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Medical Practice Variations in Emergency Services

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Abstract

This chapter explores the established literature on medical practice variation in urgent and emergency care. There are important differences between this area and studies of variation in elective care, primarily that demand for urgent care is less under the control of the health system, care pathways tend to be much more complex, and choices are often made under fraught circumstances with incomplete information. The first two sections address the context in which urgent care is delivered, in terms of the way in which care services are structured and factors known to influence the demand for urgent care. The remainder of the chapter summarizes the studies done on medical practice variation in urgent and emergency care, grouped into four main settings in which practice variation may occur: urgent primary care, prehospital EMS, the emergency department, and care following emergency admission to hospital.

Introduction

An emergency is a condition where the patient is, or believed to be, suffering from an illness or injury requiring early assessment and or management, either to save life or limb, to relieve pain and/or suffering, or to prevent further deterioration in a treatable condition in order to reduce morbidity and mortality (College of Emergency Medicine *2005*). By its very nature, care for urgent and emergency cases can be unpredictable. Physicians are faced with an urgent problem but with little or no prior knowledge of the patient and no medical notes. This inconsistency presents sizable challenges to researchers attempting to study medical practice variation in the emergency services.

Another difficulty is that while the care pathway for some hospital services, particularly simple elective procedures, consists of a very limited number of straightforward interactions, urgent care pathways can involve wide range of services, many outside the hospital itself.

Studies of variation in the emergency services must be able to either encapsulate this activity as a whole or focus on a single element of the pathway with appropriate standardization for the many different circumstances of patients passing through it.

From the point of view of variation in medical practice, there are commonly considered to be three categories of care (Wennberg *2010*). These are:

1.

"Effective" care, when there is one clear optimal treatment path for a patient

2.

"Preference sensitive" care, where multiple competing treatment options exist, with trade-offs in terms of risks and benefits for the patient

3.

"Supply sensitive" care, which describes the way in which the availability of a care resource influences the degree to which it is used

In terms of these definitions, emergency care is likely to have a higher proportion of "effective" care (i.e., situations in which hospitalization is the only option) than planned care. One might expect a lower degree of "preference sensitive" care, although studies documented in this chapter suggest that there are still many situations in urgent care where variation is driven by physician attitude. Finally, emergency care is clearly subject to "supply sensitive" care with many studies reporting emergency care resources being used based on their availability rather than patient need.

A study of cardiac care in Ontario, Canada, (Wijeysundera et al. *2010*) illustrates some of the differences in variation patterns between urgent and non-urgent care. Using a province-wide registry of patients waiting for coronary angiography, angioplasty, and bypass surgery, the researchers analyzed the care of nearly 75,000 patients referred for coronary angiography over 1 year. The patients were divided into three categories based on the urgency of their condition, drawn from five clinical parameters that are commonly used for coronary angiography triage. Each urgency score corresponded to a recommended maximum waiting time, and the categories were urgent, recommended to wait no more than 7 days, 39 % of patients; semi-urgent, waiting between 7 and 13 days, 42 % of patients; and elective, waiting 2 weeks or more, 19 % of patients. The study then compared variation in actual waiting time and relationship with recommended waits across the 14 regional Local Health Integration Networks (LHIN) of Ontario for each category. While the median waiting times for urgent cases were comparable across areas, greater differences were seen in the semi-urgent (shortest median wait time was 10 days less than the longest median wait time) and elective (20 days difference) categories. Although the median waiting times for urgent cases were similar, the percentage of urgent cases with waiting times greater than the recommended time did vary across area: from 14.2 % (Toronto Central) to 35.8 % (Champlain). These differences were statistically significant even after adjusting for patient age, sex, socioeconomic status, and underlying urgency score. The authors report that supply-side factors – particularly the availability of catheterization laboratories – had an important impact on residual wait times, although the impact changed depending on patient urgency. This suggests that in regions with limited procedural capacity, there is appropriate prioritization of urgent patients, which in turn will amplify the delays for more elective angiograms. This study demonstrates that variations in urgent and emergency care can have different patterns and drivers than variation in elective care.

The following sections outline common structures of emergency care systems, describe the main factors that drive demand for urgent and emergency care, and then explore studies of variation in various aspects of emergency care.

Service Structure

Most healthcare systems provide a range of responses to patients' perceived need for urgent treatment. In particular, the hospital's role in emergency care depends critically on the services available outside it, including preventative services (Walshe and Smith *2011*). While some elements will be familiar to most (e.g., hospital-based emergency departments or ambulance services), the way in which they are used and supported by other parts of the urgent system (such as telephone advice or nurse-run facilities for minor conditions) varies from country to country. This section describes the most common service structures used around the world.

An urgent and emergency care system has four main components:

1.

An out-of-hours supplement to regular primary care services for urgent cases, providing continuous 24-h access to primary care services

2.

An ambulance and/or paramedic service (often referred to as emergency medical services or EMS) to provide prehospital care in very serious cases

3.

Emergency departments providing specialized clinical skills focused on the assessment and management of urgent or emergent medical needs

4.

Hospitals with 24-h medical, surgical, and intensive care facilities

These elements are often now accompanied by telephone triage services that direct patients to the most appropriate services.

Arnold and colleagues (*2001*) performed an opportunistic, nonrandom survey of emergency medicine professionals from 36 countries. The countries covered a range of development levels, with 15 being from North America, Australasia, or the European Economic Area, 12 from Asia, 5 from Africa, and 3 from Central or South America. The survey found that 89 % of countries had ambulance systems, 97 % had hospital-based EDs, and 50 % recognized emergency medicine as an independent specialty. Throughout the world, many of the components of EM systems taken for granted in more advanced countries are in place in at least one center in the majority of the countries surveyed. However, many of the terms used in the survey lack internationally accepted definitions (even terms like "emergency physician" and "EMS" may be subject to different interpretations from country to country), which presents a challenge when describing the various structures providing urgent medical care around the world.

The description "urgent primary care services" covers just about all aspects for professional prehospital care that do not involve EMS. The focus of these services tends to be on the so-called out-of-hours care, as the regular opening hours of primary providers only cover one-third of a day. These may be provided through home visits to the patient by their regular family doctor outside practice hours, although the decreasing overall number of general practitioners (GPs) and their concerns about out-of-hours workload and 24-h availability have led to dissatisfaction in this group (Philips et al. *2012*). Other forms of service include GP collaboratives providing out-of-hours cover for a wide area and many varieties of urgent care centers. The facilities available in these centers can range from a late opening physician's office to a minor emergency department.

In many European countries, the response to moving beyond GP home visits for out-of-hours urgent care has been to restructure out-of-hours services, generally leading to stronger centralization of primary care centers and a proliferation of choices for patients on where and how to receive urgent care (Philips et al. *2012*). For example, some local health economies have established alternative facilities such as nurse-run minor injuries centers, some with IT links to a main hospital that make it possible to seek expert advice where the diagnosis is not clear (Walshe and Smith *2011*). In England a telephone triage service called "NHS 111" offers telephone triage to members of the general population calling about urgent but nonemergency health problems (Blank et al. *2012*). Calls are triaged by trained nonclinical call advisors and directed to a range of services such as an emergency department, an urgent care center, or a general practitioner. Some calls receive further assessment and advice by a nurse. The USA does not have government-sponsored national telephone triage access, but localized systems exist.

These innovations are not necessarily a panacea, however. Patients sometime need help navigating these new structures, and confusion about which service to use is a common reason for patients to rely on the "trusted brand" of the ED, "where the lights are always on" (House of Commons Health Committee *2013*). While advice lines are often established in the expectation that they will reduce visits to emergency departments, experience in England suggests that some of these facilities may lead to more people seeking advice or treatment (Walshe and Smith *2011*). A study from the USA (Simon et al. *2012*) showed that while the introduction of two new freestanding EDs relieved pressure on the existing hospital-based ED, the three EDs together saw an overall increase in demand. It appears that efforts to better accommodate demand for urgent care tend to increase, rather than reduce, service use.

Emergency medical services (EMS) are a type of emergency service dedicated to providing out-of-hospital acute medical care and transport to definitive care. Treatment by EMS tends to be reserved for the most serious cases. Of the countries surveyed by Arnold and colleagues (*2001*), 89 % had EMS systems and 86 % had a national phone number through which the public accessed EMS. The estimated percentage of patients presenting to hospitals with medical emergencies who arrived by EMS ranged from 2 % (Tunisia) to "almost all" (Germany). A national emergency phone number for public activation of EMS was identified in 31 countries (86 %). Although ambulances are the most common vehicle for EMS, these services can also be delivered by motorcycle, helicopter, or airplane.

Most countries organize their EMS systems around one of two models: the Anglo-American model or the Franco-German model. The difference between these systems is a simple philosophical one: whether it is better to bring the patient to the doctor or send the doctor to the patient. Under the Anglo-American system, ambulances are staffed by emergency medical technicians (EMTs) or paramedics, who are trained to provide a limited set of interventions at the scene with the aim of transporting the patient to hospital to be seen as swiftly as possible. The Franco-German model is physician led, and doctors will travel on the ambulance to provide most medical interventions required by the patient. The aim here is to provide definitive care to the patient until they are medically stable and then transfer to hospital. This is done partly on the basis that high-speed transport is an unnecessary risk.

The most ubiquitous system for emergency patient care worldwide is the hospital-based ED (often with independent status within the hospital). The designation of a place in a hospital where the most acutely ill or injured patients are cared for appears to be a universal feature of emergency care. Hospital-based EDs were reported in 35 countries (97 %), of which 26 (72 %) had independent department status within the hospital (Arnold et al. *2001*). Patients present without prior appointment, either by their own means or via EMS, and will be triaged following an initial assessment with their waiting time to assessment by a physician determined by their clinical need. A study by Sullivan et al.

(*2006*) found that 99 % of hospitals in the USA have an ED – 72 % of these were located in urban areas. However, one in three saw an average of less than one patient per hour of the day per year. Typical higher volume ED had around 28,000 visits per year. Overcrowding is a concern in the busiest EDs of many countries, particularly as visit rates can be highly variable at different times of the day. Any resultant overcrowding has the potential to worsen outcomes for all patients using the ED (Hoot and Aronsky *2008*). When overcrowding becomes particularly bad, a common management strategy is to divert EMS services to another nearby ED.

There is a well-established trend to use hospital EDs for less urgent problems, although the proportion of patients using EDs to whom this applies is debated (Ismail et al. *2013*). This can also contribute to ED overcrowding, as well as being wasteful of resources. The fact that some patients who do not need hospital emergency services nevertheless use them creates a case for shifting the balance of care away from the hospital.

A relatively recent innovation is the introduction of an intermediate step between the ED and full hospital inpatient admission. Observation and assessment wards allow patients to be observed on a short-term basis and permit patient monitoring and/or treatment for an initial 24–48-h period. They permit concentration of emergency activity and resources in one area and so improve efficiency and minimize disruption to other hospital services – for example, planned operations having to be canceled because beds were occupied by emergency patients. Most studies suggest that these wards improve patient satisfaction, are safe, decrease the length of stay, provide earlier senior involvement, reduce unnecessary admissions, and may be particularly useful in certain diagnostic groups (Cooke et al. *2003*). Following the decision to admit the patient into hospital inpatient care, they will be absorbed into the general hospital system. However, the degree to which they mix with services providing planned inpatient care delivered by the hospital varies.

Although most hospitals are open 24 h and every day of the week, the full range of support services (such as rapid imaging/scanning) may not be. For a hospital to offer 24-h availability of the full range of specialties, all facilities and experienced clinical staff treating any severely injured patient represent a large fixed cost that can only be justified at high level of utilization (Walshe and Smith *2011*). In practice therefore it is not economic for small institutions to do so. There is also evidence that smaller centers tend to have worse outcomes (Luft et al. *1987*). As a result many smaller hospital's emergency departments have closed and their activities moved elsewhere. The closure of an ED makes it harder for other activities to take place on the same site, and hence a snowball effect develops which can lead to a loss of all emergency facilities or total closure. In most European countries, the number of hospitals has fallen as the benefits of larger units have been realized.

An important part of this trend for creating regional centers has been the development of care networks linking major hospitals to smaller units, which facilitates a compromise between the need to centralize and easy access for most patients. The case for networks has been promoted for a wide range of conditions, including trauma, cancer, cardiac care, and stroke. Trauma centers dealing with the most severely injured may form part of a network of hospitals, with varying degrees of capacity for treating patients needing intermediate care. For the network to work effectively as a whole, protocols must be in place that determine which patients are transferred "upwards" to the trauma center and for EMS services to take patients directly to the appropriate place of care. Similar "downward" protocols are also required to allow pressure on the central units to be regulated and create capacity for the next wave of high-need patients. Such networks have been introduced in whole or in part in countries such as Canada, Australia, Germany, Norway, and Denmark, and England is in the process of doing so (Walshe and Smith *2011*).

