., [152]	QE	N = 4455 I = 228 C = 2217	Academic hospitalist attendings (n = 4) with house staff	Traditional academic attendings (n = 27) with house staff	Regression: demographics, diagnosis (*mortality only)*	No differences in in-hospital/30-day mortality or 7/30-day readmissions*
Khasgiwali et al., [153]	RC	N = 1916 I = 1173 C = 743	Academic hospitalist attendings (n = 5) and private hospitalists (n = 3)	Traditional academic attendings with house staff (n = 82)		No difference in 30-day readmissions*
Krantz et al., [154]	B/A	N = 493 I = 265 C = 228	Private hospitalists (n = 6) comanaging with cardiologists	Traditional cardiologist attending with house staff		No differences in 30-day readmissions*
Kulaga et al., [155]	RC	N = 2707 I = 583 C = 2124	Academic hospitalist attendings (n = 2) with house staff	Community-based physicians with house staff		30-day readmissions decreased by 32%*
Landrigan et al., [23]	B/A	N = 7748 I = 3625 C = 3823	Academic hospitalist attendings with house staff and nurse discharge planner	Community-based physicians	Regression: demographics, severity	No differences in in-hospital mortality or 30-day readmissions
Lindenauer et al., [157]	RC	N = 326 I = 137 C = 189	Academic hospitalist attendings and private hospitalists (n = 20)	Community-based physicians (n = 65)		No differences in in-hospital mortality* or 30-day readmissions*
Lindenauer et al., [158]	RC	N = 76926 I = 24772 C = 52154	Mixed practice types (n = 284)	Mixed practice types (n = 1964)	Regression: demographics, case-mix, physician volume, hospital characteristics	No differences in in-hospital mortality or 30-day readmissions

Meltzer et al., [160]	QE	N = 6511 I = 1613 C = 4898	Academic hospitalist attendings (n = 2) with house staff	Traditional academic attendings (n = 58) with house staff	Regression: demographics, case-mix, comorbidity, physician clustering	30-day mortality reduced by 35% in year two only; no differences in in-hospital/60-day/1-year mortality, 30-day readmissions, ED visits, self-reported health or pt. satisfaction
Ogershok et al., [162]	B/A	N = 2177 I = 1099 C = 1078	Academic pediatric hospitalist attendings (n = 8) with house staff	Traditional pediatric academic attendings with house staff		No differences in in-hospital mortality*, 7-day* or 31-day* readmissions
Palacio et al., [163]	RC	N = 5923 I = 3699 C = 2224	Faculty hospitalists (n = 14)	Traditional academic attendings (n = 8) with house staff	Regression: demographics, clinical data	30-day readmissions decreased by 26%
Palmer et al., [24]	QE	N = 2464 I = 829 C = 1635	Academic hospitalist attendings (n = 3) with house staff and a nurse discharge planner	Traditional academic attendings (n = 27) with house staff	Regression: demographics, case-mix,	In-hospital mortality reduced by 56% compared to subspecialty attendings; not different from generalist attendings; no difference in 30-day readmissions, pt satisfaction
Parekh et al., [164]	RC	N = 2552 I = 913 C = 1639	Academic hospitalist attendings (n = 7) with house staff	Traditional academic attendings (n = 33) with house staff	Regression: demographics, case-mix	No differences in in-hospital mortality, 14-day or 30-day readmissions
Phy et al., [165]	B/A	N = 466 I = 230 C = 236	Faculty hospitalists (n = 12) comanaging with the orthopaedic team	Academic orthopaedic attendings with surgical residents		No differences in in-hospital mortality*, 30-day readmissions* or complications*
Pinzuer et al., [166]	B/A	N = 140 I = 86 C = 54	Faculty hospitalists (n = 3) comanaging with the orthopaedic team	Academic orthopaedic surgeon (n = 1) with house staff		Complications increased by 250%*ǂ; No differences in pt satisfaction*ǂ
Ravikumar et al., [167]	B/A	N = 39769 I = 22270 C = 17499	Faculty hospitalists comanaging with the surgical team	Traditional surgical attendings with house staff		In-hospital mortality decreased by 25%*
Rifkin et al., [169]	RC	N = 455 I = 185 C = 270	Private hospitalists (n = 9)	Community-based physicians (n = 56)		No difference in in-hospital mortality, 15-day or 30-day readmissions
Roytman et al., [172]	RC	N = 342 I = 126 C = 216	Faculty hospitalists (n = 15)	Community-based physicians	Regression: demographics, severity, comorbidity	In-hospital mortality decreased for pts managed by hospitalists; no differences in rates of acute renal failure or readmission

Salottolo et al., [173]	B/A	N = 500 I = 261 C = 239	Faculty hospitalists (n = 6)	Academic trauma physicians & surgeons with house staff	Regression: demographics	No differences in in-hospital mortality or complications
Schneider et al., [25]	QE	N = 1207 I = 495 C = 712	Academic hospitalist attendings (n = 43) with house staff	Traditional academic attendings (n = 171) with house staff	Regression-demographics, comorbidity, hospital site, physician experience	No differences in in-hospital mortality, 30-day readmission, ED visit rates, pt satisfaction or self-reported health
Sloan et al., [115]	B/A	N = 1409 I = 731 C = 679	Faculty hospitalist Psychiatrists (n = 6) with physician assistants	Psychiatrists providing continuity-of-care (n = 6) with physician assistants		30-day readmissions decreased by 40%*; 30-day follow-up for a mental health visit increased by 20%*
Smith et al., [176]	RC	N = 45 I = 22 C = 23	Private critical care hospitalists with house staff	Community-based physicians with house staff		No differences in in-hospital mortality*, 7-day readmissions* or 30-day ED visits*
Somekh et al., [177]	RC	N = 750 I = 250 C = 500	Faculty hospitalists (n = 8)	Community-based physicians and a cardiologist staffed chest-pain unit	Regression-demographics, clinical data, comorbidity	Readmissions were 4x higher compared to cardiologists; no significant difference in readmissions between hospitalists and community physicians
Southern et al., [178]	RC	N = 9037 I = 2913 C = 6124	Academic hospitalist attendings (n = 5) with house staff	Traditional academic attendings with house staff	Regression-demographics, case-mix, clinical data	No differences in in-hospital/30-day mortality or 30-day readmissions
Stein et al., [180]	RC	N = 237 I = 114 C = 123	Academic hospitalist attendings (n = 16) with house staff	Community-based physicians (n = 52) with house staff or practicing solo (n = 39)		No differences in in-hospital mortality* or 30-day readmissions*
Tenner et al., [181]	B/A	N = 1211 I = 615 C = 596	Private pediatric hospitalists (n = 5)	Pediatric intensivist attendings with house staff	Regression-severity, clinical data	Pts managed by hospitalists were 2.8 x more likely to survive until discharge
Tingle and Lambert [182]	RC	N = 529 I = 355 C = 174	Non-academic hospitalists (n = 5)	Traditional academic attendings with house staff		No difference in in-hospital mortality
Vasilevskis et al., [183]	RC	N = 372 H = 120 C = 252	Mixed practice types	Mixed practice types	Regression: comorbidity, clinical data, hospital clustering	No differences in 30-day mortality or readmissions; likelihood of follow-up within 30-days of discharge increased by 83%

Wachter et al., [184]	QE	N = 1623 I = 806 C = 817	Academic hospitalist attendings (n = 14) with house staff	Traditional academic attendings (n = 26) with house staff	Regression: demographics, case-mix	No differences in in-hospital/6-month mortality, 10-day readmissions or self-reported health
Wells et al., [26]	PC	N = 181 I = 91 C = 90	Private hospitalists (n = 5)	Community-based physicians (n = 37)		No differences in 1-year readmissions, ED visit rates or 30-day follow-up visits; parents thought hospitalists were more courteous and friendly

[a] Study designs include randomized control trials (RCT), quasi-experimental designs (QE) time-series (TS), prospective cohorts (PC), retrospective cohorts (RC), before-after (B/A) and cross-sectional survey (CS)

[b] N = total sample size; I = hospitalist intervention same size; C = comparison sample size

[c] * Indicates that results are based on unadjusted analyses; ǂ indicates that a p-value or confident interval was not provided - results may or may not be statistically significant.

Appendix 2.2 Checklist for assessing study quality, modified from Downs & Black (1998).

Section 1: Reporting

1. *Is the objective/aim or hypotheses of the study clearly described within the introductory body of the manuscript?.*

If the objective is described only in the abstract, or not until the methods section, the question should be answered no.

Answer	Score
Yes	1
No	0

2. *Are the main outcomes to be measured clearly described in the Introduction or Methods section?*

If the main outcomes are first mentioned in the results section or aren't described in adequate detail for the reader to assess what was done, the question should be answered no.

Answer	Score
Yes	1
No	0

3. *Are the characteristics of the patients included in the study and the source population clearly described?*

Inclusion and/or exclusion criteria should be stated. Overall sample size must be stated.

Answer	Score
Yes	1
No	0

4. *Are the interventions of interest clearly described?*

Both hospitalist and control care should be clearly described. The number of physicians or FTEs providing care in each group must be stated.

Answer	Score
Yes	1
No	0

5. *Are the distributions of potential confounders in each group of subjects to be compared clearly described?*

A list of principle confounders (either descriptive in tabular format or in text within the methods or results section) is provided.

Answer	Score
Yes	1
No	0

6. *Are all main findings of the study clearly described?*

Quantitative outcomes data (including the numerator and denominator) should be reported for all main findings so that the reader can check any analyses and conclusions.

Answer	Score
Yes	1
No	0

7. *Does the study provide estimates of the random variability in the data for all main outcomes?*

In normally distributed data, the standard error, standard deviation or confidence intervals should be reported. In non-normally distributed data, the inter-quartile range should be reported. If the data distribution is not described, it must be assumed that the estimates used were appropriate and the question should be answered yes. If variances were provided for some but not all of the main outcomes, the question should be answered no.

Answer	Score
Yes	1
No	0

8. *Have all important adverse events that may be a consequence to the intervention been reported?*

This should be answered yes if the study demonstrated that there was a comprehensive attempt to measure and described significant adverse events related to inpatient care (i:e: in-hospital mortality, readmissions).

Answer	Score
Yes	1
No	0

9. *Have the characteristics of patients lost to follow-up been described?*

This should be answered yes when there were no losses to follow-up or when losses to follow-up were small and would not have affected the results by their exclusion. This should be answered no where a study does not report the number of patients lost to follow-up or where the number or patients excluded due to missing data was not described (retrospective studies).

Answer	Score
Yes	1
No	0

10. *Have actual probability values been reported for all main outcomes (i.e.: p = 0.02 rather than p < 0.05), except when the probability value is less than 0.001?*

Where probability values are provided for some but not all of the main outcomes, the question should be answered no.

Answer	Score
Yes	1
No	0

11. *Did the authors disclose sources of funding (if any)?*

Answer	Score
Yes	1
No	0

12. *Did the authors comment on the role of additional providers in the provision of inpatient care?*

f the authors disclosed any information relating to nursing/house-staff coverage or the provision of care provision by any other provider, the question should be answered yes.

