

Oxford Research Encyclopedia of Economics and Finance

Variations in the Adoption of Healthcare Innovation? A Literature Review FREE

Marisa Miraldo, Katharina Hauck, Antoine Vernet, and Ana Wheelock

Subject: Health Economics Online Publication Date: Apr 2019

DOI: 10.1093/acrefore/9780190625979.013.76

Summary and Keywords

Major medical innovations have greatly increased the efficacy of treatments, improved patient outcomes, and often reduced the cost of medical care. However, innovations do not diffuse uniformly across and within health systems. Due to the high complexity of medical treatment decisions, variations in clinical practice are inherent to healthcare delivery, regardless of technological advances, new ways of working, funding, and burden of disease. In this chapter we conduct a narrative literature review to identify and discuss peer-reviewed articles presenting a theoretical framework or empirical evidence of the factors associated with the adoption of innovation and clinical practice.

We find that variation in innovation adoption and medical practice is associated with multiple factors. First, patients' characteristics, including medical needs and genetic factors, can crucially affect clinical outcomes and the efficacy of treatments. Moreover, differences in patients' preferences can be an important source of variation. Medical treatments may need to take such patient characteristics into account if they are to deliver optimal outcomes, and consequently, resulting practice variations should be considered warranted and in the best interests of patients. However, socioeconomic or demographic characteristics, such as ethnicity, income, or gender are often not considered legitimate grounds for differential treatment. Second, physician characteristics—such as socioeconomic profile, training, and work-related characteristics—are equally an influential component of practice variation. In particular, so-called “practice style” and physicians' attitudes toward risk and innovation adoption are considered a major source of practice variation, but have proven difficult to investigate empirically. Lastly, features of healthcare systems—notably, public coverage of healthcare expenditure, cost-based reimbursement of providers, and service-delivery organization, are generally associated with higher utilization rates and adoption of innovation.

Research shows some successful strategies aimed at reducing variation in medical decision-making, such as the use of decision aids, data feedback, benchmarking, clinical practice guidelines, blinded report cards, and pay for performance. But despite these

Variations in the Adoption of Healthcare Innovation? A Literature Review

advances, there is uneven diffusion of new technologies and procedures, with potentially severe adverse efficiency and equity implications.

Keywords: Innovation adoption, innovation diffusion, clinical practice variation, inequalities, medical decision-making, best practice, health economics

Background

Medical knowledge is the body of information about diseases, mechanisms and pathogenesis, therapies and interactions, and interpretation of lab tests, and allows us to make evidence-based decisions about optimal treatment paths for patients and for public-health policies more broadly. Over the past decades medical knowledge has progressed rapidly, and major innovations have increased clinical efficacy of diagnosis and treatments for many conditions, leading to greatly improved patient outcomes. Innovations such as magnetic resonance imaging and the artificial heart were step changes in the way healthcare is delivered. Some innovations—such as laser surgery or Health IT—may also lower cost of treatments, leading to substantial efficiency gains in service provision, and freeing up resources to improve care for other patients. But innovations are of no use if they are not implemented in day-to-day clinical practice. Unfortunately, there are persistent and ubiquitous differences in adherence to the medical guidelines designed to promote innovations and, in turn, in the care delivered to patients with similar medical conditions and healthcare needs.

Treatment may depart from the recommended guidelines because of the specificity of health conditions or preferences of the patient. In this case, variation in the adoption of innovation may be desirable and justified. Yet, often differences in clinical decisions are due to factors that are not related to the patient's health status or preferences and can have a negative impact on health outcomes as well as on equity and efficiency of health systems. These differences are commonly known as “unwarranted variation” (Wennberg, 2002). While variation in the early stages of a new treatment can often be explained by information diffusion, persistent variation can mean that other factors are at play. Such factors associated with unwarranted variation in the adoption of innovation may relate to the patients (e.g., ability to access innovation), doctors (e.g., differences in school of thought), and providers (e.g., availability of clinical equipment), but also the way in which service provision is organized and reimbursed.

In this chapter we sought to review the literature on the determinants of adoption of innovation and the factors associated with “unwarranted variation” in adoption behavior and clinical practice. Variations in the speed of innovation adoption and in clinical practice are closely related for a diversity of reasons. First, differences in innovation adoption can lead to practice variation, i.e., providers from different schools of thought adopt different treatments for the same patients because they are more or less enthusiastic about the adoption of specific innovations. Second, some of the determinants of practice variation (e.g., training) can also affect the adoption of innovation. Third, the

Variations in the Adoption of Healthcare Innovation? A Literature Review

diffusion process for innovations is rather long. Evidence suggests that it can take up to 45 years on average for countries to fully adopt technology after it has been first invented (Comin & Hobijn, 2010). Therefore, the assessment of the determinants of the adoption and diffusion of innovation will inevitably require looking at practices long after they are first adopted, and therefore these practices may be seen as innovations by some and common practice by others.