One possible structure of such networks is illustrated by way in which trauma centers are classified in the USA. The American College of Surgeons verifies centers as functioning at one of four levels.

Level 1 centers provide the highest level of definitive care to the severely injured adult or pediatric patient and are designed to care for patients with complex, multisystem trauma. A full medical and surgical staff are available in house and able to initiate resuscitation and immediate surgery on arrival of the patient to the emergency department. Level 2 trauma facilities provide definitive trauma care and subspecialty care for severely injured adult and pediatric patients with complex trauma. Resuscitative measures can be initiated immediately, and surgical support is on call and available to the patient within 30 min. Level 3 trauma facilities provide initial evaluation and stabilization, including non-neurosurgical operative intervention, of the severely injured adult or pediatric patient. A level 3 trauma center will provide comprehensive inpatient services to those patients who can be maintained in a stable or improving condition. Critically injured patients who require specialty care are transferred to a higher-level trauma center. Level 4 trauma centers include small, rural hospitals that provide resuscitation and stabilization of the severely injured adult or pediatric patient before transfer to a higher-level trauma system hospital. Surgical care and intensive care unit capacity are generally limited, if available at all (Newgard et al. *2006*).

The hub and spoke model creates a system of emergency care that allows resources to be distributed efficiently than employing smaller, stand-alone hospitals. However, it can mean that patients travel further for emergency care and rely on successful joint working in all parts of the system. This level of joint working can be achieved by establishing clear shared protocols.

Factors Impacting Emergency Service Demand

There are many factors that might influence the demand for and use of urgent and emergency medical care. Many of these will be beyond the control of the health system and should be adjusted for in any analysis of variation. Most of these key factors are well known and studied: age and morbidity, socioeconomic status and insurance status, and distance from care services. Others are known but less well understood, generally because they are less measurable, for example, patients' attitudes to care. Other variations will be caused by the structure of the health system and medical practice variation, which are less warranted. However, even after adjusting for all the known external causes of variation, there can still be unexpected local drivers of variation to confound studies, such as the presence of industrial plants driving admissions for respiratory conditions (Aylin et al. *2001*). Care must be taken in the interpretation of any results showing unexplained variations.

The impact of increasing age on need for planned and unplanned medical care is well established. With reference to use of emergency hospital care, Blunt et al. (*2010*) showed that people in England over 85 are nearly ten times more likely to have an emergency hospital admission than someone in their 20s, 30s or 40s. The main reason for this is the association between age and morbidity. In the USA two survey-based studies of patients using urgent care (Cunningham *2006*; Shah et al. *2003*) found higher ED use by people in fair/poor health or with chronic medical conditions and higher EMS use for people whose physical and social functioning had declined. Any population-based study of medical practice variation should account for variation in age distributions between areas and any differences in underlying morbidity if such data exist.

Likewise, the impact of socioeconomic deprivation and – where applicable – insurance status on health outcome and use of emergency services is generally accepted. One of the US survey studies (Cunningham *2006*) found higher ED use by poorer people compared to other income groups. However, they also found that the uninsured had about sixteen fewer visits on average (per 100 people) compared to Medicaid enrollees, about twenty fewer visits compared to Medicare enrollees, and roughly similar levels of use compared to privately insured people. In this way, deprivation is

commonly thought of as a barrier to accessing the US healthcare system, leading to worse outcomes. However, the effect of deprivation is still felt in countries with a universal healthcare system, such as Canada. A study by Alter et al. (*2012*) found after tracking 15,000 patients who were initially free of cardiac disease for over 10 years that socially disadvantaged patients used healthcare services more than did their counterparts with higher incomes and education. Interestingly, they also found that increased service use by people with lower incomes and less education had little impact on their poorer health outcomes, particularly mortality. The impact of socioeconomic status on health service utilization is not straightforward and to an extent depends on the characteristics of the health system studied. Nonetheless, it is an important factor of health outcomes, and any observed variations in medical practice should be considered in this context.

The final easily measurable factor in patients accessing emergency care is the distance they live from the source of that care. This in itself is less accepted as a cause of legitimate variation, both because it is easily confounded by its interrelationship with other causal factors (e.g., deprived populations tend to live in urban areas, and hospitals tend to be located in towns and cities) and because the placement of care services is ultimately a function of the healthcare system. However, there is substantial evidence that a patient's distance from care significantly influences their propensity to use it. Imison et al. (*2012*) cited evidence from England that larger GP practices and greater distance from hospital are correlated with lower rates of admission and an inverse relationship between the distance to hospital beds (both acute and non-acute) and bed use. Another study showed that the residents of the English county of Devon (nearly one million people) were less likely to call their out-of-hours primary care provider the further away they lived from a center where the service was delivered (Turnbull et al. *2008*). Patients from deprived areas made more calls, but the effect of deprivation was more evident in urban than rural areas, suggesting that behavior was influenced by deprivation for patients in urban areas, while in rural areas, distance rather than deprivation may influence the decision to call. However, a study by Uva (Uva et al. *2012*) showed that rural populations in the US state of New York were more likely to rely on the emergency department for pediatric care than metropolitan areas, after controlling for insurance type, ethnicity, sex, and clinical risk group category. The distance people live from care services has been shown to impact patterns of service use, although the manifestation of these effects can vary between health systems. While less influential than age, morbidity, and socioeconomic status, studies should consider whether the mix of urban and rural services is likely to be a significant contributor to observed variation.

Less well documented is how the patient's own attitude to their care influences their use of emergency services. Understandably, this is much harder to measure than quantifiable factors such as age, deprivation, or rurality. Blank et al. (*2012*) point to evidence that patients may be more likely to comply with telephone triage decisions which are clinically appropriate and that patient satisfaction with the triage decision also improved the rate of compliance. Hsia et al. (*2011*) studied the proportion of patients who leave without being seen in the ED across the US state of California. They found that the percentage varied greatly over hospitals, ranging from 0 % to 20 %, with a median of 2.6 %. Rates were greater in EDs that saw a higher proportion of low-income and poorly insured patients. Campbell (*1999*) used a questionnaire to 5,000 patients attending general practice in West Lothian, Scotland, to understand variation in patients' perception of medical urgency. They found a wide distribution of perceived urgencies and noted that while deprivation was statistically significant in increasing perceived urgency, the effect was only small. They also observed an association between patients' perceptions of doctor availability (following a non-urgent consultation request) and the patient having a heightened sense of their own medical urgency.

There are other factors that drive variation which are properties of the health system – and therefore could be considered unwarranted. Evidence of "supply-induced" demand in healthcare utilization is

well documented (Wennberg *2010*), with many studies showing that the use of healthcare is more closely correlated with factors such as the number of surgeons available than with population health need. In addition to the care resources available, emergency care use will also be influenced by the quality of those resources (e.g., the effectiveness of preventative care) and the efficiency with which multiple care services are able to provide coordinated care (Blunt *2013*). There will be interphysician variation in resource use, particularly in cases where clear clinical guidelines do not exist. This may be present within departments or be locally concentrated into regional practice variation (Wennberg *2010*). Lastly, physicians may alter their clinical behavior because of the threat of malpractice liability, often termed defensive medicine. This may be particularly evident in specialties at high risk of litigation, such as emergency medicine (Studdert et al. *2005*).

In summary, there are a number of factors that impact the demand for emergency care services. Some are largely outside the control of the health system (e.g., age and socioeconomic status) and should be standardized for in any analysis of variation in service use or health outcomes. Other factors where the relationship is less clear cut or are more challenging to measure should also at least have been considered by researchers as potential explanation for any observed variation. Lastly, there are a number of factors which may induce variation which are properties of the health system itself (e.g., supply of services).

Opportunities for Medical Practice Variation

The remainder of this chapter summarizes published studies on medical practice variation in urgent and emergency care. Pathways for emergency care are often more complex than those for elective care, and a patient with an urgent condition may be seen in several different settings before definitive care is provided. The studies are grouped into four main settings in which practice variation may occur: urgent primary care, prehospital EMS, the ED, and care following emergency admission to hospital.

Primary Care

Patients in need of urgent care will have medical needs that range from minor concerns to serious life-threatening events. The least severe cases will be treated in some form of primary care service. There are three main ways primary care can result in medical practice variation in urgent and emergency services. First, a patient might require urgent care at a time when their usual primary care provider is not available (e.g., outside office hours). Assuming their condition is not thought to be life-threatening, they are likely to use an out-of-hours primary care service. Second, issues relating to their regular primary care (such as poor access to their primary care provider) might result in an exacerbation of a condition that is usually manageable in primary care, but now requires emergency hospital admission. These events are classed as ambulatory care-sensitive admissions and have been the subject of many studies for over 20 years (Blunt *2013*). Lastly, patients may rely on emergency services as their regular source of primary care (e.g., frequent visits to the emergency department for conditions that would normally be dealt with by a family doctor). There are substantial concerns that this is an inappropriate method of delivering care, both from the point of view of congesting emergency department and using expensive hospital resources where not needed, and lack of continuity of care for the patient (Ismail et al. *2013*).

The first interaction a patient seeking urgent care has with the health systems of developed countries may be to have their case triaged over the telephone. In a systematic review of the literature on

appropriateness of telephone triage decisions, Blank et al. (*2012*) examined 28 observational studies from around the world. An “appropriate” triage decision is one that refers the patient to the right level of service, for example, emergency department versus general practice, and with the right timing, for example, immediate use of general practice versus making an appointment in a few days. If triage refers a patient to services which may be unable to deal with the seriousness of the health problem, then it may be unsafe. If it refers the patient to intensive services which the acuity of their problem does not require, then it is inefficient. Similar notions of “appropriateness” are well established in more general studies of medical practice variation (Wennberg *2010*) as is the challenge of assessing appropriateness in the lack of a standardized operational definition or uniform understanding as to what is appropriate and what is not. While many validated triage systems do exist for use in the ED setting, the challenges of assessing the patient over the telephone add an additional layer of ambiguity. In Blank’s review, a median of 77 % of telephone triage decisions were found to be appropriate (but variation between studies was large, between 44 % to 98 %) and the evidence base comparing different types of triages was small and inconclusive. Variation could not be explained by type of service or method of assessing appropriateness. Though it is common for medical practice variation to be explored geographically, none of the triage studies took this approach. This is likely to be because triage services are often located in call centers that will take calls from many different regions, often be hundreds of miles away from the patient. Telephone triage (and newer online services) can be used by urgent care systems with the intention of directing patients to the most appropriate source of care and optimizing the way the system resources are used. Variation in medical practice is not well studied in these services, and their configurations can present some unique challenges for researchers. Variations in routine referrals to secondary care by family doctors, or general practitioners (GPs) (i.e., those made during a practice’s regular opening hours), have been studied extensively. The majority of these referrals will be elective (non-urgent), and a common assumption is that referrals made out of hours would usually be emergencies and therefore less likely to be influenced by medical practice variation. This hypothesis was explored by Rossdale et al. (*2007*) in a 150-doctor out-of-hours cooperative operating in the city of Bristol, England, serving a population of around 170,000 patients. They tested factors that had already been shown to effect doctors’ daytime hospital referral rates, which fell into two groups. Patient factors included age, morbidity, and deprivation and doctor factors included sex, employment status, number of out-of-hours contacts, years since qualification, general practice where they work, and time and place of contact. An extra advantage of studying GP cooperatives is that a large number of doctors cover the same large population, meaning that any variability between GPs should be more apparent than if they were restricted to patients from their own practices. In fact, the study did find substantial variation in raw referral rate for urgent secondary care between GPs in the cooperative. When GPs were grouped into quartiles according to their referral rates, there was an almost fivefold difference in referral rates between the bottom and top quartiles. When adjusting for patient and doctor factors, only three variables were found by the study to be significant factors in explaining the variation: the sex of the clinician, the time of the consultation, and the place of the consultation. The experience of the GP as measured by employment status, number of years since registration, total number of out-of-hours patient contacts, and place of daytime practice did not influence referral rates. Referral rates increased if seen by a female GP, if consultation took place between 11 pm and 7 am, and if the consultation was at the patient’s home. However, while these variables explained some of the variation, there was still a substantial amount unexplained. They concluded that most of the predictors of variation remain unknown and may lie in some of the “softer” doctor factors identified in the literature which a quantitative study was not able to test.