Answer	Score
Yes	1
No	0

13. *Did the authors include a statement on whether incentives (monetary or otherwise) were provided to physicians to enhance their performance?*

Answer	Score
Yes	1
No	0

14. *Did the authors include a statement on whether the use of hospitalists were mandatory for managing the care of specific groups of inpatients?*

Answer	Score
Yes	1
No	0

15. *Did the authors disclose the name, geographic location and type of the hospital(s) where the study took place?*

For multisite evaluations, the source population and a description on how sites were selected must be included to answer yes. If only the type of hospital is disclosed, the question should be answered no.

Answer	Score
Yes	1
No	0

Section 2: External validity

16. *Were the subjects who were eligible to participate in the study representative of the entire population from which they were recruited?*

The study must identify the source population and describe how participants were selected in order to answer yes. Patients would be representative if they comprised the entire source population (i.e.: an entire year of hospitalizations to a general medical unit where study physicians comprise all practice structures for inpatient care), an unselected sample of consecutive patients, or a random sample. Where a study does not report the proportion of the source population from which the patients are derived or systematically excludes a portion of patients (i.e.: patients with private health insurance), the question should be answered no.

Answer	Score
Yes	1
No	0
Unable to determine	0

17. *Were subjects who actually participated representative of the entire population from which they were recruited?*

The proportion of patients who participated among those eligible should be stated. Validation of a representative sample would include demonstrating that the distribution of main confounders was the same in the study sample and source population.

Answer	Score
Yes	1
No	0
Unable to determine	0

18. *Were the staff and facilities where patients were treated representative of treatment the majority of patients would receive?*

For this question to be answered yes, the study should demonstrate that care in the study groups were similar to that which would be provided to the source population. The question should be answered no if for example, a large proportion of care is provided by a physician practice structures not included in the one of the study groups.

Answer	Score
Yes	1
No	0
Unable to determine	0

Section 3: Internal Validity-Bias

19. *Was an attempt made to blind those measuring the main outcomes to the intervention allocation?*

Answer	Score
Yes	1
No	0
Unable to determine	0

20. *If any of the results were based on "data dredging", was this made clear?*

Any analyses that had not been planned at the outset of the study should be clearly indicated and justified. If no unplanned analyses were reported, the question should be answered yes.

Answer	Score
Yes	1
No	0
Unable to determine	0

21. *Is the length of follow-up between the intervention and the outcome the same for all patients?*

Where follow-up is the same for all participants, the question should be answered yes. If different lengths of follow-up were adjusted for (i.e.: survival analyses), the question should be answered yes.

Answer	Score
Yes	1
No	0
Unable to determine	0

22. *Were the statistical tests used to assess the main outcomes appropriate?*

Statistical tests must be appropriate to the distribution of the data. Non-parametric methods should be used for non-normal data and small sample sizes. Data should be adjusted for the clustering of patients within physicians.

Answer	Score
Yes	1
No	0
Unable to determine	0

23. *Was compliance with the intervention appropriate?*

Where there was non-complication with treatment allocation of where there was significant contamination of one group by the other's care providers, the question should be answered no.

Answer	Score
Yes	1
No	0
Unable to determine	0

24. *Were the main outcomes used valid and reliable?*

For studies where the outcome measures are clearly described, the question should be answered yes. Denominators for outcome measures should include only the population at risk (for example, readmissions should only be counted among patients surviving to discharge).

Answer	Score
Yes	1
No	0
Unable to determine	0

Section 4: Internal Validity-Confounding/Selection Bias

25. *Were patients recruited from the same population?*

The question should be answered as unable to determine where information concerning the source population is not described.

Answer	Score
Yes	1
No	0
Unable to determine	0

26. *Were subjects recruited over the same time periods?*

Studies which used a before-and-after design should be answered no. For a study which does not specify the time period over which patients were recruited, the study should be answered as unable to determine.

Answer	Score
Yes	1
No	0
Unable to determine	0

27. *Were study subjects randomized groups?*

Studies which state that subjects were randomized should be answered yes except where the method of randomization would not ensure random allocation. For example, alternate allocation would score a 0 because allocation is predictable.

Answer	Score
Yes	1
No	0
Unable to determine	0

28. *Was the randomized assignment concealed from both patients and health care providers until recruitment was irrevocable?*

All non-randomized studies should be answered no.

Answer	Score
Yes	1
No	0
Unable to determine	0

29. *Was there adequate adjustment for individual-level confounding in analyses from which the main findings were drawn?*

This question should be answered no where: the main analyses were based on analyses of actual treatment rather than intention to treat; the distribution of patient confounders were not described; or the distribution of known confounders was different between groups and not taken into account in analyses. In non-randomized studies, if the effects of patient-level confounders were not investigated or confounding was demonstrated but not adjusted for, the question should be answered no.

Answer	Score
Yes	1
No	0
Unable to determine	0

30. *Were losses of patients to follow-up taken into account in the analyses?*

If the proportion of patients lost to follow-up was too small to affect main findings, the question should be answered yes. If the number of patients lost to follow-up are not reported, the question should be answered as unable to determine.

Answer	Score
Yes	1
No	0
Unable to determine	0

Section 5: Statistical Power

31. *Did the manuscript include a power calculation?*

Where a power or sample size analyses was undertaken, the question should be answered yes, even where the actual power/sample size was insufficient.

Answer	Score
Yes	1
No	0

32. *Did the study have sufficient power to detect a clinically important effect?*

Answer	Score
Yes	1
No	0
Unable to determine	0

Appendix 2.3 PRISMA Checklist: Do hospitalist physicians improve the quality of inpatient care?

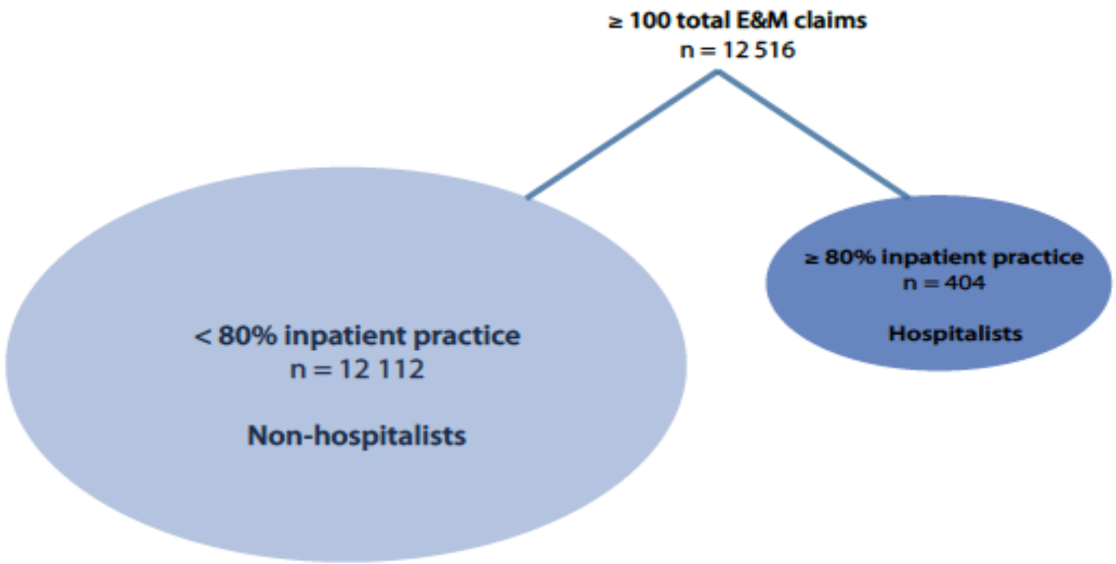
Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	31
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	31, 32
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	34-36
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	35
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	39
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	39, 41
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Figure 2.2 (pg. 41)
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	40, 41

Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	40, 42
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	42 Appendix 2.1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	42
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	42
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	42, 50-51 Appendix 2.2
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	42, 50
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	39, 40 Figure 2.2 (pg. 41)
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	43-49; 54 Appendix 2.1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	43-49; 54 Appendix 2.1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Figure 2.3 (pg. 58) Figure 2.4 (pg. 61) Figure 2.5 (pg. 63)
Synthesis of results	21	Present the main results of the review. If meta-analyses are done, include for each confidence intervals and measures of consistency.	53 Figure 2.3 (pg. 58) Figure 2.4 (pg. 61)
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Figure 2.5 (pg. 63)

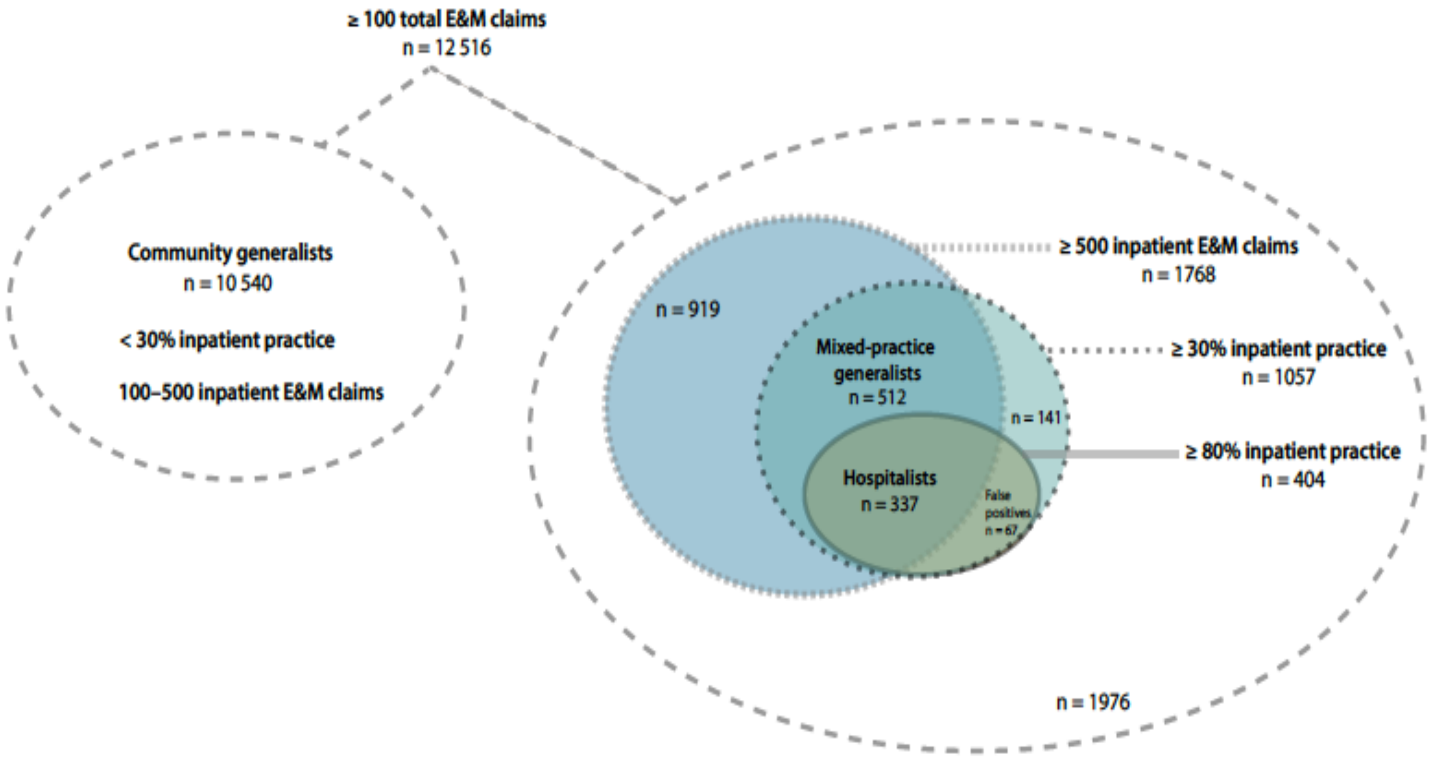
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	62-64 Appendix 2.1
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	65, 66
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	70, 71
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	67-70, 72
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Indicated in publication

Appendix 3.1 Concordance between two functional frameworks used to define hospitalists.