This review covers the factors associated with variations in both innovation and clinical practice across different medical specialties. With respect to innovation, there is research on both organizational and clinical innovation. We examine the latter but not the former. In general, much of the literature in this field is descriptive or qualitative, focusing on describing factors that are associated with innovation adoption or practice variation. We found that the majority of the literature focuses on factors that affect clinical practice and how it differs across clinicians (clinical-practice variation) without making a distinction as to whether that practice refers to old or innovative treatments. The empirical methods used by the reviewed studies vary, but a common approach is to use small area level data. The methodology assumes that small units of analysis are homogeneous with respect to factors which influence healthcare utilization, and that thus any observed differences should be attributed to variations in practice style between clinicians. While this assumption is convenient when data are limited, it raises concerns with regard to the measurement of practice variation as well as the assessment of its determinants. Many studies tend to use aggregated data across physicians and therefore are not able to distinguish demand-side from supply-side factors that affect variation (Stano, 1985; Folland & Stano, 1990; Grytten & Sørensen, 2003). Many area-level studies do not control for patient sorting, nor physician selection of healthcare providers, learning, or social interactions. In addition, the “geographical or area” level considered in these analyses might mask variations at other levels (Dranove, Ramanarayanan, & Rao, 2006). More recently, research has focused on using patient- and physician-level data, which overcomes some of these issues.

Finally, there is a strong publication bias, in that most research relates to high-income countries. The lack of evidence with regard to low- and middle-income countries limits our ability to systematically identify factors that explain practice variation and variation on the adoption of innovation at global level.

Methods

We conducted a narrative literature review to identify articles presenting either a theoretical framework or empirical evidence of factors that affect clinical practice and which might explain differences in the adoption and diffusion of innovation.

The search was performed in Pubmed and EBSCO databases with no time restriction (from the beginning of the databases). “Unwarranted variation, medical decision(s), medical practice, clinical (physician) utilization and physician practice patterns [MeSH term]” were used as keywords to search for variation in medical practice. “Small area

Variations in the Adoption of Healthcare Innovation? A Literature Review

analysis [MeSH term]" and "regional (geographic) variation(s)" were used as keywords to define the level at which variation occurs. "Operative surgical procedures [MeSH term], diagnostic techniques and procedures [MeSH term], and treatment" were used to identify literature related to the health services of interest, within the context of "Health (medical) care." Further limitations required humans to be the subjects of research, articles written in English, and with an available abstract. The same keywords were adopted for the search in EBSCO database; MeSH terms were expanded, and the search results were limited to peer-reviewed journals. Further relevant articles (both peer-reviewed and working papers) have been found by means of a snowballing approach.

Titles and abstracts were reviewed to assess their relevance. Further inspection into full text was carried out to examine articles whose relevance and validity could not be judged by abstract alone. In order to concentrate on the assessment of variation in medical treatment without the interference of factors specific to therapeutic treatments (e.g., drug-adverse reaction or comorbidities that occur and last over time), empirical studies were limited to medical treatment in the categories of ambulatory care and surgical procedures.

Findings

The factors associated with practice variation and heterogeneity in the adoption of innovation can be classified into those related to the patient, those related to the physician, those related to the provider and those related to the healthcare ecosystem.

Patient-Level Factors

Many studies focus on specific aspects of patients' characteristics as a source of practice variation. Patient characteristics firstly include medical need, age, gender, and other individual characteristics, such as comorbidities and genetic factors that can affect the epidemiology of diseases, clinical outcomes, and the efficacy of treatment (Yiannakoulias, Hill, & Svenson, 2009; Panigrahi, Roman, & Sosa, 2010; Caldon et al., 2005). Secondly, differences in patients' preferences can be an important source of variation. Medical treatments may need to take such patient characteristics into account if they are to deliver optimal outcomes, and consequently, resulting practice variations should be considered warranted and in the best interest of patients. However, socioeconomic or demographic characteristics, such as ethnicity, income, or gender are often not considered legitimate grounds for differential treatment. When these characteristics are associated with medical-decision variation, inefficiency and inequity in resource allocation are often the outcome.