The team extended their study by using qualitative methods to explore these "softer" factors (Calnan et al. *2007*). They include each doctors' satisfaction with the specialty being referred to, perceived importance in making or confirming a diagnosis, clinical guidelines for management and referral, feedback of routine referral data, and past experience of or future threat of litigation or complaint. Many of these factors are based on the notion that high referrers may be more risk averse. The study focused on GPs' own accounts of their decision-making and the reasoning behind their decisions to admit or not. A sample of GPs from across the spectrum of referral rates was interviewed. The interviews explored the importance of a range of different dimensions which included those associated with the GP, the patient, and services.

The researchers found that one way of distinguishing between high, medium, and low referrers was by the way GPs expressed confidence in their skills. Low referrers tended to be confident and placed high importance on their experience as doctors and the length of time they had worked as GPs. In contrast, GPs from the high-referring group tended to talk in less confident ways and sometimes expressed a feeling that their knowledge was insufficient. While all GPs interviewed felt experience was relevant to referral practices, high-referring GPs tended to link their decisions to their experience of negative outcomes and viewed increased caution following negative experiences as a good thing. Confidence also appeared to be related to how comfortable GPs felt with uncertainty, with high- and medium-referring GPs expressing caution and discomfort, while low-referring GPs were more willing to accept a degree of risk. The study notes that their finding that level of confidence was a key element in decision-making has interesting implications given that there are many studies that demonstrate that GPs are poor at judging their own competence (Davis et al. *2006*). While competence was not assessed, they did find that there was close agreement between GPs' own perceptions of their relative referral rates and actual practice, with all five high referrers and all five low referrers being accurate in their assessments of their behavior. However, three with medium status saw themselves as low referrers, one as high, and one did not know their referral status. GPs had not been informed of their referral status before being asked the question. Lastly, they noted that GPs felt they did not have the same access to feedback on the outcomes of their patients – which they could use to inform future referral decisions – as they did in their regular daily practice.

The study also examined physician attitude to available care services and the social situation in which they saw the patient. There was little variation between GPs in the significance attached to the patient's clinical condition (all GPs emphasized the importance of patients' clinical status in their decisions to admit), nor how the GPs perceived out-of-hours care work. However, one GP remarked that they were more likely to worry about out-of-hours care patients than those he sees in his daily practice, because daytime patients have a means of getting back to him should they need to. There were also few differences among referral groups in the importance placed on the social situation of the patient, including the state the patient was in when visited, their housing and general environment, and whether they lived alone. All three groups of GPs said that they took account of what the patient and their family wanted (particularly if this was not to be admitted), but only high referrers said they would be influenced by a patient's wish that they should be admitted. Low referrers were less likely to reverse a decision based on request from patients and family, seeing their role as "selling" their decision to family and carers. The researchers found that some service-related factors appeared to be influential when they concerned the availability of alternatives to inpatient admission and the ease of admission to hospital. Although there were few differences between high, medium, and low referrers in their feelings about the ease of admitting a patient, they did feel the influence of the local commissioner's policy to reduce admissions. Also, high referrers had negative attitudes toward intermediate care which related to difficulties they had experienced in trying to access this for patients. This group of studies demonstrates ways of using both quantitative and qualitative methods

to detect and understand medical practice variation. They also highlight the importance of physician attitude in explaining variation.

The issue of the influence of colleagues on decisions to admit was explored by Rashid and Jagger (*1990*), who looked at six pairs of GP trainers and trainees enrolled in a vocational training scheme in Salford, England. They found trainees as a group referring patients to hospital with a significantly greater degree of urgency than trainers, the significant difference between pairs. However, they also found that while referral rates differed significantly between pairs, referral rates of trainers did not differ significantly from their trainees within the pairings. That is, trainees tended to follow their trainer's referral patterns. They note that this could be one explanation of why differences in referral rates between general practitioners persist, although this finding could be confounded by the influence of practice characteristics and availability of hospital resources.

Ingram et al. (*2009*) used a postal survey to explore GP attitudes to out-of-hours referrals in the same Bristol out-of-hours cooperative studied by Rossdale and others and the two neighboring out-of-hours providers. The survey included 41 questions on the GPs' attitudes to hospital referral. These responses were then compared with GP out-of-hours activity and referral rates and information about the GPs (age, experience, etc.). In contrast to the earlier qualitative study, the correlation between what type of referrer (high, medium, low) GPs thought they were and their referral rates was low, indicating that there was a general lack of awareness about their own referral rate compared to those of others. However, it was statistically significant ($P = 0.002$), and its low value may be related to the small proportion of GPs (5 %) that felt they were high referrers. Of the 41 individual questions on attitude in the survey, only three questionnaire items from the tolerance of risk and uncertainty dimension had statistically significant correlations with referral rates. These indicated that GPs who believe that they are cautious have higher referral rates; those who believe they are carrying out risk assessment and those who believe they are good at living with uncertainty and risk both have lower referral rates. A risk score was derived by summing the responses to these three questions. A linear regression model, controlling for place of visit, had shown that female doctors were significantly more likely to refer patients to hospital than male doctors ($P = 0.039$), confirming one of the earlier results. However, when the risk score was included in the model, the sex difference was no longer significant and the risk score had a stronger association with referral rate ($P < 0.001$), indicating that it is GPs with a lower tolerance of risk that are more likely to admit patients to hospital out of hours irrespective of sex.

Admissions for "ambulatory care-sensitive" conditions (ACSCs) are defined as clinical conditions for which the risk of emergency hospital admission can be reduced by timely and effective ambulatory care. Despite having been in use for over 20 years in countries such as the USA, UK, and Australia, there is still a lack of consensus on which conditions should be included, although most studies employ a list created by the Victorian Department of Human Services in Australia (Purdy et al. *2010*). "Ambulatory care" refers mainly to primary care, community services, and outpatient care. While shortfalls in preventative care for these conditions undoubtedly create extra demand on EDs, the prevalence of these events tends to be measured by the number of emergency inpatient admissions because inpatient diagnostic data are generally more reliable. It is important that an admission of this type is not seen in isolation, but considered in the context of the care pathway that led up to it because this is where the prevention – or lack thereof – happens. Higher rates of emergency admission could indicate suboptimal ambulatory care because the health of the individual had obviously deteriorated. The negative outcome is not that a patient in distress was admitted to hospital, but that their health had deteriorated to a level at which that became necessary. These rates have been used since the early 1990s to gauge access to quality of primary care. Much of the research has focused on relating population factors (such as insurance coverage, socioeconomic status, and ethnicity) to rates of ACSC

admission. However, there is a growing body of evidence comparing variation in rates between areas, and selection of this evidence is presented below.

In one of the original ACSC studies, Billings et al. (*1993*) focused on how the many determinants of age- and sex-adjusted ACSC admission rates in New York city varied by average income at the ZIP code level. They found a consistently strong association between hospital admission rates and area income for a broad range of ACSC conditions. For all ACSCs combined, low-income areas had rates four times higher, with almost 70 % of the variation explained by area income. This so far outweighs differences in disease prevalence and incidence, though they are still important. Similarly, ethnicity had only a small effect in most conditions. Lifestyle factors such as serious alcohol and substance abuse problems explained variations in some conditions for certain age groups. The final factor to be explored was physician decision-making, specifically possible differences in admission criteria among physicians serving low-income patients and those serving high-income patients. The researchers note that these differences in physician decision-making might relate to factors such as differences in clinical training and attitudes toward risk, but might also involve the need to incorporate access-related considerations in the admission decision process for indigent patients, including concerns about linkage to outpatient care, the adequacy of family/social support, or the ability or willingness of the patient to comply with an outpatient treatment regimen. Many of those factors are similar to those studied in GP attitudes to risk studied in the English out-of-hours service.

The method the Billings study used to do this was automated disease staging (based on discharge data), which was used to evaluate the severity of the patient's illness. While this revealed substantial variation among ZIP codes in relative severity levels, it did not display a consistent pattern of higher severity among patients from high-income ZIP codes. For many diagnostic categories, low-income areas had higher levels of severity, suggesting a stricter threshold for admission for low-income patients. For example, in applying disease staging to diabetes admissions, 49.5 % of patients from low-income ZIP codes had disease stage scores of 3.0 or higher, whereas only 38.5 % of patients from high-income ZIP codes had scores in this highest range. This study was later expanded to eighteen urban areas in North America (Billings et al. *1996*), finding that ACSC admission rates differed significantly among the US urban areas studied (Portland, Oregon, had 6.85 admissions per thousand population, whereas New York City had 15.16 per thousand) and large differences between low- and high-income areas remained regardless of citywide rates or geographic area. Substantial variations exist between areas that are not explained by the morbidity of their populations, which the authors ascribe to medical practice variation.

The Department of Veterans Affairs Health Administration (VHA) in the USA operates system-wide electronic medical records (EMRs), which present a useful resource for the study of medical practice variation. Finegan et al. (*2010*) used the VHA's centralized and comprehensive databases to examine geographic variation of ACSC hospitalizations in US veterans' healthcare system. A significant advantage of having access to a full medical record is that the researchers were able to analyze prevalence-based hospitalization rates rather than the population-based hospitalization rates used in most ACSC studies. That is, ACSC hospitalization rates were calculated per 1000 enrollees with an ACSC rather than just per 1000 population. Geographic variation in the raw rate of ACSC hospitalization in the VHA system was notable. Even at network level, the lowest was 30 and the highest was 50 ACSC hospitalizations per 1000 ACSC patients. The researchers also tested a range of patient and provider characteristics in a multiple regression to explain variation between VHA medical centers (VAMC). Although 27 variables were collected and tested for their relevance to ACSC hospitalizations, only 10 were statistically significant and kept in the final analysis. The numbers of ACSC patients seen at each center and case-mix characteristics were the key explanatory variables, which explained 78 % of the variation in ACS hospitalizations. The other eight variables

(two enabling and six provider characteristics) added 12 % of explanatory power. Low income was associated with high ACSC hospitalization rates, as was the number of patients who died in a VHA hospital, number of medical residents, rurality of the hospital, and size of hospital (in terms of building footage). Shorter travel time and more long-term care beds were associated with fewer ACSC hospitalizations. Interestingly, research funding was inversely correlated with ACSC hospitalizations. The number of acute beds was not significant, which may suggest that "supply-induced demand" did not seem to be a major factor for the VHA. After controlling for confounding factors, substantial variation across networks persisted with rates of the highest being 1.4 times that of the lowest. The authors highlight distinct regional patterns in the variation, suggesting broader influences on medical practice variation than simple differences between units. Most of the observed variation was linked to characteristics of patients and their conditions. Some hospital factors where associated with a small degree of variation, and 10 % of observed variation remained unexplained. This emphasizes variation in the underlying prevalence of ACSCs and the importance of adjusting for it when studying variation.

The VHA-based study noted the influence of staff levels on variation in ACSC admission patterns. Chang et al. (*2011*) used ACSC admissions to explore the impact of variation in the adult primary care physician workforce in the USA. They used a 20 % national sample of fee-for-service Medicare beneficiaries (over 65 years old) and analyzed 100 % of their physician and hospital claims, separated into 6542 primary care service areas (PCSAs). A high degree of variation in adult primary care physician workforce was observed across areas, with an almost twofold difference in primary care FTEs per 100,000 beneficiaries between the lowest and highest quintiles (median of 64.7 per 100,000 beneficiaries in the lowest quintile PCSAs versus 103.2 per 100,000 beneficiaries in the highest quintile PCSAs). Beneficiaries residing in PCSAs with lower levels of physicians-to-population ratio were more likely to have had any or multiple chronic conditions, while more beneficiaries residing in PCSAs with higher levels of primary care FTEs had chronic conditions. After adjusting for patient and area covariates, beneficiaries residing in the highest quintile of primary care FTEs had 9 % fewer ACSC hospitalizations. The adjusted rates of the highest compared with lowest quintile were 72.53 ACSC hospitalizations per 1000 beneficiaries compared to 79.48. There were also significant trends in the association of primary care FTEs with mortality and acute care facility Medicare spending. This study suggests that the level of primary care staffing explained some of the variation in ACSC hospitalization rates.

These patterns are not restricted to North America. Tian et al. (*2012*) used a database of all National Health Service emergency hospital admissions in England in 1 year to investigate variations in admissions for ACSCs among English administrative areas known as local authorities (serving around 300,000 people on average). After standardizing for the age, sex, and socioeconomic status of the population in each local authority, they found that emergency hospital admissions for ACSCs in the local authorities varied from 9.2 to 24.5 per 1,000 population. Of all local authorities in England, 73 % (238) were either above or below 2 standard deviations of the mean. However, the authors do note that other factors, such as ethnicity, morbidity level, and environmental factors, that were not adjusted for in the analysis could also explain the variation. In fact, regional variations in ACSC rates are found in many Western countries. Ansari et al. (*2002*) identified significant variations in discharge rates for selected ACSCs at the level of Primary Care Partnerships in the state of Victoria, Australia. Magan et al. (*2008*) observed significant variation in age- and sex-adjusted ACSC hospitalization rates in persons 65 years or older living in different small areas of the Community of Madrid. Sheridan et al. (*2012*) found there was considerable variation in ACSC discharge rates between the counties of Ireland, with significantly lower rates of hospitalization observed in more urban areas including Cork, Dublin, and Galway. It is notable that these variations are observed in many different

contexts and designs of health system. These studies do not suggest causes of these unwarranted variations (beyond some sort of shortfall in the quality or accessibility of primary care), but it is a distinct possibility that they are induced by medical practice variation.