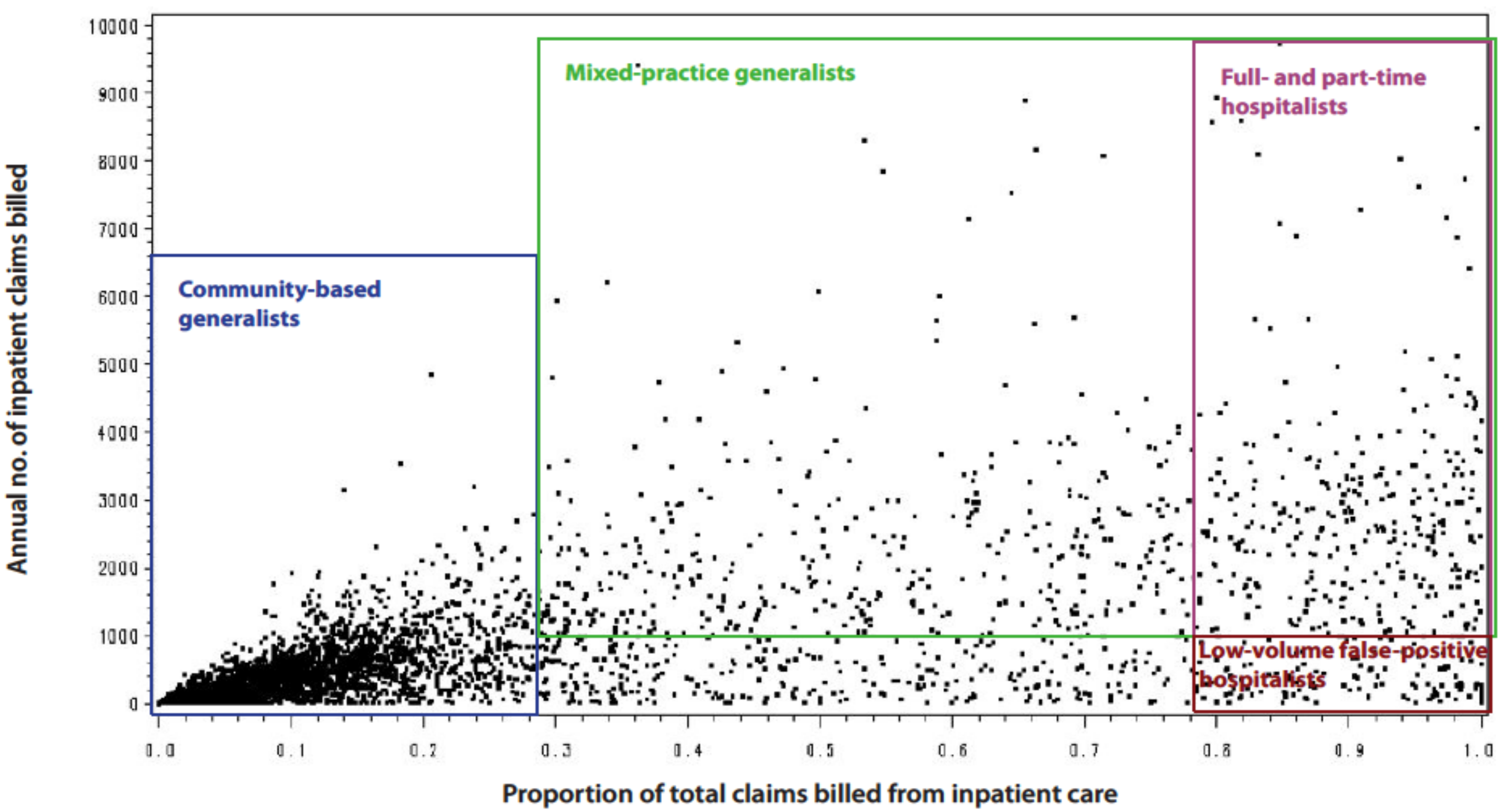
3.1[A] Number of active Ontario general practitioners/family physicians and general internists categorized as hospitalists in fiscal year 2010/2011, according to the framework of Kuo *et al.,* [75] (≥ 80% of physicians' clinical practice generated from inpatient evaluation-and-management claims, for physicians with ≥100 total services; n = 12,516. Excludes 409 physicians with < 100 total claims).



3.1 [B] Number of active Ontario general practitioners/family physicians and general internists categorized as hospitalists in fiscal year 2010/2011, according to the framework described in Chapter 3 [242] (≥ 80% of physicians' clinical practice generated from inpatient evaluation-and-management claims, for physicians with ≥500 inpatient services; *n* = 12,516. Excludes 409 physicians with < 100 total claims). The hospital-based physicians consist of 211 full-time hospitalists (≥ 2,000 inpatient claims) and 126 part-time hospitalists (500-1,999 claims).

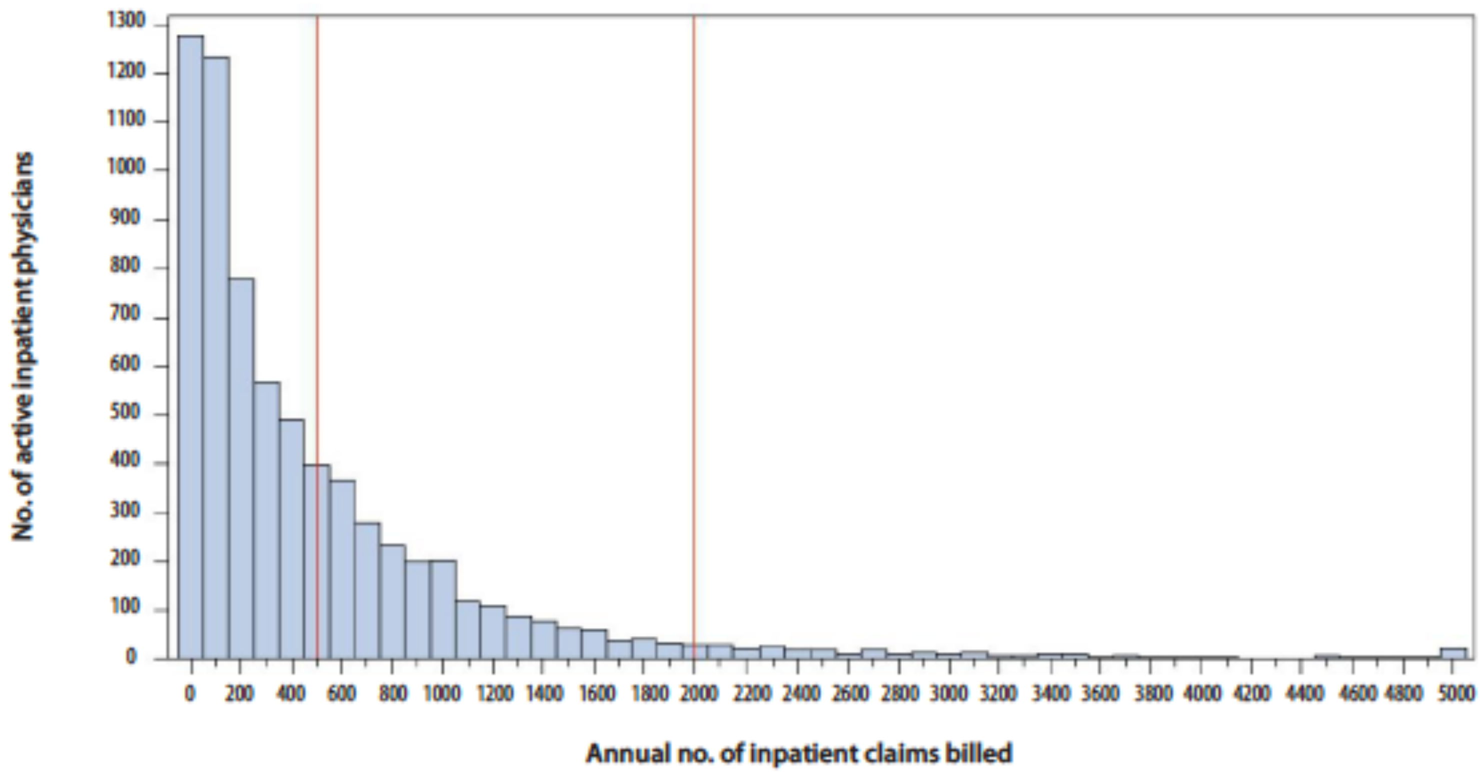


3.1[C] Frequency distribution of active Ontario general/family physicians and general internists according to annual inpatient volume and proportion of claims generated from inpatient care, for fiscal year 2010/2011 (n = 19,925).