In a similar manner to monitoring hospitalizations for ACSCs (those that should generally be preventable with effective primary care), Ontario's District Health Councils monitor ED visits for a set of "sentinel non-urgent conditions" (SNCs) that could be treated in primary care settings. The SNC indicator is designed to be specific rather than sensitive, hence does not capture all such conditions; however, it is proposed as a marker for ED visits that could be managed elsewhere. Altmayer et al. (*2005*) explored geographic variation in the proportion of ED visits for these conditions across EDs in Ontario, Canada. Patients under 1 year old or more than 74 years old were excluded, as were patients that were admitted to hospital from the ED. Over a 1-year period, there were more than five million eligible ED visits. Of these, about 7 % were for SNCs. Age-standardized rates per 100,000 population were calculated by patient county of residence, irrespective of where the patient received care. Researchers found that the SNC indicator demonstrated much greater geographic variation than total ED visits: comparative rate ratios range from 0.3 to 7.1 for the indicator and from 0.6 to 3.8 for total ED visits. Counties with lower population density had substantially higher rates of ED use for SNCs, whereas in urban counties, the rates of SNCs were much lower. The authors suggest that this might reflect the fact that less populated and more remote communities often have limited access to primary care alternatives, including family or general physicians, nurse practitioners, walk-in clinics, and urgent care centers. However, it should be noted that in some rural settings, ED facilities are intentionally used to deliver non-urgent care. Other reasons for the variability seen include differences in patients' knowledge of local care availability, different patient perceptions about appropriate ED use, or true differences in the prevalence of the sentinel conditions. It seems that unexplained variations are found in urgent hospital use for almost any set of conditions that can normally be managed in primary care, and this exceeds the variation observed in general hospital use.

Another study tried to identify attributes of small-area populations that are related to the provision of high proportions of total ambulatory care in emergency departments (Mustard et al. *1998*). The researchers examined 1 year of ED use for the 657,871 residents of the City of Winnipeg, Canada, split into 112 geographically contiguous neighborhoods, with a mean neighborhood population of just under 6000. The overall proportion of ambulatory care provided by emergency departments was 4.9 %; the proportion varied across neighborhoods, ranging from 2.6 % to 10.8 %. While it is possible that this variation is based on differences in the underlying need of the areas, the study was unable to identify evidence to support this. They give an example that populations with a larger proportion of elderly residents, which might be expected to have a higher incidence of urgent or emergent medical events as a proportion of total need for ambulatory care, were not found to receive a higher proportion of total ambulatory care in emergency departments. Finally, the authors suggest that in the absence of strong evidence that variation was associated with underlying need, the cause could be related to structural features of the distribution of primary healthcare providers and accessibility of conventional primary care. Both studies of variation in levels of primary care being delivered in the ED strike a final, cautionary note. Although patients may be seeking primary care from an inappropriate provider, their reasons for not accessing conventional primary care must be understood and addressed, or strategies to divert non-urgent patients from the ED may not result in cost savings and could lead to inappropriate and potentially harmful refusal of care.

In summary, these studies have shown many examples of variation in primary care, even after adjusting for factors such as age and sex. Some of these examples were explicitly linked to medical practice variation, such as the way primary care physicians refer patients for unplanned hospital admissions out of hours. In these cases variation tends to be associated with the time and place of

consultation, the physicians' personal approaches to managing risk, and also the availability of other services. Other types of variation – such as the rate of unplanned hospital admissions that should be preventable with good primary care – demonstrate variations which cannot be explained by population health need factors alone and may be caused by medical practice variation.

Prehospital Emergency Medical Services

Patients with severe medical emergencies are likely to call for mobile emergency medical services. These can take the form of basic or advanced life support ambulances and paramedics on motorcycles or even helicopters and airplanes. These services are often delivered in complex situations and many factors influence outcomes, making studies of medical practice variation more challenging. In particular, it is hard to differentiate demand for the service (warranted variation) from supply-induced demand due to service structure (unwarranted variation).

For example, Shin et al. (*2012*) described EMS systems operating in seven countries of the continental, southeastern, and East Asian countries, covering a population of around 300 million people. They used a web-based survey to create a baseline study of the 11 EMS systems, addressing population demographics, service levels, provider characteristics, and system operations. The EMS systems were defined as areas with their own dispatch systems, ground ambulance, destination emergency hospitals, and service protocols. Nine EMS systems covered urban areas, while the other two were a mix of urban and suburban. They found that the average numbers of ambulance stations and ambulances per 100,000 population were 1.2 and 1.5 (range 0.0–2.3 for stations and 0.3–3.2 for ambulances). The average number of all EMS practitioners (EMTs and paramedics) per 100,000 population was 12.6 (range 4.0–55.7). The number of transports over 8 months per 100,000 population ranged from 1,916 to 6,205. These utilization rates may be related to accessibility of EMS or EMS call incidence itself.

In the USA, only a small percentage of patients seen in emergency departments are transported by ambulance, and children use ambulances less frequently than adults. Private transportation is the predominate mode of transport to the ED for pediatric patients in all critical care categories (except spinal cord injury). Maio et al. (*1996*) studied the relationship between pediatric transport rates per hundred thousand child population and socioeconomic status factors across four EMS Medical Control Authorities (MCAs) in Michigan, USA. The researchers used a methodology based on Wennberg's small-area analysis of variation in medical resource utilization to analyze records of over 3,000 cases that were responded to as a nonscheduled emergency response and resulted in the patient being transported to a hospital by ambulance. They found substantial differences in pediatric transport rates between the MCAs. While there was no evidence that differences in the MCA population age structure were confounding the findings, it was suggested that transport rates of children under 5 years old were driving the variation. The study noted significant inverse correlations between transportation rate and income, educational level, and availability of personal transport. However, there was no significant correlation between transport rate and primary care physicians per 100,000 pediatric population. They also examined mortality, noting that increased ambulance use was significantly correlated with a higher death rate from EMS-related diseases. Not only do rates of EMS use vary by area, but so do the rates at which EMS services transfer patients to hospital.

While the Maio study is useful, it is relatively small and constrained to four areas. Peacock and Peacock (*2006*) examined differences in workload of ambulance services across England and investigated factors linked to high demand. Combining emergency call numbers with area-level population characteristic data across 27 ambulance service areas in England at two time points, 5

years apart, they found that call rates varied widely across the country. Their most recent data noted that London was the highest (140 calls/1,000), with Hereford and Worcester having the lowest call rate (60 calls/1,000 people). They found a moderately strong positive correlation between call rate and deprivation for both 1997 and 2002 (r = 0.49 and 0.53, respectively). There was a stronger positive correlation with population density for both years (r = 0.70 and 0.68). There was no evidence that these effects were confounded by differences in age distributions. However, these two factors only explained 56 % of the total variability in call rates between areas, and hence a substantial proportion of the variability remained unexplained.

Air medical transport is an important component of trauma care in some countries. However, there are persistent and significant challenges in the identification, at the time of prehospital vehicle triage, of patients who will likely benefit from air medical dispatch. Tiamfook-Morgan et al. (*2008*) explored regional variation in how often helicopter emergency medical service (HEMS) request met the triage guidelines in four regions of Massachusetts, USA. Based on 100 trauma scene requests, they found that 73 met the HEMS triage guidelines. There was broad variation (50–94 %) between different regions' likelihood of guideline-compliant HEMS missions. A multivariate analysis revealed that age and transport distance significantly contributed to the probability of the guidelines being met. A model including these variables and mechanism of injury showed a significant association between referring region and likelihood of meeting the criteria. This confirmed that the association between referral region and guideline compliance remained even after adjustment for patient characteristics and logistics. However, they note that the rigorous nature used to judge compliance with the criteria may not have done justice to prehospital providers' need to exercise judgment. Prehospital providers may be making helicopter activation decisions that – while falling outside the agreed-upon guidelines – represent rational use of HEMS. The implication is that different regions may have different thresholds for HEMS activation. Other than regional variation in the appropriateness of HEMS use, there were few easily identifiable predictors of the alignment of air medical dispatches with triage criteria.

In addition to the variation in the levels of use of emergency medical services, there are also opportunities for medical practice variation in treatment decisions made in the prehospital setting. Zive et al. (*2011*) studied site-level variation in transport practices following EMS assessment of patients suffering out-of-hospital cardiac arrest (OOHCA). The Resuscitation Outcomes Consortium (ROC) is a network of 9 regional clinical centers consisting of 11 major North American sites investigating OOHCA including US and Canadian communities with geographic dispersion and diversity, serving an estimated 23.7 million population and including more than 260 EMS agencies (made up of fire-based and private and third-party governmental EMS agencies). Around 30,000 patients were divided into two groups: those where resuscitation had been attempted (58 %) and those where it had not. The untreated group included patients with known do-not-resuscitate orders, those for whom treatment was considered futile (as defined by protocol or law at each site), and those who were obviously dead. For patients where resuscitation was attempted, 59 % were transported to hospital and 8 % survived to hospital discharge. While the majority of patients encountered across all sites were treated by EMS, site values range from 36 % to 69 %. Significant site-level variation was also identified in the proportion of treated patients who were transported (49–88 %) and survival to hospital discharge for both EMS-assessed (0.7–8.3 %) and EMS-treated (1.9–16.0 %) patients. Most transported patients had transport initiated without documented return of spontaneous circulation (ROSC), but again this varied significantly by site (14–95 % transports initiated). Despite site variation, survival outcomes were notably better for patients transported after ROSC (18–44 % survived) compared with those transported without documented ROSC (1–21 % survived). The same registry was also used by Nichol (Nichol et al. *2008*) to explore incidence and outcomes of OOHCA.

They report similar regional variations (fivefold variation in survival after EMS-treated cardiac arrest and fivefold variation in survival after ventricular fibrillation) and also suggest that it is plausible that the use of secondary prevention in patients with established cardiovascular disease is more common in some regions compared with others. While this would reduce the occurrence of OOHCA if secondary prevention attenuated the risk of arrhythmia, the magnitude of regional variation in medication use is much less than the magnitude of variation in cardiac arrest observed by Nichol and others. They also note the influence of bystander CPR on outcomes, yet only 31.4 % of treated cardiac arrests (84.8 % of bystander-witnessed) received it. These studies identify the presence of variation in treatment decisions and outcomes in EMS. However, they also illustrate the complexity of studying medical practice variation in this setting, for example, the degree of variation being induced by the action of bystanders.

EMS involvement with patients suffering major trauma may still be required even after the patient reaches a hospital. Often persons presenting to non-tertiary care facilities can be stabilized and rapidly transferred to higher-level centers for specialized care. Both the variability of interhospital trauma transfer practices among non-tertiary care hospital EDs and factors (clinical, demographic, and hospital based) associated with the ED transfer of injured patients to a tertiary center were explored by Newgard et al. (*2006*). Using data from the Oregon Trauma Registry in the USA, the researchers assessed transfer patterns between 42 non-tertiary care hospitals over a 6-year period. In that time, more than 10,000 patients presented to a non-tertiary care hospitals and required either admission or interhospital transfer. Just over 40 % were transferred to a trauma center. They used 21 clinical, demographic, and hospital-level variables potentially associated with interhospital transfer from the ED to a tertiary care hospital. A multivariable logistic regression models demonstrated several clinical, demographic, and hospital-based variables to influence transfer. Those that increased the likelihood of transfer were comorbid conditions, age 0–14 years, hospital type, injury severity, and level of hospital. Those that reduced it included being intoxicated, age older than 74 years, having a cardiac arrest in the ED, mechanism of injury, having a chest tube placed, and increasing distance from the nearest higher-level center. The study found substantial variability in interhospital transfer patterns between hospitals that persisted after stratifying by hospital level and adjusting for important clinical, demographic, and hospital-level factors. The adjusted odds ratio for transfer from individual hospital EDs ranged from 0.27 (95 % CI = 0.13–0.56) to 25.2 (95 % CI = 10.2–62.3). The authors note that ideally, determining whether an injured patient requires transfer to a higher level of care hospital should be based on clinical factors, resource availability, and patient need, yet the results suggest that several other factors may be motivating transfer decisions and the non-tertiary hospital in which the patient presents is the strongest predictor for whether an injured patient is transferred to a tertiary center.