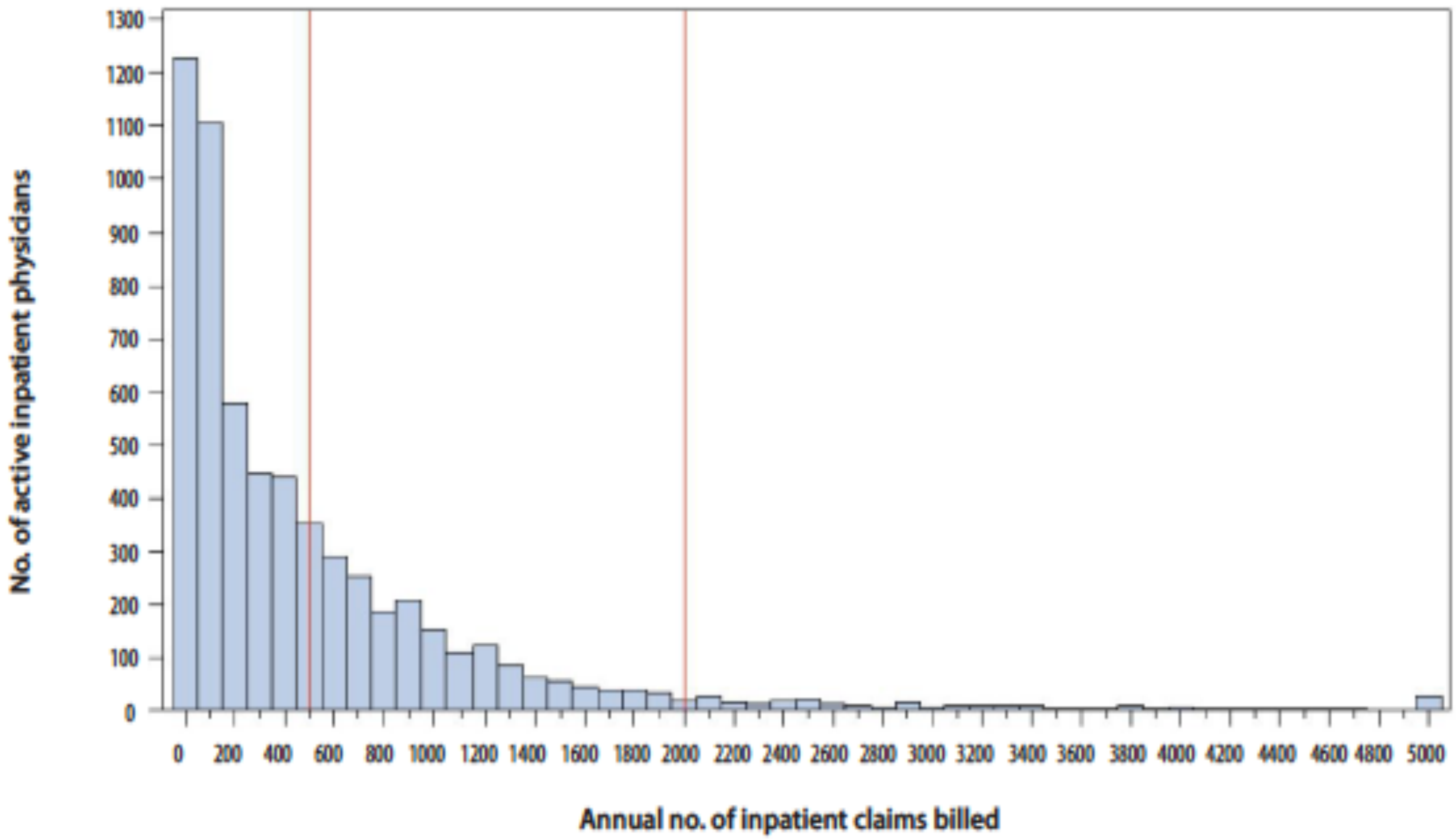
Appendix 3.2 Selected frequency distributions of active Ontario general practitioners, family physicians, and general internists according to the annual number of inpatient evaluation-and-management claims billed.

3.2 [A] Fiscal year 1996/1997



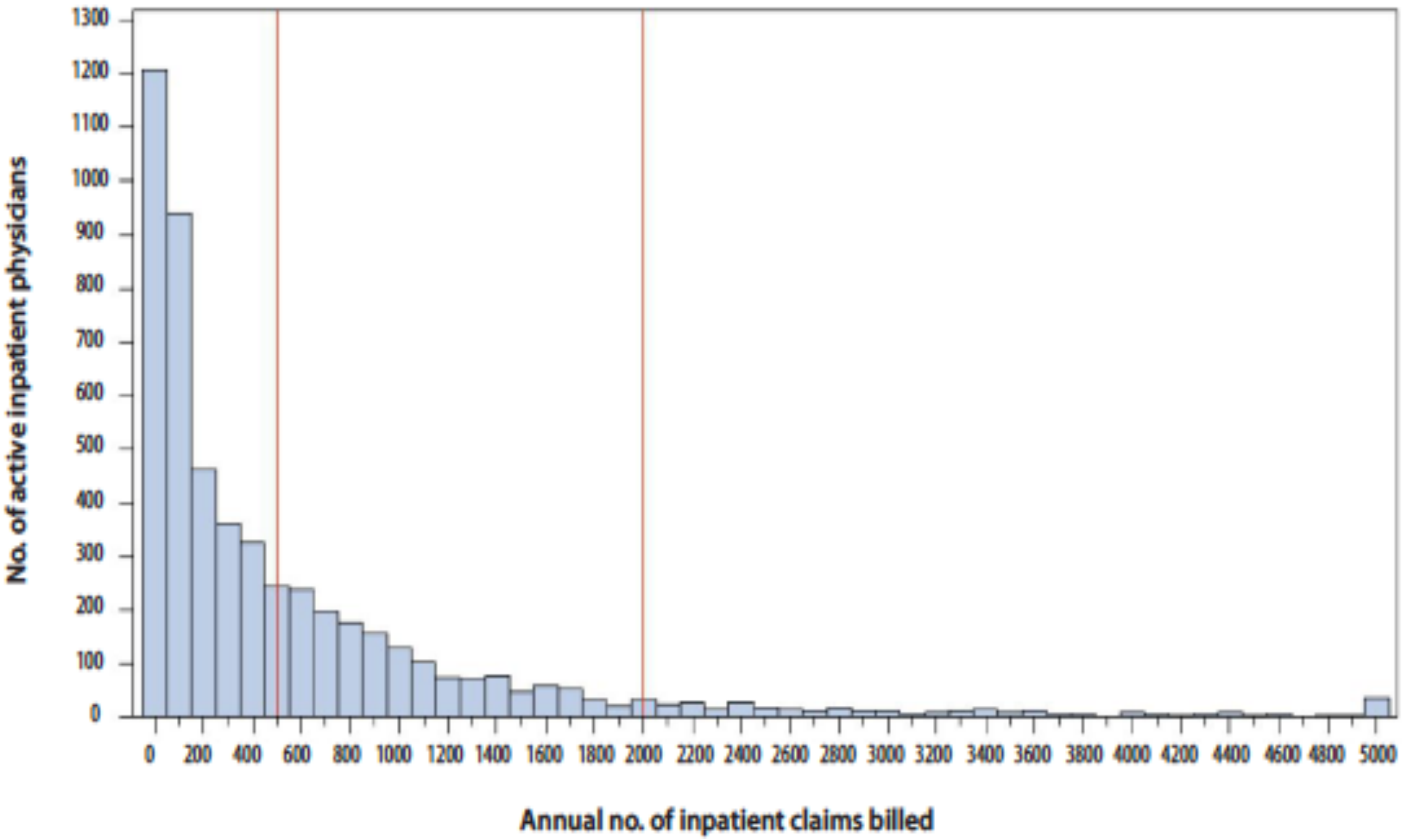
[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 4,281 active physicians with < 10 inpatient claims

3.2 [B] Fiscal year 2000/2001



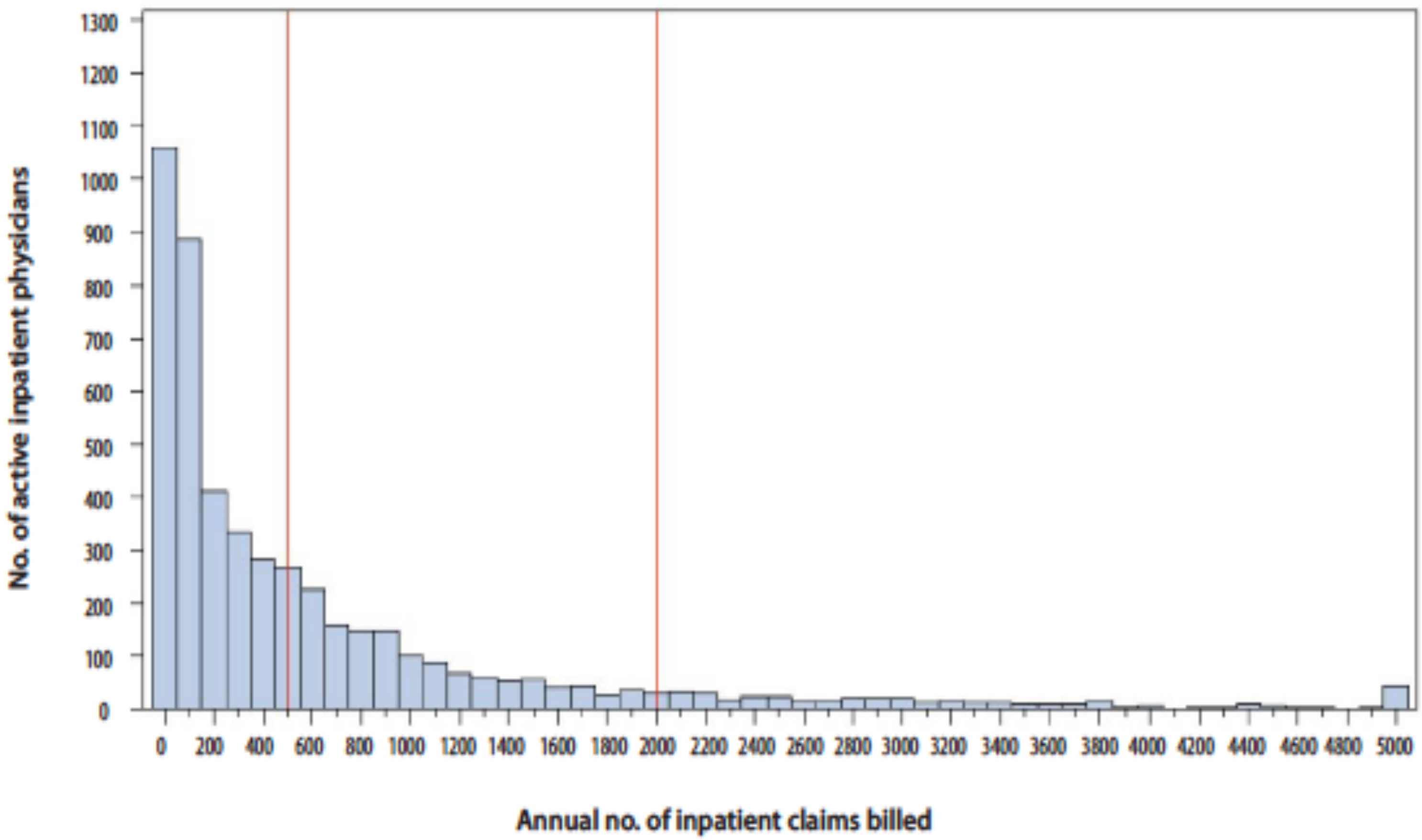
[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 4,989 active physicians with < 10 inpatient claims.

3.2 [C] Fiscal year 2004/2005



[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 6,376 active physicians with < 10 inpatient claims.