While there is clearly substantial variation, it is impossible to know which levels of transport may be "correct." Lower levels of transport may represent undertriage, whereas high levels may be overtriage. However, even within the overall rate of transport from a site, there may be variation in the accuracy of triage, meaning that overtriage and undertriage can be present simultaneously. As noted by Tiamfook-Morgan et al. (*2008*), the American College of Surgeons (ACS) has posited that an undertriage rate of 5–10 % for triage to high-level trauma center care is considered unavoidable and is associated with an overtriage rate of 30–50 %. There is no universally accepted rate of appropriate overtriage and undertriage, and in fact there is no "gold standard" for measuring triage accuracy. Furthermore, the triage situation is also becoming increasingly complicated by system issues which range from ED diversion to subspecialist unavailability. The lack of an ideal standard increases the likelihood of medical practice variation.

In addition to the North American Resuscitation Outcomes Consortium (ROC)′s work on out-of-hospital cardiac arrest, it also maintains a prospective multicenter observational registry of severe traumatic injury called the ROC Epistry-Trauma. Covering institutions in eight US sites and three Canadian sites with a total catchment population of 20.5 million, it was used by Minei et al. (*2010*) to explore the annual incidence of cases of severe traumatic injury per 100,000 population over a 12-month period. There were around 7,000 cases, with wide variability in injury mechanism across sites. For example, the proportion of motor vehicle occupant injury ranged from 15.2 % in Toronto to 45.3 % in Alabama. The proportion of patients pronounced dead in the field ranged from 5.5 % in Seattle to 21.8 % in Vancouver. When the incidence rate was adjusted for age and sex, the incidence per 100,000 census population ranged from 14.3 to 95.3 (median 37.4, IQR 24.6–69.6) and the adjusted mortality rate per 100,000 census population ranged from 3.8 to 29.2 (median 7.6, IQR 5.2–16.2). The rate of severe traumatic injuries transported also varied; the adjusted incidence per 100,000 census population ranged from 11.0 to 78.6 (median 27.7, IQR 14.1–43.4). Geographic variation on all measures was significant ($p < 0.001$). The authors propose that the observed differences in incidences and outcomes likely reflect differences in the underlying risk of severe trauma, as well as the local approach to organizing emergency response and post-resuscitation care in hospital. The results of their study suggest that differences in injury mechanism may partly – but not completely – explain differences in outcomes. Approximately half of the deaths recorded by the study occurred after arrival to hospital and were not immediately lethal. The authors call into question variation in hospital volume, resources, operating room availability, resuscitation techniques, and intensive care and post-injury management protocols as potential contributors to the variation in outcomes. They note that the twofold variation in survival after severe trauma demonstrates that severe trauma is a treatable condition. It seems that variation in this particular aspect of EMS is strongly influenced by design of services, which is one aspect of medical practice variation.

In summary, variations in EMS services are particularly challenging to study for a number of reasons. The studies that have attempted this found notable variations in demand for services, treatment decisions made by those services, and outcomes for patients. However, the sheer variability in settings and contexts in which EMS services are delivered requires extensive data collection to be able to adjust for the many factors that may influence care. In the absence of these data – and accepted guidelines for decision-making – it is difficult to establish what degree of the observed variation is due to medical practice variation.

Emergency Departments

Just as with prehospital urgent care, use of emergency department (ED) services is closely related to population health need. However, while it is true that a large proportion of underlying demand is linked to demographic factors and health need, some demand can be generated by the structure of the health system itself.

A common reason for presentation to the ED is respiratory difficulties, such as moderate to severe exacerbations of asthma. Asthma control can be elusive, and some people with asthma return frequently. Rosychuk and coauthors (*2010*) used large population-based administrative health databases to explore interregional differences in the province of Alberta, Canada. Specifically, they compared the presentation rates, outcomes, ED visit durations, and follow-up visits based on the hypothesis that the major urban regions of Edmonton and Calgary would differ from the rest of the province – so-called non-major urban (NMU) regions. The researchers monitored all ED visits coded with a defined set of asthma diagnoses over a 6-year period – a total of nearly 200,000 visits,

approximately 2 % of the total number of ED visits for any reason in the province. Patients were assigned to the regional health authorities (RHAs) where they lived, rather than where they attended ED, and visit rates were directly standardized by age and sex. While the rates in Edmonton and Calgary (8.3 visits per 1,000 people and 6.9, respectively) were relatively stable over time, the study notes that NMU regions started the 6-year period much higher (around 21 visits per 1,000 people) but declined until the second half of the study period where rates stabilized around 15.5 visits per 1,000 people. All regions had statistically different rates ($p < 0.001$ for each year). The same team also explored variations in ED use for patients with exacerbations of their chronic obstructive pulmonary disease (COPD) (Rowe et al. *2010*). Many patients who experience severe attacks require assessment in EDs and, due to severity and comorbidities, often require prolonged treatments there. While there are standardized treatment guidelines for COPD, there are differences between countries and between EDs. Using the same 6-year extract of Alberta administrative health databases, the researchers examined outcomes at the conclusion of an ED visit and subsequent follow-up visits (both in ED and non-ED settings) for older adults presenting to EDs for COPD. During the 6-year study period, there were 85,330 ED visits for acute COPD, of which 67 % were discharged from the ED. Median ED length of stay was longer in large urban areas (Calgary, 5 h 9 min; Edmonton, 4 h 58 min) than in other regions of Alberta (1 h 17 min). Admissions resulted from 32 % of visits and varied among regions.

The authors suggest that the lower rates in urban regions might be explained by acute asthma cases being treated outside the ED, either because of ED overcrowding, improved access to after-hours care in major centers, or improved application of evidence-based management in primary care. Also, higher rates in NMU regions might reflect the more limited care options available to rural patients; if this is true then it implies that asthma cases treated in NMU EDs should in general be less severe than those treated in the urban regions. Support for the ED overcrowding theory comes from the observations that the patients with asthma who presented to Edmonton and Calgary region facilities experienced longer stays regardless of whether they were discharged or admitted to hospital. These studies both observe significant unexplained variation and present a plausible link between the variation and service structure. However, a key challenge is to quantify the degree of variation attributable to such factors.

Using data from the 2003 Community Tracking Study (CTS) household survey in the USA, Cummingham (Cunningham *2006*) examined the extent of variation in ED use across communities and how this variation is related to many of the population and health system characteristics commonly proposed as explanations for the rising number of ED attendances. The survey collected data on health insurance coverage, access to care, and use of services in sixty randomly selected communities covering about 46,600 people. The respondents were asked how many times they had attended the ED in the last 12 months and which of those attendances resulted in inpatient stays. The researchers used a person-level multivariate regression analysis to examine the impact of various factors on discretionary ED usage (interestingly, the study discounted visits that resulted in inpatient admission on the basis those visits were the least discretionary). Person-level variables were derived entirely from the CTS household survey and included age, sex, ethnicity, general health status, number of chronic conditions, citizenship status, and insurance status. These were combined with community-level variables describing health system factors such as indicators of outpatient capacity constraints, a deprivation measure, and measures of the availability and proximity of hospital EDs. The study found considerable variation in ED use across the twelve CTS case study sites. While average was around 32 ED visits per 100 people, this varied from a high of almost 40 visits per 100 in Cleveland to about 21 visits in Orange County, California. In the regression model, insurance status and demographic, socioeconomic, and health factors are strongly related to individuals' ED use. However, ED use was significantly associated with the following features of the health system:

- Communities with high-ED use tended to have greater outpatient capacity constraints than communities with lower ED use, as indicated by significantly longer average appointment waiting times.
- While high-ED-use communities also contained more hospital EDs relative to the population than low-ED-use communities had, the study found no statistically significant differences in the average distance to the ED between high- and low-use communities.
- Longer waiting times for appointments with physicians and a higher number of physician office visits relative to the number of physicians in a community tended to increase ED visit levels. The authors suggest that may reflect the fact that physicians with full practices more likely to refer such patients to the ED.
- The study also found that enrollment in HMOs tended to suppress people's use of EDs, but only in the lower-income groups.

However, the cumulative effect of all these population and health system factors explains only about 40 % of the variation between sites (with population characteristics alone explaining 25 % of the variation). When controlling for these factors, the difference between high-ED-use communities and low-ED-use communities was still 14 visits per 100 people.

While enjoying extensive coverage of the USA, the Cummingham study was based on patient self-reported usage of the ED. Lowe et al. (*2009*) on the other hand made use of administrative claim datasets for all Oregon Medicaid enrollees to explore regional variation within that state. This was composed of 130 primary care service areas (PCSAs), which had an average population 27,340 – although the number of subjects enrolled in each PCSA varied from 56 to 41,647. The analysis was done by first adjusting the PCSA ED utilization rates for enrollee demographics (age, gender, ethnicity, Oregon Health Plan eligibility – an enhancement to Medicare) and chronic conditions, and then a linear regression was used to determine the association between PCSA characteristics and ED use. The PCSA characteristics were distribution of ethnicity, levels of poverty, levels of hospital access, staffing levels, and primary care capacity. Crude estimates of ED visit rates showed more than a 20-fold variation. After adjusting for enrollee characteristics, significant variation remained. While patient-level explanatory variables were generally statistically significantly associated with ED use, the effect size was sometimes of little practical importance. In the final multivariate model, three community characteristics showed significant association with ED utilization rate, including primary care capacity (when expressed as the estimated ratio of available to needed provider visits), driving time to the nearest hospital, and presence of a hospital in the PCSA. More primary care capacity and longer driving times were associated with less ED use, while the presence of a hospital within the PCSA increased it (this factor remained significant even after a further adjustment for driving time to the nearest hospital). The study concludes that these three community characteristics explained about 40 % of the variation in the predicted ED utilization rates – similar to the results of the Cunningham study.

Medical practice variations, as well as variation in service demand, also exist in the way patients are treated once they arrive in the ED. Pediatric head trauma is a common presentation at EDs in the USA. However, pediatric traumatic brain injury (TBI) requiring neurosurgical intervention is far less frequent. While pediatric TBI can be readily diagnosed with computed tomography (CT), such evaluations carry a heavy public health burden of cost and radiation exposure and use of clinical decision rules for mild TBI – if reliable – would be preferable. Mannix et al. (*2012*) explored variation in CT use in children (<19) with minor head injury discharged home after examination at the emergency department of 40 pediatric hospitals. These hospitals were located in 17 of the 20 major metropolitan areas in the USA and account for >70 % of all freestanding children's hospitals in the

USA. They supplied patient-level data including demographics, payer source, episode of care information, diagnosis codes, and resource use information (including imaging procedure codes) for nearly nine million ED visits over a 5-year period. Just 1.8 % of visits fell into the category of being discharged home with minor head injury, and another 0.07 % received a diagnosis of significant head injury. The study found that hospital-specific rates of minor head injury and significant head injury ranged from 0 % to 3.1 % and 0.02 % to 1.03 %, respectively, as might be expected given variation in case mix. There was also a significant variation in the rate of patients with minor head injury that received CT imaging (median, 36 %; IQR, 29 %–42 %; range, 19 %–58 %). However, the study did not find any correlation between imaging rates for minor head injury patients and inpatient admissions for minor head injury. Nor were imaging rates correlated with return ED visits in 1 week (after minor head injury) or incidence of significant head injury. While observing that age did not appear to influence the rate of CT imaging, the authors note that it is unclear how hospital-specific factors, such as case mix, may relate to the variability in imaging rates. The same database was use to explore variation of diagnostic techniques for suspected pneumonia (Neuman et al. *2011*). The use of chest radiographs for identifying pneumonia is relied on by clinicians to make accurate diagnoses. However, clinicians are trying to minimize the use of unnecessary testing especially with ionizing radiation. In the 5-year period, the proportion of children with a diagnosis of pneumonia who were given a chest x-ray (CXR) varied between 38 % and 88 % (IQR 72–82 %). They also observed that hospital-specific rates of CXR for children with other respiratory discharge diagnoses varied widely. No relationship was found between use of CXR and incidence of pneumonia diagnoses, nor were there differences in CXR rates between pneumonia patients hospitalized and those sent home. From these studies, it is clear that the use of at least two types of test (CT and CXR) varies widely among pediatric emergency departments, but does not appear to be related to case-mix or subsequent treatment.