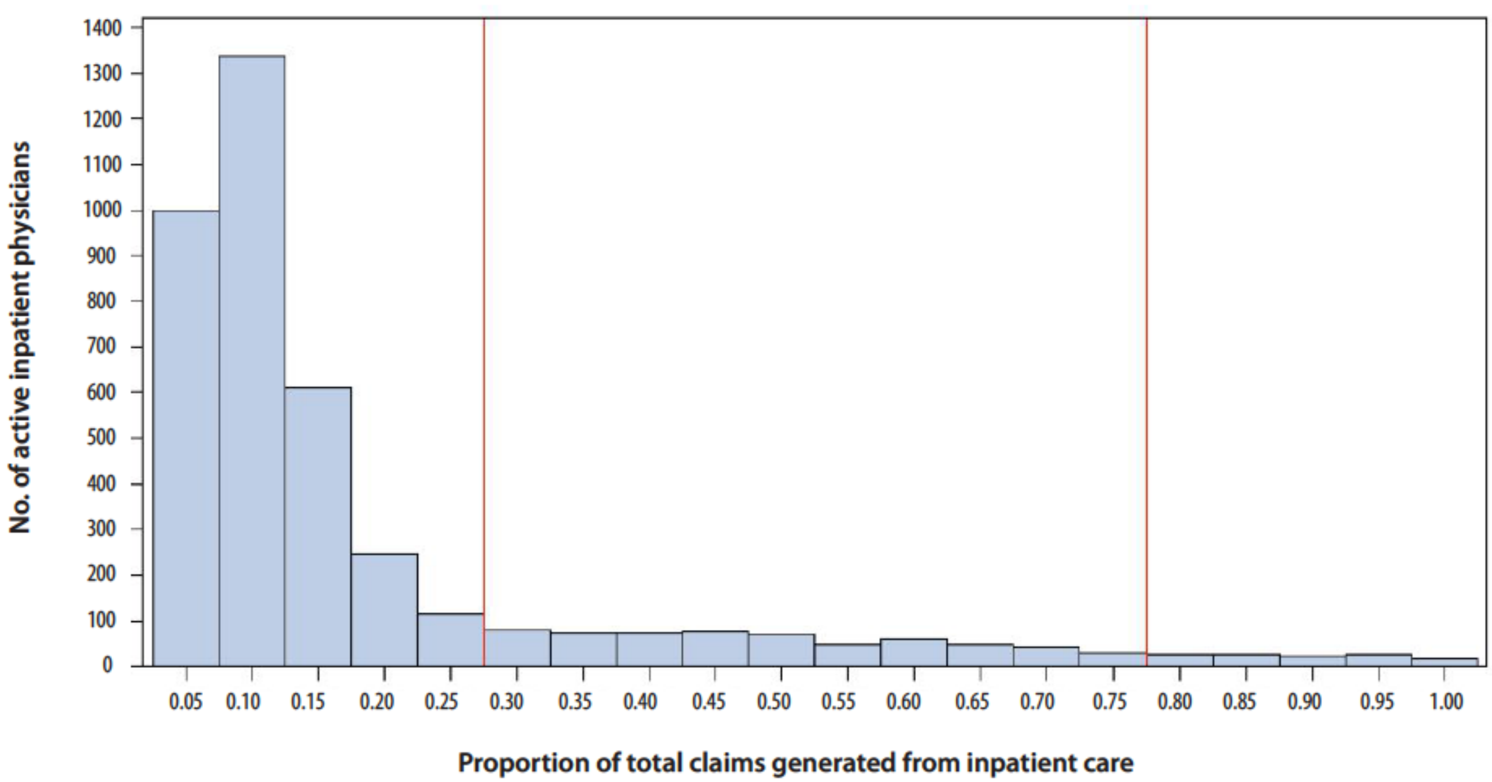
3.2 [D] Fiscal year 2008/2009



[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 7,270 active physicians with < 10 inpatient claims.

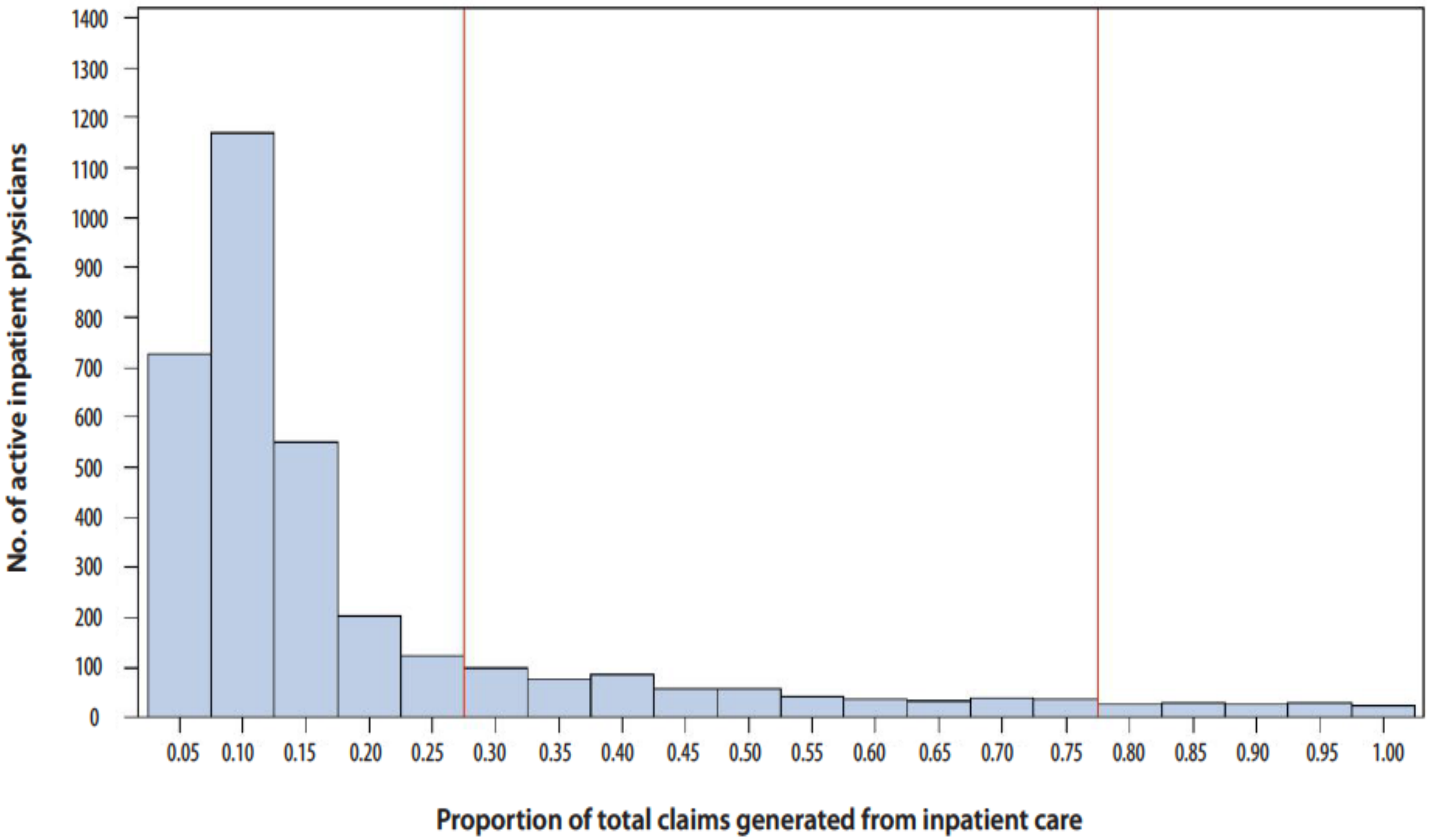
Appendix 3.3 Selected frequency distributions of active Ontario general practitioners, family physicians, and general internists according to the proportion of total claims generated from the care of hospital inpatients.

3.3 [A] Fiscal year 1996/1997



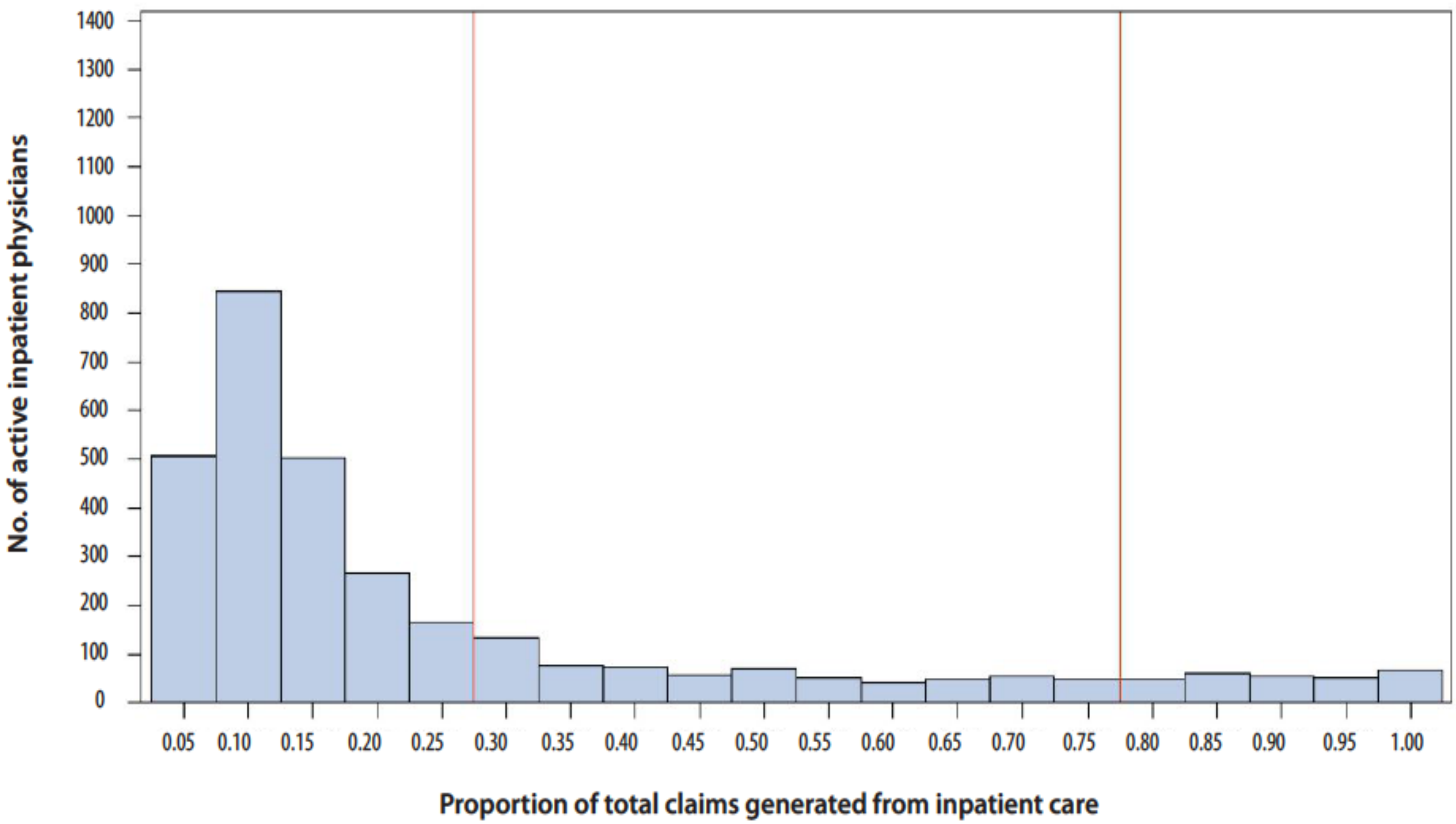
[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 5,152 active physicians with < 1% inpatient practice.