This observation was confirmed by Kim et al. (*2012*) who studied use of diagnostic imaging for dizziness in the EDs of the Kaiser Permanente system in Northern California, USA. Dizziness is one of the most common reasons for visiting the emergency department (ED) in the USA and accounts for more than 1.5 million ED visits each year. Most patients are discharged home with a benign diagnosis and prognosis. However, some patients have potentially serious underlying diagnoses such as stroke, and the need to adequately evaluate for these causes often leads to prolonged ED evaluations that consume significant resources. While neuroimaging techniques (such as CT scans and brain magnetic resonance imaging) can improve management and triage decisions for ED patients with dizziness, they are a costly resource. It might be assumed that less unexplained variation would be observed within a single health system. Nearly 6 % of adult Kaiser Permanente members that had at least one ED visit in 2008 listed a chief complaint of dizziness; 27.2 % of these had at least one neuroimaging study. The variation in raw rates of imaging between EDs was 1.5-fold from a low of 21.8 % to a high of 32.8 %. Age, sex, and vascular risk factors were all associated with obtaining a neuroimaging study. Even after adjustment for patient-level factors such as these and for ED factors such as overall proportion of patients with dizziness, patient volume, and proportion of patients with dizziness who were admitted, the variation persisted almost unchanged (range 22.6–31.1 %). Variation in use of MRI was even greater at 6.4-fold. The variation in rates of imaging did not appear to be related to the number of patients diagnosed with stroke, especially when using head CT scans. The authors note that while variation across health systems and more widely dispersed geographic areas might be expected, these EDs were part of a regional integrated health program which might have been expected to exhibit less variation.

While Kim and colleagues found notable variation in CT imaging rates within a single health program, Prevedello et al. (*2012*) sought to explore the interphysician variability in the use of head

CT within emergency departments in a single hospital. They studied 1 year of visits to the adult-only emergency department of a large urban academic tertiary care hospital, both in general and for patients with atraumatic headache. Of the 55,281 study visits, 4919 (8.9 %) generated head CT examinations. Unadjusted head CT ordering rates per physician ranged from 4.4 % to 16.9 % and varied significantly between individual physicians. The researchers used a logistic regression model to adjust for the patient's age, sex, severity and disease categorization, the physician's experience and sex, and the time of day of the ED visit. The adjusted model still showed significant interphysician variability in head CT use with approximately twofold variation (6.5–13.5 %). Adjusted rates of head CT imaging for patients with atraumatic headaches varied approximately threefold between physicians (21.2–60.1 %). The authors note that the fact that variation in use persists after controlling for factors that are known to affect imaging ordering patterns may suggest that variation could be due to physician knowledge gaps, practice style variation, or risk tolerance.

The decision to admit a patient to an inpatient bed, as well as variation in test ordering, can be another area exhibiting substantial medical practice variation. Although there are some definitive indications for hospital admission, for many conditions the decision to hospitalize versus outpatient therapy can be discretionary. For example, there has been documented variation in the rates of admission from ED following transient ischemic attacks (TIAs). TIAs are known to be a strong predictor of subsequent stroke and death, and just over half (54 %) of TIA cases in the USA were admitted to the hospital following their ED evaluation. Using administrative data obtained from nearly all community, non-federal hospitals in 11 states of the USA, Coben et al. (*2008*) explored some factors thought to be responsible for this variation with the aim of determining the influence of hospital characteristics and sociodemographic factors on ED disposition, after controlling for clinical characteristics. The study sample was limited to ED visits by individuals 30 years of age and older who had a principal diagnosis of TIA, which was 0.4 % of the total ED visits. Of these, 53.3 % were admitted to the hospital following ED evaluation, and significant differences were noted in ED disposition by state and by hospital. Eight states had nearly half of ED cases for TIA result in admission (range 47.3 %–62.0 %), while three states (Maine, Utah, Vermont) had approximately one-third of ED cases for TIA result in admission (range 31.3 %–37.2 %). The researchers then used a regression model to examine the impact of factors including patient demographics, comorbidities, and hospital characteristics. They found that clinical characteristics were strongly associated with hospital admissions. Patients with between four and eight coexisting illnesses were nearly three times as likely to be admitted as patients with none, while patients with prior use of anticoagulants, prior stroke, and diabetes were less likely to be admitted. However, in addition to these legitimate causes of variation, rural residence of the patient and small numbers of beds at the treating facility were associated with a lower likelihood of admission, while Medicare coverage increased the likelihood of admission. The authors suggest that the variation in ED disposition and lack of change in disposition patterns over time reflects an overall system of care with ingrained patterns of clinical management variation, including those who prefer to evaluate these cases on an outpatient basis.

In a smaller but more general study by Jain et al. (*2010*), the researchers explored intra-physician variation in resource use patterns in the emergency departments of two freestanding tertiary care children's hospitals in the same city over a 3-year period. However, one (ED1) was staffed by academic faculty physicians, while the physicians in the other (ED2) were not academically affiliated. Case-mix adjusted hospital admission rates among physicians varied nearly threefold (6.3–18 %) for ED1 and eightfold (2.5–19.4 %) for ED2. They also studied the use of intravenous therapy (varied twofold and threefold) and CT scans (varied twofold and fivefold). Unsurprisingly, the study found that higher-than-expected use of laboratory tests and imaging by physicians was significantly associated with longer stays in the ED for the patients (r 0.41 and 0.48, $p < 0.05$), and physicians with

higher-than-expected use of laboratory tests had higher-than-expected use of imaging (r 0.62, $p < 0.01$) and intravenous therapy (r 0.51, $p < 0.01$). However, rate of patients returning to the ED was not significantly correlated with any category of resource use. The study showed that significant variation exists in physician use of common ED resources even after risk adjustment for severity of illness and case mix. The authors note that practice variation such as this may represent an opportunity to improve healthcare quality and decrease costs. Arguably, a hospital admission is perhaps the most resource-intensive decision an ED physician makes and one that can lead to another cascade of resource use opportunities.

Lougheed et al. (*2006*) focused on variation in inpatient admission rate via the ED following acute exacerbation of asthma among regions of Ontario, Canada. They found age- and sex-adjusted rates of admission per 1,000 adults who exhibited more than threefold variation (from 0.65 to 2.10), which was unlikely to be caused by variation in the incidence and prevalence of asthma alone. The researchers studied ED visits with a disposition diagnosis of asthma in a stratified sample of 14 Ontario hospitals over a 1-year period, a total population of nearly two million people, and found statistically significant variation in ED visit rates among sites for both children and adults ($p < 0.001$). Visit rates ranged from 8.7 to 23.8 per 1,000 (children) and 1.7 to 9.7 per 1,000 (adults). The proportion of ED visits for asthma that resulted in admission also varied significantly: 1.2–22.4 % (children, 19-fold variation) and 0.4–12.7 % (adults, 32-fold variation). Finally, they found significant variation in hospitalization rates per 1,000 population ranging from 0.14 to 2.34 per 1,000 population (children, 17-fold variation) and 0.02–0.46 per 1,000 (adults, 23-fold variation) – but there was no significant relation between ED visit rates and hospitalization rates for children or adults. The researchers concluded that variation in hospitalization rates was primarily caused by the variation in the likelihood of inpatient admission rather than by the variation in ED visit rates in both age groups.

A common tool used to reduce variations in medical practice between units (and physicians) is the imposition of clear guidelines for treatment (when clinically appropriate). A follow-up study by Lougheed et al. (2009) examined site-specific differences in ED practice patterns and consistency with guidelines for acute asthma cases in a stratified sample of 15 Ontario hospitals over 1 year. The researchers used a validated questionnaire to collect detailed information on sociodemographics, asthma history and control, access to care, and usual ambulatory care, including medications and self-management practices. Other details were extracted from the ED medical record. They found that asthma severity, comorbidities, access to care, and prehospital management varied significantly among sites. In terms of medical practice variation, the researchers also found significant variation between sites in documentation of peak expiratory flow, use of systemic steroids in ED and on discharge, and referrals to asthma services ($p < 0.001$). The proportion of patients admitted was directly related to time to receive systemic steroids in ED in adults ($r = 0.76$; $p = 0.004$). The authors comment that despite publication and revision of national and international guidelines, significant gaps persist in emergency management of asthma. This is an important finding for those wishing to reduce medical practice variation in any area.

Studies of unwarranted variation often discuss the influence of supply-induced demand. In the context of the ED, this can often mean the availability of inpatient beds into which to admit patients. When inpatient beds are scarce, patients indicated for admission will remain in the ED longer, and general waiting times in the ED will increase – as will ED crowding. This in turn increases the likelihoods that a patient will leave without being seen and ambulances will be diverted. Prolonging ED length of stay may also compromise quality of care, including delayed fibrinolysis for myocardial infarction and stroke and poorer outcomes in trauma patients. Vermeulen et al. (*2009*) developed a novel approach to relating ED lengths of stay to inpatient bed availability. They theorized that the effect of inpatient bed availability on ED delays depends on the extent to which daily new admissions to

hospital are matched with new discharges. That is high ratio of daily inpatient admissions to discharges would increase next-day ED length of stay and vice versa. If correct, this effect should be most pronounced among high-acuity ED patients (who are more likely to require inpatient beds) and those requiring admission to the hospital, particularly medical (rather than surgical) admissions. To test this theory, the researchers conducted a cross-sectional study of all adult and pediatric ED visits in acute care facilities from over a 3-year period in the greater Toronto area, Canada, covering a population of 5.1 million people and 21 EDs. Their primary outcome was the absolute difference, in minutes, in next-day 50th percentile ED length of stay, per incremental change in the admission-discharge ratio at the same hospital. The study found a positive association between the inpatient admission-discharge ratio and the next-day 50th percentile ED length of stay. The overall mean (standard deviation in brackets) 50th percentile ED length of stay was 218 (51) minutes. Relative to an inpatient admission-discharge ratio of 1.0, a ratio less than 0.6 was associated with an 11-min (95 % confidence interval [CI] 5–16 min) decrease in next-day ED length of stay, whereas at ratios 1.3–1.4, ED length of stay was significantly prolonged by 5 min (95 % CI 3–6 min), respectively. The researchers found that this effect was more pronounced among higher-acuity ED patients. While admission-discharge ratios among medical inpatients affected next-day ED length of stay, the same was not true for surgical inpatients. The study also observed a significant relationship between the admission-discharge ratio and next-day time to initial emergency physician assessment, primarily among higher-acuity patients. Lastly, the researchers observed a flattening of ED length of stay beyond an admission-discharge ratio of 1.4 which they suggest may be the "diversion" by the EMS system of out-of-hospital patients from very busy to less busy EDs. In this way, variations in the way patients receive treatments can be induced for reasons that are essentially about variation in the availability of services (similar to examples already discussed in out-of-hospital care).

On a similar topic, Studnicki et al. (*2011*) looked at the way patient and hospital characteristics influence variation in the percentage of all hospital admissions that originate in the ED. With the rationale that the ED is now the major pathway for admission to US hospitals, they sought to explore differences in characteristics of admissions that occur through the ED compared with those that enter the hospital via other routes. Studying emergency department visits and hospital admissions occurring at 192 short-term acute medical and surgical hospitals in the US state of Florida, they detected seven patient-level characteristics (aggregated at the hospital level) and three hospital-level characteristics that retained significant associations with variation in the percentage of admissions that originate in the ED after controlling for a range of 27 factors in a multivariate model. Three of these variables were found to be characteristics influencing admissions from the ED (an increasing percentage of Hispanics and decreasing percentages of patients with commercial or other government as pay source), and four significant variables were characteristics of non-ED hospital admissions (increasing average age and the percentage of ACSC admissions and decreasing percentages of Medicaid and commercially insured patients). Of the hospital-level factors, total ED visits and the percentage of ED visits admitted were both found to be positively associated with the percentage of total hospital admissions that come through the ED. The researchers observe that overall, larger hospitals tend to receive a lower percentage of admissions through the ED, whereas smaller hospitals with older patient populations in areas with restricted access to primary care appeared to be admitting most of their patients through the ED. The authors conclude that, despite the predominance of Medicare in these hospitals, the ED is becoming a more generalized route for hospital admissions – accommodating patients who might fail to meet any stringent test of a true emergency.

Green and Becker (*1994*) argue that much of the small-area variation in rates of surgical procedures results from differences in physicians' decision-making when facing diagnostic and therapeutic uncertainty in clinical practice. They point to evidence that variations are greatest among surgical

procedures for which the indications are least clear. They set out to test this "uncertainty hypothesis" by first using a small-area variation analysis to stratify the US state of Michigan by hospital discharge rates for acute cardiac ischemia (ACI). Second, they selected a pair of demographically similar communities with different discharge rates. This pair was used for direct examination of care records for all patients with ACI from their hospital EDs. Medical records were analyzed in a logistic regression model with ED disposition as the dependent variable. Independent variables were age, sex, preexisting hypertension, other chronic conditions, prior coronary artery bypass surgery or balloon angioplasty, ACI-TIPI score, hospital, and insurer. The variation in ACI admissions was fourfold (range 33–153 discharges per 10,000 population). The regression model accounted for a large share (60 %) of the variation in age- and sex-adjusted area rates. There was a strong inverse relationship between mean income and utilization. In their community pair, the higher-admitting community had an ACI admission rate of 153 per 10,000 compared with the lower-admitting community's rate of 56. However, the results of the logistic regression using factors drawn from patient notes did not support the uncertainty hypothesis. The community in which a patient lived was not a significant predictor of admission, after other factors had been adjusted for. The ED physician's admitting practices did not appear to differ significantly between the high- and low-admitting hospitals. The authors conclude that, at least for ACI, population-based area discharge rates do not necessarily reflect case-based decision rates, pointing to the much more detailed information they were able to obtain from case note review and suggesting that the administrative data traditionally used to analyze physician decision-making may lead to error. It must be noted that the availability and quality of administrative data have improved remarkably in the 20 years since this study was performed. However, while this study suggests that site-level variation was largely explained by patient-level clinical data, a substantial amount of variation (40 %) was still unexplained – despite access to unusually detailed clinical data.
Using a similar approach, Komaromy et al. (*1996*) stratified the US state of California by small-area hospitalization rates for asthma, diabetes, and congestive heart failure. However, they explored physician practice style using a survey of physicians. The survey presented 15 clinical vignettes and one question on "social admission" to gauge physician practice style and disposition to admit. The authors surveyed a random sample of 1,530 emergency physicians, general internists, and family and general practitioners in 40 medical service areas (response rate 71 %). The study found significant variation across areas in both the clinical ($P < 0.0001$) and social ($P < 0.001$) admission scores. A physician's practice type tended to be influential on their propensity to admit, with emergency physicians having significantly higher clinical admission scores than other physicians, whereas physicians who practice in staff model or large-group model HMOs had significantly lower clinical admission scores than physicians practicing in other settings. The researchers observed that variation in hospitalization rates was significantly correlated with physicians' clinical ($r = .34$, $p = 0.03$) and social ($r = .36$, $p = 0.02$) admission scores. In contrast to the Green and Becker study above, Komaromy and colleagues found that when physician admission scores were aggregated to area level, the between-area variation in both clinical and social admission scores were significantly greater than the within-area variation. This indicates a genuine area effect in clinicians' propensity to admit, both for clinical and social reasons. The aggregated area-level admission scores were also associated significantly with the hospitalization rates for the three conditions combined. However, when analyzed alongside community sociodemographic factors in a multiple regression model, the association between aggregate physician practice style and hospitalization rates was no longer significant.
In summary, the majority of ED utilization is driven by population age, sex, and health need. However, some of the utilization is shaped by health system design such as the availability and ease of use of other urgent care services. After patients arrive in the ED, there is evidence of variation in

test ordering and the propensity to admit to an inpatient setting. These variations in resources use do not appear to be related to ED visit rates nor outcomes for patients. Variations were observed between regions, areas, units, and individual physicians and sometimes persisted even when clear clinical guidelines were in place. Many underlying causes of this variation have been proposed and tested, but a substantial amount of variation remains unexplained.

After Emergency Admission

Studies of medical practice variation in emergency medical services understandably tend to focus on variations in care up to the point of admission. However, there is still substantial scope for variation in treatment and outcomes for patients following an emergency admission to hospital, and a number of studies in this area are discussed here.

A common assumption is that medical practice variation is most apparent in circumstances where there are no clear guidelines on the most appropriate course of action. One such situation is tracheostomy for severely injured patients with respiratory failure who require mechanical ventilation. There is much debate surrounding the timing of tracheostomy, and any variation in timing across institutions could well cause variation in rates of the procedure because the later tracheostomy is performed the greater opportunity a patient will have for liberation from the ventilator before the tracheostomy. Nathens et al. (*2006*) set out to determine the extent of this variation and to identify either patient or institutional characteristics associated with higher rates of tracheostomy. The researchers selected over 17,000 patients who were over 16 years old and had an Injury Severity Score (ISS) greater than 9 and diagnosis of acute respiratory failure from a voluntary registry of hospitalized trauma patients admitted to more than 770 trauma centers (the American College of Surgeons National Trauma Data Bank) over 3 years. The dataset contains both patient-level data (including demographics, mechanism of injury, procedures, hospital course, complications, and outcomes) and facility-level data (including hospital size, teaching status, and region). The mean rate of patients who underwent tracheostomy during their hospitalization across centers was 19.6 per 100 hospital admissions, but the site-level rates ranged from 0 to 59 per 100 hospital admissions. When stratifying cases by patient- or injury-specific factors, the study found patterns such as older patients and those with selected preexisting diseases (chronic obstructive pulmonary disease, coronary artery disease, diabetes, stroke, dementia, obesity) were more likely to receive a tracheostomy, and the presence of specific injuries (as well as their mechanism and severity) was strongly associated with a decision to perform a tracheostomy. However, the study did not find any association with either gender or insurance status. A large variation in rates still persisted after stratifying patients by mechanism, age, ISS, severe chest or head injury, and spinal cord injury. These variations were explored using a regression model which incorporated both patient and institutional characteristics. However, after adjusting for patient-level factors, the authors found that none of the measured institutional characteristics entered the model as statistically significant predictors of tracheostomy, although evidence of a significant relationship between insurance status and likelihood of tracheostomy did appear (with government-sponsored or self-pay patients less likely to undergo tracheostomy than those with private insurance). While none of the facility-level factors were significant predictors of tracheostomy in themselves, their presence was found to explain 6 % of the variation between sites. The patient-level factors contributed 14 %, meaning that overall just 20 % of the variation was explainable by the factors examined in this study. Given the clinical depth of the data to which the researchers had access, this seems to be a very low figure. Cases such as this inevitably raise questions as to whether some crucial explanatory variable was missing from the dataset. It is possible to test the validity of this argument by creating a dummy ideal variable with a

known direct relationship with the outcome variable. If the study is missing a key variable, inserting the dummy into the regression model should dramatically increase the amount of variation explained. However, if the variation is random (or related to the interactions between two or more variables), adding a dummy will have little effect.

The Nathens study created a range of dummy patient-level variables with a range of strengths of relationship to a patient having a tracheostomy. The result was that the total explained variance increased from 20 % to only 24 %. Using this technique allowed the researchers to be confident that the variation is highly unlikely to be driven by an untested patient characteristic, whether or not it is directly observable. In this case the authors were left to conclude that there was significant unexplained variation in the rates of tracheostomy in critically injured patients with acute respiratory failure and that variation might reflect preconceived notions of efficacy among physicians practicing in the absence of evidence to guide care.

While variation is perhaps unsurprising in the absence of guidelines, what impact does their introduction have on medical practice variation? Dossett et al. (*2011*) used the same National Trauma Data Bank to explore unwarranted variation in the use of the prophylactic inferior vena cava (IVC) filter for thromboembolism prophylaxis after major trauma. For the majority of patients, chemical prophylaxis is adequately efficacious and considered as the standard of care. However, prophylactic IVC filters may be considered as an alternate treatment strategy in high-risk patients or those with contraindications to anticoagulation. The Eastern Association for the Surgery of Trauma (EAST) has guidelines that set out criteria for prophylactic IVC filter placement. The researchers used these to describe the national variation in the use of the prophylactic IVC filter among US trauma centers and identify whether patient or center factors contribute to any detected variation. They used a 5-year extract from the National Trauma Data Bank and excluded patients under 17 years old, those who had a diagnosis of deep venous thrombosis or pulmonary embolism listed in the complications field, or died within a day of being admitted. Over one and a half million patients and nearly 23,000 prophylactic IVC filters from 680 centers were used in the analysis. When the rate of prophylactic IVC filter placement was calculated per patient meeting EAST criteria, the median rate was 1.1 (IQR, 0.2–3.3), indicating that the distribution of rates was centered on this guideline. However, the study still observed more than 10-fold variation in rates, suggesting extreme over- and underuse according to the guideline. The authors stratified their results by several factors identified as possible contributors to center variability to understand the variability in rates of prophylactic IVC filters. Variation was statistically significant between regions ($p < 0.001$) and could not be completely explained by either patient or center characteristics. The authors speculate that a “regional culture” phenomenon contributes to the variation. If physicians continue to practice patterns they observed during training, and most physicians practice in the state in which they trained, the “regional culture” can contribute to sustain regional practice patterns. Even within geographic regions, the use of prophylactic IVC filters varied up to 10-fold. Although individual patient characteristics (even characteristics that are impossible to account for with the available data) often drive the decision to place prophylactic IVC filters, the study concludes it is unlikely that they account for the entirety of the observed center variation. This demonstrates that unexplained variation in treatment for emergency patients can persist even away from the often fraught environments of urgent care.

Chen et al. (*2012*) used data from the US Veterans Health Administration to examine ICU admitting patterns for patients at their initial presentation to the hospital. The study made use of data from 118 hospitals, covering 48 states, and nearly 300,000 patients were admitted to these hospitals from the ED or the outpatient clinic. However, the study was particularly concerned with patients for whom ED, outpatient clinic, and ICU physicians made triage decisions based largely on presenting patient severity and had gone directly to the ICU when first arriving at the hospital. This represented 31,555

cases, 10.9 % of all admissions. Hospitals varied widely in the proportion of patients admitted to the ICU, even after adjusting for predicted mortality and diagnosis on admission; the percentage of patients admitted direct to the ICU ranged from 1.6 % to 29.5 % across hospitals for patients with median predicted mortality. The adjusted models included patient severity, diagnosis, and ICU occupancy (all at the time of admission), along with the level of specialty care offered at the hospital. Even after further adjustment for occupancy and hospital type, rates of admission to the ICU still varied from 1.2 % to 38.9 % across hospitals. Patient severity and diagnosis explained 10 % of the total variation in the proportion admitted to ICU between hospitals, with ICU occupancy and the facility's complexity level explaining only an additional 0.4 % of variation leaving 90 % of the variation unaccounted for. Around 50 % of patients admitted to the ICU had 30-day predicted mortality of 2 % or less, yet interestingly less than half of cases with predicted mortality greater than 30 % were admitted to the ICU. The study found that hospitals varied widely in the proportion of patients admitted to the ICU at all levels of patient 30-day predicted mortality risk. The authors conclude that their results demonstrate that there is a notable level of patients not using the ICU when it should be used (undertriage) and at the same time a notable level of patients using it when it should not be used (overtriage).

In addition to variation in admission to ICU, mortality for emergency patients using ICU also varies notably. Carr et al. (*2009*) explored the contribution of post-cardiac arrest care to the variability in mortality of patients that achieve initial return of spontaneous circulation after cardiac arrest. The researchers used data from the Acute Physiology and Chronic Health Evaluation (APACHE) database, an ICU clinical information system used by participating hospitals within the USA for benchmarking and quality improvement. They examined all adult patients admitted to an APACHE hospital ICU with the diagnosis of cardiac arrest over a 3-year period, and patient demographics, admission source, primary admission diagnosis, and detailed laboratory and physiologic variables were collected in the first 24 h of ICU admission. In total the study used data from over 5,500 patients in 39 hospitals (covering a range of types and US regions). The researchers used regression techniques to explore the contribution of various factors of the post-cardiac arrest outcomes for this cohort of patients. Unsurprisingly, patient-level factors associated with in-hospital mortality included age, acute physiology score, Glasgow coma score on ICU admission, and the need for mechanical ventilation on admission. However, the researchers found that even after this level of adjustment, interhospital variation in standardized mortality was still significant, ranging from 46 % to 68 %. They also observed an inverse relationship between the volume of cardiac arrest patients treated in the ICU and in-hospital mortality. It is appropriate to ask to what extent this variation relates to treatment in ICU, or to variations in urgent care received prior to ICU or is simply unavoidable.

This kind of variation in post-admission emergency care is not restricted to trauma and ICU patients. Lee et al. (*1997*) provide similar examples from a study of poststroke rehabilitation services. Depending on the needs of the patient, community referral practices, and the availability of services, poststroke rehabilitation can take place in any of a variety of inpatient and ambulatory care settings. The study used multiple linear regression applied to 1 year of Medicare data for a 20 % random sample of Medicare beneficiaries with an admission to an acute care hospital for stroke (those that survived their index admission) in 151 metropolitan statistical areas (MSAs). This approach was able to explain 34 % of the variability in choice of any rehabilitation setting and similar regression models explained only about a third of the variation in the inpatient rehabilitation hospital and skilled nursing facility lengths of stay. Interestingly, the model had more predictive power when describing the length of stay in the index admission, accounting for 54 % of the variation and establishing a link with variations during the initial, more urgent part of the care pathway, suggesting that variation increases as urgency decreases. The authors conclude that a substantial amount of inter-MSA variability in utilization and intensity of poststroke rehabilitation services cannot be explained by differences in

measured patient characteristics. The patient variables rarely explain or account for more than a third of practice variation, and often they explain substantially less than that.