3.3 [B] Fiscal year 2000/2001



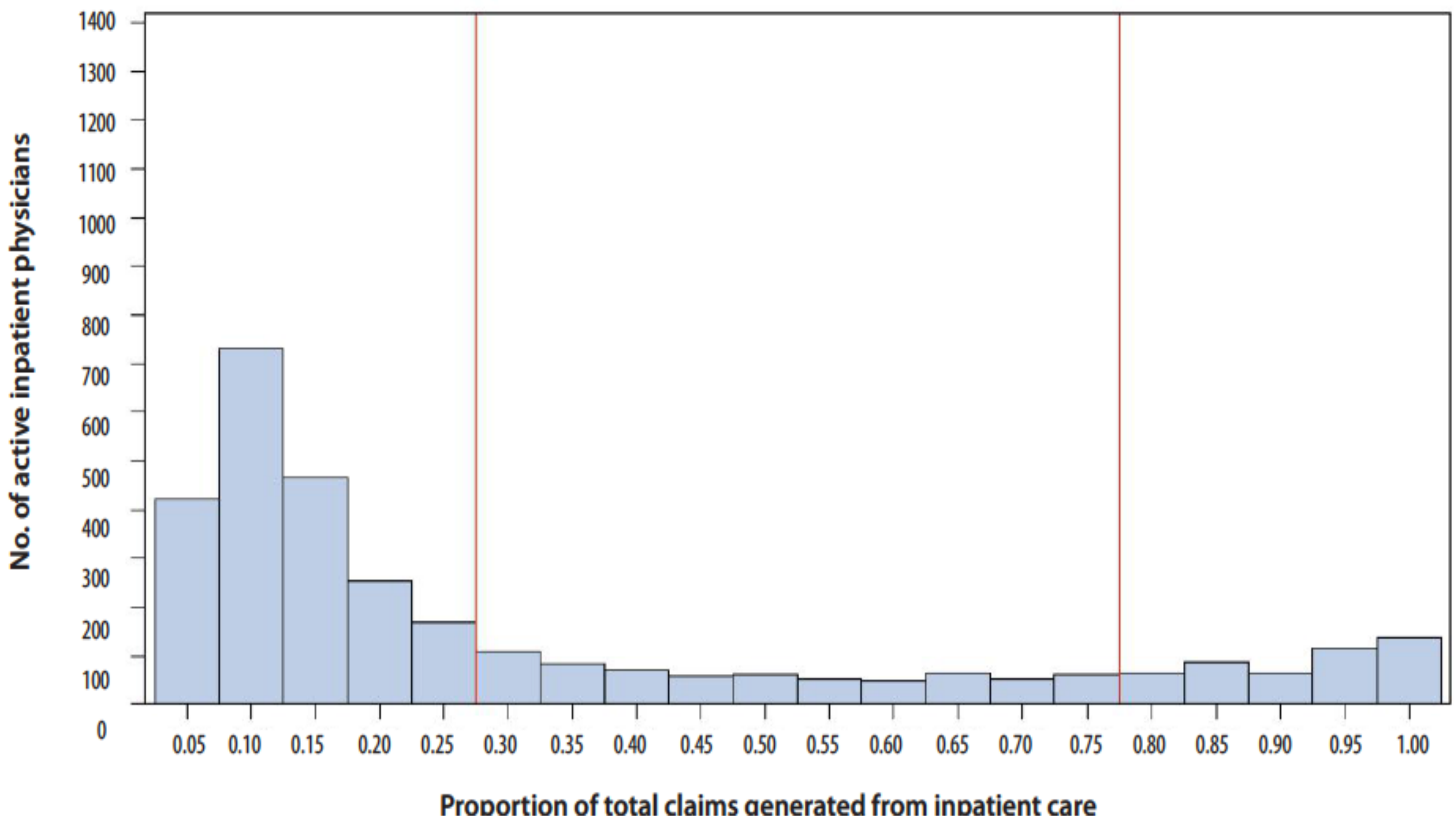
[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 5,921 active physicians with < 1% inpatient practice.

3.3 [C] Fiscal year 2004/2005



[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 7,227 active physicians with < 1% inpatient practice.

3.3 [D] Fiscal year 2008/2009



[a] Vertical red lines indicate the proposed thresholds for part-time and full-time hospitalists from Table 3.1 (pg. 90), conceptual framework. Excludes n = 7,920 active physicians with < 1% inpatient practice.

Appendix 3.4 Proportion of total inpatient evaluation-and-management claims billed to Ontario's Health Insurance Plan (OHIP) by active Ontario physicians, by medical specialty and selected fiscal years.

	Fiscal Year; Proportion of Total Inpatient E&M Claim Billed*				
Medical Specialty	**1996/1997**	**2000/2001**	**2004/2005**	**2008/2009**	**2010/2011**
Anesthesiology	1.7	2.4	3.0	3.5	3.9
Diagnostics	0.5	0.4	0.3	0.2	0.4
General Internal Medicine	14.7	12.9	11.4	8.9	8.9
General Practice/Family Medicine	32.1	29.6	29.7	28.4	27.0
Internal Medicine Specialties	18.8	19.5	20.4	20.8	20.2
Obstetrics & Gynecology	1.0	0.9	0.7	1.1	1.1
Pediatrics	4.3	4.0	4.3	3.9	3.8
Psychiatry	19.4	23.6	23.7	23.1	24.5
Surgery	7.4	6.7	6.4	10.1	10.2

* Proportions may not sum to 100% due to rounding.

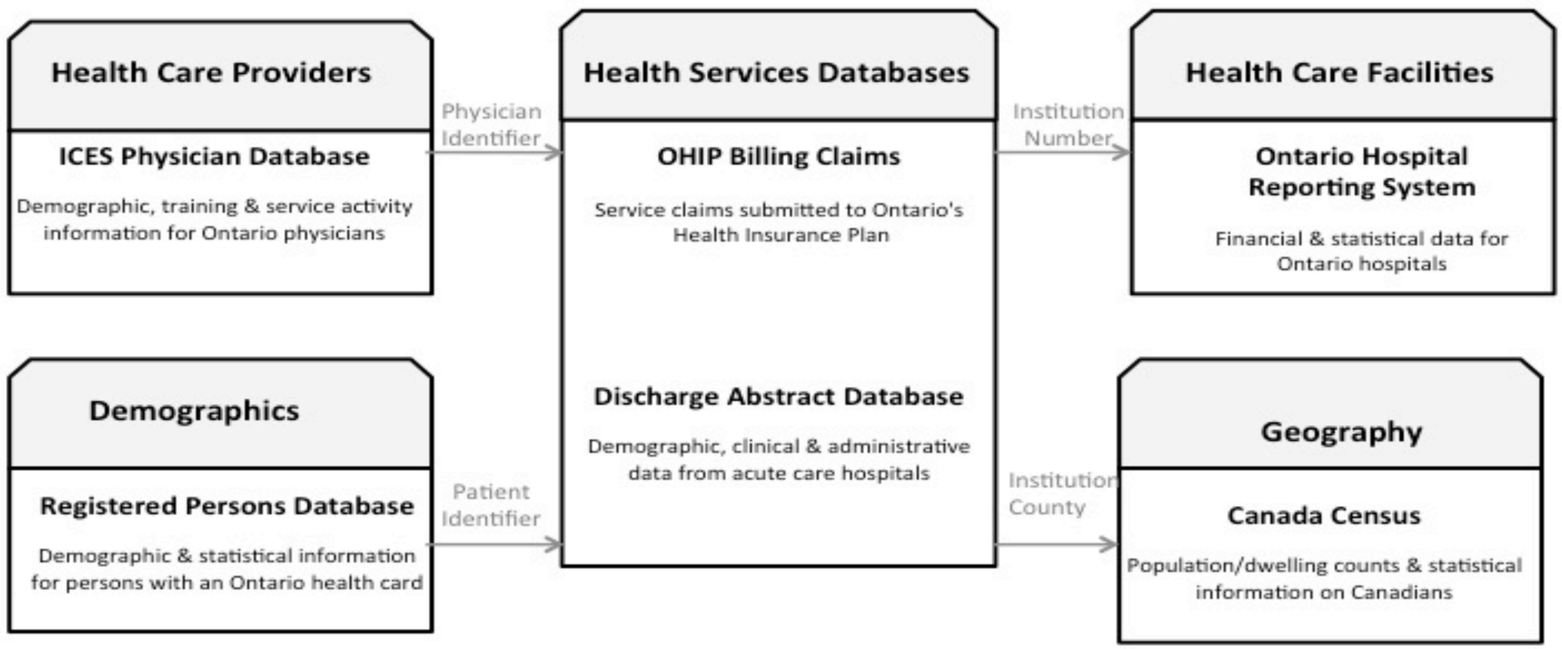
†Diagnostics consists of diagnostic radiology, nuclear medicine, and all laboratory specialties.

Appendix 3.5 Median inpatient volumes billed to Ontario's Health Insurance Plan (OHIP) by physicians providing inpatient services, by selected medical specialty and fiscal years.

	1996/1997		2000/2001		2004/2005		2008/2009		2010/2011	
Inpatient Volume Metric *	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Evaluation-and-Management Claims Billed										
General Internal Medicine	1319 (1357)	967 (1853)	1194 (1306)	868 (1607)	1052 (1185)	659 (1505)	1028 (1111)	619 (1518)	1031 (1147)	569 (1577)
General Practice/Family Medicine	349 (523)	158 (479)	355 (612)	123 (472)	394 (819)	80 (459)	431 (936)	72 (473)	435 (963)	60 (430)
Internal Medicine Specialties	851 (1166)	445 (1224)	834 (1210)	444 (1161)	770 (1133)	374 (1048)	685 (1024)	331 (888)	623 (920)	305 (786)
Pediatrics	550 (721)	343 (741)	512 (622)	336 (632)	488 (645)	318 (615)	415 (746)	272 (501)	368 (584)	257 (475)
Psychiatry	1292 (1562)	657 (1991)	1452 (1608)	873 (2248)	1369 (1524)	811 (2073)	1341 (1434)	847 (1938)	1365 (1426)	885 (1906)
Surgery	392 (477)	222 (502)	335 (447)	161 (451)	326 (455)	149 (401)	484 (539)	328 (602)	474 (517)	330 (602)
Calendar Days With OHIP Claims for Inpatient Care										
General Internal Medicine	174 (114)	188 (209)	157 (108)	166 (206)	136 (104)	127 (193)	120 (92)	104 (152)	115 (90)	10 2 (148)
General Practice/Family Medicine	118 (106)	89 (185)	107 (102)	72 (176)	91 (98)	48 (155)	86 (95)	43 (144)	79 (89)	38 (125)
Internal Medicine Specialties	134 (106)	125 (201)	127 (103)	109 (185)	107 (94)	80 (156)	97 (87)	72 (130)	90 (83)	66 (117)
Pediatrics	135 (106)	116 (194)	126 (94)	117 (157)	107 (85)	92 (130)	90 (72)	76 (111)	83 (67)	74 (100)
Psychiatry	63 (88)	11 (109)	70 (96)	9 (143)	64 (93)	6 (125)	64 (91)	8 (124)	64 (90)	9 (130)
Surgery	144 (102)	140 (184)	124 (98)	107 (171)	117 (94)	98 (156)	153 (99)	158 (172)	150 (97)	156 (166)

* Means with standard deviations in parentheses; medians with interquartile range in parentheses. Physicians who billed fewer than 100 evaluation-and-management claims in 2010/2011 were excluded to prevent skewing of averages.