Ko et al. (*2007*) built on previous international comparisons between the USA and Canada in the treatment of AMI by exploring whether regional variations in the utilization of medical therapy and cardiac-invasive procedures within the USA may play a role in explaining differences in AMI treatment patterns. In short, the likelihood of the discrepancy in cardiac procedure rates between the USA and Canada reflects regional differences in practice patterns rather than national differences in the respective healthcare delivery systems. Their study compared medication use, invasive cardiac procedure use, and 30-day risk-standardized mortality rates of nearly 40,000 fee-for-service Medicare beneficiaries hospitalized with AMI in the USA and 5,600 similarly aged patients in Ontario, Canada. Mortality rates were standardized using the in-hospital prediction risk score from the Global Registry of Acute Coronary Events (GRACE). Despite the wide geographical range of the study sites, the baseline characteristics and illness severity across the US regions and Ontario were not substantially different, and 30-day standardized mortality rates were not substantially different when compared across all geographic regions. Despite this underlying similarity, the study found that there were substantial differences in cardiac catheterization use between regions in the USA. The rates in Ontario were most similar to the Northeastern United States. Similar utilization patterns of percutaneous coronary intervention and coronary artery bypass surgery were observed, with the Northeastern United States again being more similar to Ontario than other regions of the USA. However, physicians in the Northeastern United States and Ontario were more likely to evaluate ischemia noninvasively after AMI and had the highest utilization rates of stress tests during hospitalization. The study found a strong association between the use of cardiac catheterization and the availability of cardiac-invasive facilities. Cardiac-invasive procedures are highly dependent on the availability of resources, and unsurprisingly the lower utilization rates in the Northeastern United States and Ontario were associated with a lower supply of cardiac-invasive facilities. Interestingly, patients who received cardiac catheterization in the Northeastern United States and Ontario had similar demographic and admission characteristics compared with other regions with higher utilization rates, implying that the northeastern regions and Ontario did not seem to be restricting invasive procedures to more severe cases than other regions or were seeing fewer severe cases. While the optimum rate of cardiac catheterization following AMI is unknown, regions where invasive procedures were less frequent did not appear to have worse short- or long-term survival after adjustment for patient and hospital factors. As the researchers point out, the Northeastern United States does not face similar resource constraints as Ontario (due to the different natures of their respective health systems), so it is more difficult to understand why the Northeastern United States consistently performed fewer cardiac-invasive procedures, had a smaller number of invasive facilities, and performed lower proportion of cardiac-invasive procedures per facility than other US regions. The researchers also studied the use of evidence-based medical therapies and found that these varied significantly less across regions. However, this analysis did find a 12 % absolute difference for beta blockers and 6 % for angiotensin-converting enzyme inhibitors among the highest to lowest utilization regions among ideal candidates. The authors comment that there were no obvious reasons to explain why regional variations in medical treatment existed, as published evidence that demonstrates its effectiveness is widely available and evidence-based therapies can be prescribed at a low cost.

A number of other studies have also demonstrated that variations in care persist following emergency treatment. Alter et al. (*2005*) also explore variation of cardiac intervention for patients with AMI. They collected 3 years of data on a cohort of new AMI patients hospitalized in most of the Canadian provinces aged between 20 and 105, excluding patients whose AMI was coded as an in-hospital complication or those with total length of stay of less than 3 days. This cohort was then used to examine the extent to which interregional and inter-institutional outcome variations could be

explained by contextual neighborhood and hospital characteristics. The researchers used stepwise regression techniques to examine the impact of multiple factors combined. However, they found that no more than 7 % of the variation for any risk-adjusted outcomes (cardiac readmission or mortality) could be explained by multiple socioeconomic, ethnic, and geographical variables, after adjusting for age, sex, and age-sex interaction.

Studies of variation in emergency inpatient outcomes are not restricted to North America. In the UK, Stewart et al. (*2002*) examined variation in heart failure outcomes between hospitals in Scotland. Most hospital inpatient stays and day cases in Scotland are recorded on a national computerized database (the Scottish Morbidity Record). Hospital discharge data are also linked to the Register General′s death records. This allowed the researchers to track readmission and mortality outcome for any individual (anonymized) patient, using 5 years of data for hospital inpatients discharged (dead or alive) following an acute admission with heart failure. For this study, the researchers specifically focused on patients with just one discharge with a principal diagnosis of heart failure and no other heart failure-related hospitalization within 5 years of the study period. This created a cohort of nearly 32,000 patients treated across 29 hospitals. The researchers found variation in the unadjusted, in-hospital, and subsequent 1-year case fatality rates. Even after substantial adjustment for age, sex, comorbidity, length of stay, year of discharge, size of hospital, and socioeconomic status, there were still twofold differences in the case fatality rates between hospitals in Scotland. However, less variation was observed in readmission (within 30 days or 1 year) for patients discharged alive from hospital.

In another British study, Roberts et al. (*2003*) sought to explain the variation found in an earlier British Thoracic Society (BTS)/Royal College of Physicians audit of acute hospital care for exacerbations of chronic obstructive pulmonary disease (COPD) that revealed a 90-day mortality of 14 % and observed wide variation between hospitals. Treatment of COPD cases is of great importance in the UK, being responsible for more than 6 % of all admissions and 10 % of acute medical admissions in the UK and having a high mortality. The Roberts study audited the mortality outcome at 90 days following acute admission for COPD in hospitals subdivided by type and size using audits from a random sample of 30 hospitals in England and Wales stratified by size and teaching status. Cases were identified prospectively over an 8-week period, and data were collected retrospectively at 90 days following admission, collecting 23 process items suggested by previous audit as valuable or by the BTS guidelines as essential management interventions and two outcome measures (death and length of stay). These data were collected on nearly 1,300 patients, in an evenly distributed mix of teaching hospitals, large district general hospitals (DGHs), and small DGHs. The researchers found that mortality at 90 days was 14 % overall (the majority of whom died in hospital) with wide variation between centers (IQR 9–19 %). Mean mortality rates were lowest in the teaching hospitals (4.8 %) and highest at the small DGHs (12.3 %). Performance status, blood urea, and mean arterial pH levels varied between sites but were not significantly different between groups. Odds ratios of mortality relative to the teaching hospitals adjusted for these three factors showed that although the performance status of patients in small DGHs was worse than in the other two types of hospital, it did not account for the higher mortality observed. When the data were analyzed alongside resource and organizational factors, the researchers observed that higher mortality was associated with fewer doctors (OR 1.5) and with fewer patients being under the care of a specialist physician (OR 1.8). Notably, small DGHs had fewest resources.

Cudnik et al. (*2010*) investigated the variability in clinical outcomes among the level I trauma centers in the US state of Ohio. The state has a population of 11 million people and 11 American College of Surgeons-verified level 1 trauma centers (out of a total of 36 trauma centers). The study used data on nearly 17,000 cases from the Ohio Trauma Registry, which captures variables such as age, sex,

ethnicity, insurance status, date and time admission, injury type, Injury Severity Score, and a range of clinical measures (such as the EMS-recorded systolic blood pressure, Glasgow Coma Scale, ED thoracostomy, etc.). The researchers extracted data for patients 16 years of age and older who were transported directly from the incident location to one of the level 1 TCs dispersed throughout the state. Trauma cases transferred from non-trauma centers and lower-level trauma centers were excluded to remove any potential bias due to variations in care that may have been provided prior to arrival at the level I center. As might be expected, there was considerable variability between trauma centers in the unadjusted mortality rates, ranging from 4 % to 24 %. When the rates were adjusted for the differences in patient characteristics using a multivariable logistic regression analysis, this variability persisted. Adjusted mortality ranged from an OR of 0.93(95 % CI = 0.47 to 1.84) to an OR of 6.02 (95 % CI = 3.70–9.79). The authors conclude that the results show considerable variability in the processes and outcomes of patients and likely the care they receive even within centers that have been verified as at similar standards.

Imison et al. (*2012*) explored variation in the length of time older people in England spend in hospital following an emergency admission. Length of stay, and the associated hospital bed use, has been the focus of considerable policy attention in England and has been reducing consistently for some time. Despite this, 10 % of patients will stay longer than 2 weeks. The authors note that the difference in observed length of stay between those over 65 and those under 65 admitted as an emergency is also stark. In 2009/2010, the average length of stay was approximately 3 days for patients under 65, but 9 days for patients over 65. Among over 65s, the average length of stay varied from 7 days (for those aged 65–74) to 11 days (for those aged 85 and over). Imison and colleagues studied every emergency admission for patients over 65 years old in English NHS hospitals for 1 year. They observed a 2.2-fold variation in unadjusted length of stay for patients over 65 years old. Rates of emergency bed days per person were calculated at primary care trust (PCT) level. These are areas of 300,000 residents on average that are responsible for commissioning secondary care for their population. The rates were standardized for age, sex, and need using the Hospital and Community Health Services needs index. After this adjustment, the researchers observed a 3.6-fold variation in emergency bed days per person over 65 between PCTs. They found that length of stay was noticeably higher in the PCT group with highest bed use. They also note that the PCT group with the lowest rate of bed days had higher satisfaction scores on their General Practitioner Patient Survey; the PCT group with the highest use of bed days scored 8 % lower on this measure.

These studies emphasize that emergency admissions and their outcomes are the product of the whole care system. This is an important point to consider when undertaking studies of variation in longer-term measures following urgent care.

Finally, a major study by Fisher et al. (*2003a*, *b*) explored a range of outcomes for Medicare patients in the USA and related these to regional variations in Medicare spending. The study used two emergency conditions (patients hospitalized for either AMI or hip fracture) and two mixed conditions (patients hospitalized for colorectal cancer and general care for respondents to a survey). To avoid the results being unduly influenced by differences in disease levels between patients, the study selected only patient in the last 6 months of their lives (and whose ages were between 65 and 99). Combined, the study examined over 800,000 patients across more than 300 hospital referral regions using a mixture of chart reviews, discharge abstracts, and claims data. Rather than analyzing the Medicare costs of individuals, which would be subject to regional illness levels and price, the team chose to examine a normalized measure of intensity of treatment: the quantity of medical care provided overall to similarly ill patients. They found that illness levels in each of the four study cohorts differed little across quintiles of care intensity but that healthcare utilization rates and spending (for all four study samples) increased steadily and substantially as the expenditure index for a given geographical area

increased. The result was that patients in the highest-spending quintile received about 60 % more care than residents of the lowest-spending quintile, a difference that was driven largely by more frequent use of the hospital as a site of care, more frequent physician visits, greater use of medical subspecialists, and more frequent diagnostic tests and minor procedures. Despite these clear differences in care intensity, the researchers found that outcomes were mixed across the quintiles. The two emergency conditions gave a conflicting message, with average predicted mortality rates at 1 year for hip fracture patients that were slightly but significantly lower in areas with greater care intensity, while for AMI patients average predicted mortality rates at 1 year were higher in areas with a higher care intensity. Overall the researchers found no consistent trend toward greater illness burden in areas applying a greater intensity of care, nor any evidence to suggest that the pattern of practice observed in higher-intensity regions led to improved survival, slower decline in functional status, or improved satisfaction with care. This approach was extended to the Canadian province of Ontario (Stukel et al. *2012*) using data from Ontario Health Administrative Databases for a total of nearly 400,000 patients with AMI, congestive heart failure (CHF), hip fracture, or colon cancer with surgical resection. Patients staying less than 3 days for AMI were excluded. The researchers found a twofold variation in spending across hospitals, despite similar outcomes in mean predicted 30-day mortality across all levels of hospital spending. Age- and sex-adjusted 30-day mortality rates were 0.1 % lower in the highest-spending hospitals and were lowest for AMI and 2.0 % lower for hip fracture. The age- and sex-adjusted rate of AMI patients readmitted with a major cardiac event rate was 17.4 % (highest spending) versus 18.7 % (lowest spending), and the age- and sex-adjusted 30-day readmission rate was 23.1 % versus 25.8 % for patients with hip fracture. The researchers suggest that the difference in outcome of higher intensity of care between the USA and Ontario is related to the nature of the Ontario health system, a province with global hospital budgets and fewer specialized healthcare resources than the USA. In this environment, authors note that outcomes following an acute hospitalization were positively associated with higher hospital spending intensity.

This final study combines emergency conditions with care that may be emergency or elective. Despite the common assumption that emergency care has a higher degree of warranted variation, and the demonstration that in some cases urgent treatment has different variation patterns to elective care (Wijeysundera et al. *2010*), the many studies in this chapter have explored large variations in urgent and emergency care that could not be explained by case-mix or contextual factors.

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