Appendix 4.1: Description of administrative data sources and proposed linkages



Appendix 4.2 Descriptive characteristics of attending physicians by inpatient clinical claims volume. Ontario, Canada 2009-2011 (*n* = 3,546).

Variables	**Low-Volume (< 500 inpatient claims/year)**	**Medium-Volume (500-1,999 inpatient claims/year)**	**High-Volume (≥ 2,000 inpatient claims/year)**
Sample Size*	2,002 (56.5)	1,209 (34.1)	335 (9.4)
Mean Age ± SD	45.7 ± 10.8	49.1 ± 10.9	46.9 ± 10.6
Mean Years Since Graduation ± SD	18.6 ± 11.3	22.5 ± 11.5	20.1 1 ± 11.2
Male Gender (%)	64.6	73.2	68.4
Canadian Medical Graduate 9%)	83.4	78.6	66.9
General Practice/Family Medicine (%)	87.9	74.3	61.5
Hospitalist (%)	0.0	11.8	52.8
Metropolitan Area of Practice (%)			
Population ≥ 1,250,000	22.7	21.0	38.8
Population 500,000 - 1,499,999	10.5	9.8	13.1
Population 100,000 - 499,999	21.8	24.8	36.4
Population 9,000 - 99,999	19.5	24.4	10.5
Population < 9,000	25.6	20.1	1.2
Average Annual Inpatient Workload			
Mean Inpatient Clinical Services Billed	226 ± 150	978 ± 396	3,217 ± 1,540
Mean Number of Calendar Days Worked in Hospital	92 ± 65	191 ± 79	233 ± 58.3
Mean % of Total Billings Attributed to Inpatient Care	11.7 ± 17.9	29.8 ± 25.1	72.8 ± 22.8

- Means ± standard deviations are shown for continuous variables; frequencies with (%) are shown for categorical variables. Proportions may not add to 100%

Appendix 4.3 Multilevel logistic regression models: outcomes of care by physician clinical claims volume, patient, physician and hospital characteristics/ Ontario, 2009-2011 (*n* = 55,484)

4.3 [A] Mortality within 30-days of admission

	Odds of Mortality (95% CI			
Variable[a]	***Heart Failure***	***Pneumonia***	***COPD***	***Delirium***
<u>*Fixed Effects*</u>				
Annual Inpatient Claims Volume				
Low-Volume	1.00	1.00	1.00	1.00
Medium-Volume	0.78 (0.67, 0.91)	0.73 (0.64, 0.84)	0.93 (0.80, 1.10)	0.82 (0.56, 1.18)
High-Volume	0.69 (0.59, 0.82)	0.62 (0.53, 0.73)	0.79 (0.67, 0.95)	0.81 (0.55, 1.20)
Patient Characteristics				
Age (scaled by 5 year increments)	1.28 (1.20, 1.37)	1.36 (1.31, 1.42)	1.19 (1.15, 1.23)	1.07 (1.01, 1.13)
Gender				
Male	1.00	1.00	1.00	1.00
Female	0.88 (0.78, 0.98)	0.86 (0.78, 0.94)	0.89 (0.80, 0.99)	0.90 (0.70, 1.15)
Age x Gender Interaction	0.93 (0.88, 0.99)	1.02 (0.98, 1.06)	1.05 (0.10, 1.11)	0.96 (0.92, 1.00)
Income Quintile				
Q1 (lowest)	1.09 (0.93, 1.29)	1.10 (0.95, 1.28)	1.04 (0.87, 1.23)	0.93 (0.62, 1.37)
Q2	0.99 (0.84, 1.17)	0.93 (0.80, 1.08)	1.02 (0.85, 1.22)	1.00 (0.68, 1.45)
Q3	0.96 (0.81, 1.14)	0.88 (0.76, 1.03)	1.07 (0.89, 1.28)	0.99 (0.69, 1.47)
Q4	0.95 (0.80, 1.12)	0.98 (0.84, 1.14)	1.03 (0.85, 1.24)	1.08 (0.74, 1.56)
Q5 (highest)	1.00	1.00	1.00	1.00
Predicted Severity at Admission	1.16 (1.09, 1.22)	1.28 (1.20, 1. 37)	1.34 (1.28, 1.40)	1.07 (1.04, 1.11)

Year of Admission (2010/2011)	0.94 (0.84, 1.04)	0.94 (0.85, 1.03)	0.95 (0.87, 1.03)	0.89 (0.70, 1.14)
Disease-specific Comorbidities				
Cancer	2.10 (1.53, 2.88)	5.87 (4.38, 7.87)	-	4.32 (2.56, 7.29)
Cardiac Dysrhythmia	0.92 (0.76, 1.12)	-	-	-
Cardiomegaly	0.94 (0.72, 1.17)	-	-	-
Cerebrovascular Disease	1.12 (0.78, 1.62)	1.70 (1.32, 2.18)	-	-
Cognitive Impairment	-	-	-	1.14 (0.91, 1.42)
Congestive Heart Failure	-	1.35 (1.19, 1.54)	1.18 (1.03, 1.35)	-
COPD	1.22 (1.06, 1.40)	-	-	-
Dementia	1.67 (1.31, 2.12)	2.18 (1.83, 2.58)	-	-
Diabetes	-	0.82 (0.72, 0.95)	0.93 (0.82, 1.07)	-
Drug Toxicity	-	-	-	1.03 (0.67, 1.58)
Fracture (pre-existing)	-	-	-	0.97 (0.72, 1.31)
Heart Valve Disease	1.25 (1.05, 1.49)	-	-	-
Hypertension	-	-	0.94 (0.82, 1.08)	-
Hyponatremia	1.08 (0.82, 1.43)	-	-	-
Hypotension	1.65 (1.12, 2.43)	1.81 (1.30, 2.52)	-	-
Infection/Septicemia	-	-	-	1.56 (1.14, 2.13)
Liver Disease	1.08 (0.52, 2.25)	2.29 (1.52, 3.44)	-	-
Pleural Effusion	-	1.12 (0.88, 1.42)	-	-
Pneumonia	-	-	-	1.14 (1.03, 1.26)
Previous Myocardial Infarction	2.12 (1.53, 2.96)	-	1.31 (0.93, 1.86)	-
Renal Failure	1.95 (1.56, 2.43)	1.94 (1.65, 2.28)	1.22 (1.02, 1.45)	-
Tachypnea	-	1.86 (0.86, 4.05)	-	-

Physician Characteristics				
Medical Specialty				
General Internist	1.00	1.00	1.00	1.00
Family Physician	1.08 (0.94, 1.24)	0.85 (0.74, 0.99)	0.81 (0.70, 0.95)	0.97 (0.69, 1.35)
Gender				
Female	1.00	1.00	1.00	1.00
Male	1.23 (1.08, 1.40)	1.16 (1.03, 1.30)	1.15 (1.00, 1.31)	1.03 (0.79, 1.36)
Age (scaled by 5 year increments)	1.08 (0.99. 1.18)	1.06 (0.97, 1.15)	0.97 (0.88, 1.06)	1.16 (0.98, 1.38)
Years in Practice (scaled per 5 year increments)	0.94 (0.87, 1.02)	0.97 (0.90, 1.05)	1.05 (0.97, 1.14)	0.89 (0.75, 1.04)
Hospital Characteristics				
Academic Hospital				
No	1.00	1.00	1.00	1.00
Yes	0.80 (0.66, 0.97)	0.72 (0.58, 0.91)	0.80 (0.66, 0.99)	0.91 (0.63, 1.32)
Hospital location (residents/km^2)				
Mixed Urban/Rural (≤ 400)	1.00	1.00	1.00	1.00
Urban (> 400)	1.08 (0.91, 1.28)	1.19 (0.99, 1.43)	1.07 (0.89, 1.27)	0.98 (0.69, 1.38)
Random Effects				
Level-two Variance (Physicians)	0.07 (0.04)	0.13 (0.04)	0.09 (0.05)	0.16 (0.10)
Level-three Variance (Hospitals)	0.03 (0.02)	0.08 (0.02)	0.03 (0.02)	0.09 (0.04)
Deviance (-2LL)	10,214	11,944	9,916	2,107

4.3 [B] Odds of 30-day mortality or readmission

	Odds of Mortality or Readmission (95% CI)			
Variable[a]	***Heart Failure***	***Pneumonia***	***COPD***	***Delirium***
Fixed Effects				
Annual Inpatient Claims Volume				
Low-Volume	1.00	1.00	1.00	1.00
Medium-Volume	0.81 (0.72, 0.92)	0.76 (0.68, 0.86)	1.02 (0.90, 1.15)	0.77 (0.60, 1.00)
High-Volume	0.75 (0.66, 0.86)	0.69 (0.60, 0.79)	0.96 (0.84, 1.08)	0.67 (0.51, 0.89)
Patient Characteristics				
Age (scaled by 5 year increments)	1.11 (1.07, 1.16)	1.16 (1.13, 1.19)	1.05 (1.03, 1.08)	0.98 (0.95, 1.01)
Gender				
Male	1.00	1.00	1.00	1.00
Female	0.85 (0.78, 0.93)	0.91 (0.84, 0.98)	0.87 (0.80, 0.94)	0.93 (0.78, 1.10)
Age x Gender Interaction	0.99 (0.95, 1.02)	1.01 (0.98, 1.02)	1.04 (1.01, 1.07)	0.98 (0.94, 1.02)
Income Quintile				
Q1 (lowest)	1.11 (0.98, 1.27)	1.11 (0.98, 1.26)	1.11 (0.98, 1.28)	1.00 (0.77, 1.31)
Q2	0.96 (0.85, 1.10)	0.98 (0.86, 1.11)	1.05 (0.92, 1.20)	0.95 (0.72, 1.24)
Q3	0.97 (0.85, 1.11)	0.92 (0.81, 1.05)	1.04 (0.90, 1.19)	0.93 (0.70, 1.24)
Q4	0.96 (0.84, 1.10)	1.00 (0.88, 1.13)	0.98 (0.85, 1.13)	0.98 (0.74, 1.29)
Q5 (highest)	1.00	1.00	1.00	1.00
Predicted Severity at Admission	1.01 (0.98, 1.03)	1.15 (1.12, 1.19)	1.37 (1.22, 1.52)	1.08 (1.03, 1.13)
Year of Admission (2010/2011)	0.92 (0.84, 0.99)	0.96 (0.89, 1.04)	0.89 (0.82 0.97)	0.96 (0.89, 1.02)

Disease-specific Comorbidities				
Cancer	1.75 (1.37, 2.22)	3.18 (2.55, 3.97)	-	4.11 (2.87, 5.89)
Cardiac Dysrhythmia	1.05 (0.91, 1.22)	-	-	-
Cardiomegaly	0.76 (0.38, 1.51)	-	-	-
Cerebrovascular Disease	1.03 (0.77, 1.38)	1.32 (1.06, 1.66)	-	-
Cognitive Impairment	-	-	-	1.17 (1.03, 1.33)
Congestive Heart Failure	-	1.15 (1.03, 1.29)	1.18 (1.06, 1.32)	-
COPD	1.11 (1.00, 1.24)	-	-	-
Dementia	1.29 (1.06, 1.57)	1.61 (1.38, 1.86)	-	-
Diabetes	-	0.93 (0.87, 1.04)	1.00 (0.91, 1.10)	-
Drug Toxicity	-	-	-	0.97 (0.71, 1.33)
Fracture (pre-existing)	-	-	-	1.04 (0.86, 1.26)
Heart Valve Disease	1.19 (1.04, 1.37)	-	-	-
Hypertension	-	-	0.92 (0.83, 1.02)	-
Hypotension	1.38 (1.00, 1.91)	1.40 (1.04, 1.89)	-	-
Hyponatremia	1.21 (0.97, 1.51)	-		-
Infection/Septicemia	-	-	-	1.52 (1.28, 1.81)
Liver Disease	1.14 (0.61, 2.11)	1.70 (1.22, 2.36)	-	-
Pleural Effusion	-	1.07 (0.87, 1.32)	-	-
Pneumonia	-	-	-	1.09 (0.98, 1.21)
Previous Myocardial Infarction	1.59 (1.22, 2.07)	-	0.98 (0.72, 1.33)	-
Renal Failure	1.60 (1.36, 1.88)	1.53 (1.34, 1.76)	1.08 (0.93, 1.24)	-
Tachypnea	-	1.31 (0.67, 2.60)	-	-

Physician Characteristics				
Medical Specialty				
General Internist	1.00	1.00	1.00	1.00
Family Physician	0.98 (0.88. 1.08)	0.82 (0.73, 0.93)	0.88 (0.79, 0.98)	0.87 (0.69, 1.10)
Gender				
Female	1.00	1.00	1.00	1.00
Male	1.15 (1.04, 1.26)	1.14 (1.03, 1.26)	1.09 (0.99, 1.19)	1.02 (0.82, 1.28)
Age (scaled by 5 year increments)	1.05 (0.98, 1.12)	1.02 (0.95, 1.09)	0.98 (0.92, 1.04)	1.12 (1.06, 1.18)
Years in Practice (scaled by 5 year increments)	0.95 (0.89, 1.01)	0.99 (0.93, 1.06)	1.02 (0.96, 1.08)	0.90 (0.94, 0.97)
Hospital Characteristics				
Academic Hospital				
No	1.00	1.00	1.00	1.00
Yes	0.91 (0.79, 1.05)	0.82 (0.69, 0.97)	0.88 (0.77, 1.00)	0.90 (0.71, 1.15)
Hospital location (residents/km^2)				
Mixed Urban/Rural (≤ 400)	1.00	1.00	1.00	1.00
Urban (> 400)	1.03 (0.90, 1.16)	1.14 (0.99, 1.32)	1.13 (1.00, 1.27)	0.99 (0.79, 1.23)
Random Effects				
Level-two Variance (Physicians)	0.04 (0.02)	0.08 (0.03)	0.04 (0.02)	0.10 (0.04)
Level-three Variance (Hospitals)	0.02 (0.01)	0.04 (0.01)	0.02 (0.01)	0.02 (0.01)
Deviance (-2LL)	15,273	15,874	16,223	3,740

4.3 [C] Acute length of stay

	Percent Change in Acute Length of Stay (95% CI)			
***Variable*[a]**	***Heart Failure***	***Pneumonia***	***COPD***	***Delirium***
Fixed Effects				
Annual Inpatient Claims Volume				
Low-Volume	1.00	1.00	1.00	1.00
Medium-Volume	1.27 (1.22, 1.33)	1.24 (1.19, 1.29)	1.21 (1.17, 1.26)	1.18 (1.09, 1.30)
High-Volume	1.40 (1.33, 1.48)	1.33 (1.27, 1.39)	1.29 (1.23, 1.35)	1.28 (1.16, 1.42)
Patient Characteristics				
Age (scaled by 5 year increments)	1.05 (1.04, 1.06)	1.04 (1.03, 1.04)	1.03 (1.03, 1.04)	1.06 (1.05, 1.08)
Gender				
Male	1.00	1.00	1.00	1.00
Female	1.07 (1.04, 1.10)	1.08 (1.05, 1.10)	1.11 (1.08, 1.13)	0.98 (0.93, 1.04)
Age x Gender Interaction	0.98 (0.97, 1.00)	1.00 (0.99, 1.00)	1.02 (0.98, 1.00)	0.97 (0.95, 0.99)
Income Quintile				
Q1 (lowest)	1.04 (1.00, 1.09)	1.02 (0.98, 1.05)	0.98 (0.95, 1.02)	1.07 (0.99, 1.16)
Q2	1.03 (0.98, 1.07)	1.00 (0.97, 1.04)	1.02 (0.98, 1.06)	1.10 (1.01, 1.19)
Q3	1.02 (0.98, 1.06)	1.00 (0.96, 1.04)	0.98 (0.94, 1.02)	1.03 (0.95, 1.13)
Q4	1.01 (0.97, 1.06)	1.02 (0.98, 1.06)	0.97 (0.94, 1.01)	1.04 (0.95, 1.13)
Q5 (highest)	1.00	1.00	1.00	1.00
Predicted Severity at Admission	1.15 (1.11, 1.20)	1.15 (1.04, 1.26)	1.11 (1.05, 1.1.18)	1.05 (1.03, 1.08)
Year of Admission (2010/2011)	1.02 (1.00, 1.05)	0.95 (0.93, 0.98)	0.99 (0.99, 1.02)	1.04 (0.98, 1.10)

Disease-specific Comorbidities				
Cancer	1.37 (1.27, 1.49)	1.15 (1.08, 1.23)	-	-
Cardiac Dysrhythmia	1.03 (0.98, 1.08)	-	-	-
Cardiomegaly	1.09 (0.98 1.34)	-	-	-
Cerebrovascular Disease	1.23 (1.11, 1.35)	1.13 (1.05, 1.21)	-	-
Cognitive Impairment	-	-	-	1.25 (1.14, 1.37)
Congestive Heart Failure	-	1.25 (1.20, 1.30)	1.24 (1.20, 1.29)	-
COPD	1.20 (1.16, 1.24)	-	-	-
Dementia	1.22 (1.14, 1.31)	1.11 (1.06, 1.17)	-	-
Diabetes	-	1.12 (1.08, 1.16)	1.08 (1.05, 1.11)	-
Drug Toxicity	-	-	-	1.11 (0.92, 1.34)
Fracture (pre-existing)	-	-	-	1.17 (0.96, 1.43)
Heart Valve Disease	1.20 (1.15, 1.26)	-	-	-
Hypertension	-	-	1.09 (1.06, 1.12)	-
Hyponatremia	1.24 (1.15, 1.34)	-	-	-
Hypotension	1.51 (1.35, 1.69)	1.08 (0.98, 1.19)	-	-
Infection/Septicemia	-	-	-	1.64 (1.45, 1.85)
Liver Disease	0.95, (0.76, 1.17)	1.21 (1.09, 1.33)	-	-
Pleural Effusion	-	1.73 (1.63, 1.85)	-	-
Pneumonia	-	-	-	1.32 (1.21, 1.44)
Previous Myocardial Infarction	1.50 (1.37, 1.64)	-	1.31 (1.18, 1.44)	-
Renal Failure	1.49 (1.42, 1.56)	1.21 (1.16, 1.26)	1.18 (1.13, 1.23)	-
Tachypnea	-	1.09 (0.88, 1.34)		-

Physician Characteristics				
Medical Specialty				
General Internist	1.00	1.00	1.00	1.00
Family Physician	1.19 (1.13, 1.24)	1.04 (0.99, 1.09)	1.08 (1.03, 1.13)	1.16 (1.07, 1.27)
Gender				
Female	1.00	1.00	1.00	1.00
Male	0.98 (0.94, 1.02)	0.95 (0.92, 0.98)	0.95 (0.91, 0.98)	0.87 (0.81, 0.93)
Age (scaled by 5 year increments)	1.02 (0.99, 1.05)	1.01 (0.99, 1.04)	1.01 (0.99, 1.04)	0.99 (0.95, 1.04)
Years in Practice (scaled by 5 year increments)	1.01 (0.98, 1.04)	1.02 (0.99, 1.04)	1.00 (0.99, 1.03)	1.01 (0.97, 1.06)
Hospital Characteristics				
Academic Hospital				
No	1.00	1.00	1.00	1.00
Yes	1.10 (1.00, 1.20)	0.99 (0.92, 1.06)	0.94 (0.86, 1.03)	1.17 (1.01, 1.36)
Hospital location (residents/km^2)				
Mixed Urban/Rural (≤ 400)	1.00	1.00	1.00	1.00
Urban (> 400)	1.01 (0.94, 1.09)	0.96 (0.90, 1.02)	1.00 (0.93, 1.08)	0.99 (0.87, 1.13)
Random Effects				
Level-two Variance (Physicians)	0.06 (0.01)	0.04 (0.00)	0.04 (0.00)	0.05 (0.01)
Level-three Variance (Hospitals)	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)	0.04 (0.01)
Deviance (-2LL)	34,743	41,200	42,091	12,701

Appendix 4.4. ICD-10-CA diagnosis codes used to identify dropped study cohorts and condition-specific comorbidities.

Additional Disease Cohorts	**ICD-10-CA Codes**
Admission Diagnosis or Diagnosis Most-Responsible for Length of Stay	
Chest Pain/Angina	I20, R07
Enteritis	A00-A09, J10.8, J11.8, K50-K52
Condition-Specific Comorbidities	
Chest Pain/Angina [276,277].	
Chronic Obstructive Pulmonary Disease	J41-J44
Diabetes with Complications	E10-E14 excl. E10.9, E11.9, E12.9, E13.9, E14.9.
Hypertension	I10, I11, I13, I15
Peripheral Artery Disease	I70-I79, Z95.5, Z95.8, Z95.9
Previous Myocardial Infarction	I21, I25.2
Enteritis/Colitis [278-280]	
Cancer	C00-C97
HIV/AIDS	B20-B24
Renal Failure	N17-N19, R34, Z99.2
Aetiology of Infection:	
Amoebiasis/Protozoa	A06, A07
Bacterial	A00, A03-A05
Salmonellae	A01, A02
Viral	A08, J10.8, J11.8
Non-infectious (Colitis)	K50-K52
Unknown Infective	A09
In-Hospital Complications	
Deep Venous Thrombosis	I26, I80, T80.1
Hospital-Acquired Pneumonia	J12-J18
Hospital-Aquired Sepsis	A04.7, A40, A41, A49.9, T80.2, U80.1, U81.0
Post-Admission Fracture	S22, S32, S42, S52, S62, S72, S82, S92, T02, T10 T12

Pressure Ulcer	L89
Shock/Cardiac Arrest	I21, I46, R57, T78.0, T78,2, T79.4, T80.5, T81.1, T88.2, T88.6
Upper Gastrointestinal Bleed	K22.3, K22.6, K25.1, H25.2, K25.3, K25.9. K26.0, K26.1, K26.
Urinary Tract Infection	N39.0, T83.5