A caveat of practically all studies that investigate the importance of socioeconomic factors is that differences may be due to genuine variation in medical need, and/or other unobserved factors such as patient preferences. While most studies adjust for medical complexity the latter is often disregarded in the literature. Moreover, it is widely documented that healthcare (unmet) needs are higher in groups with lower

Variations in the Adoption of Healthcare Innovation? A Literature Review

socioeconomic profile (Braveman, Egerter, & Williams, 2011), which suggests that we should observe higher utilization of healthcare among disadvantaged groups. Another problem of the studies is that patient-level factors tend to be correlated. For example, minority ethnic groups often have lower income and socioeconomic profile in general, which makes it difficult to isolate the impact of ethnicity, particularly if measures of other factors such as income are not reliable. Most observational studies rely on multiple regression analysis to disentangle the role different factors play in clinical practice (e.g., Walker, 1979). A further difficulty is sample selection; i.e., groups with a lower socioeconomic profile may be more likely to be admitted to certain hospitals, which in turn makes it difficult to isolate the impact of patient-specific from hospital-specific factors. Studies on patient-level characteristics should be interpreted in light of these caveats.

Most studies focus on the association of patient-level factors with underuse or overuse of services. However, socioeconomic factors have frequently been shown to also affect the type of procedure that patients receive in contexts in which patients' preferences play marginal roles in treatment selection. For example, open surgery has been shown to be more prevalent than laparoscopic surgery in individuals with lower socioeconomic status (Jacoby et al., 2009). Studies typically investigate patient factors using individual- (patient-) level data; in most cases these are administrative data, but a few studies use survey data. Some studies use data that is aggregated to a certain extent, usually at small area or hospital level. In the remainder of this section we will discuss evidence on the role specific patient characteristics play in clinical practice.

Ethnicity has been identified as an important demographic factor associated with treatment variation across a wide range of procedures. While genetic differences between different ethnic groups can play a role in the prevalence and incidence of disease, differences in treatment choice should be explained solely by health need, patient preferences and, potentially, willingness to pay. Yet, practice variation across different ethnic groups is well documented across a broad range of disease areas. In particular, in the United States, ethnicity has been found to be associated with lower use by black people of cardiovascular procedures including coronary artery bypass grafting and percutaneous transluminal coronary angioplasty (Hannan & Kumar, 1997), coronary angiography (Garg et al., 2002), cardiac catheterization (Mirvis, Burns, Gaschen, Cloar, & Graney, 1994), cardioverter-defibrillator implants (Groeneveld, Heidenreich, & Garber, 2005) radiation therapy (Baxter, Rothenberger, Morris, & Bullard, 2005), cataract surgery (Javitt et al., 1995), tooth-preserving dental treatment (Kressin et al., 2003), radical prostatectomy and radiotherapy (Klabunde, Potosky, Harlan, & Kramer, 1998; Nambudiri et al., 2012), and eight common surgical procedures (Carlisle, Valdez, & Shapiro, 1995). There are some studies that find no significant effect of ethnicity, for example, in the treatment of distal radial fractures (Fanuele et al., 2009), total hip replacement (Judge, Welton, Sandhu, & Ben-Shlomo, 2010), or coronary angiography (Laouri et al., 1997). Barnato, Lucas, Staiger, Wennberg, and Chandra (2005) show that ethnicity related differences in the treatment of acute myocardial infarction (AMI) narrowed or disappeared when they controlled for hospital related factors. Finally, some studies find

Variations in the Adoption of Healthcare Innovation? A Literature Review

that ethnicity is associated with overuse, e.g., for hysterectomy in European immigrants to Canada (Roos, 1984), knee replacement in British patients (Judge et al., 2010), and tooth-preserving treatment in Asian Veteran Affairs patients (Kressin et al., 2003).

The *gender of the patient* has also been linked to practice variations. There is an extensive literature that shows underuse of surgical treatment for female AMI patients, despite evidence that, on average, female patients could exhibit higher medical complexity (Garg et al., 2002). Ayanian and Epstein (1991) find that women who are hospitalized for coronary artery disease undergo fewer major diagnostic and therapeutic procedures than men, but the authors concede that they lack detailed clinical data to adjust for legitimate sources of variation. Garg et al. (2002) and Laouri et al. (1997) find that even after careful risk adjustment, coronary angiography is performed significantly less often in women. These results have been confirmed for the United Kingdom (Clarke, Gray, Keating, & Hampton, 1994, Kee, Gaffney, Currie, & O'Reilly, 1993, Petticrew, McKee, & Jones, 1993) and Switzerland (Santos-Eggimann, Paccaud, & Gutzwiller, 1989), but not Sweden (Alfredsson et al., 2009). Discrimination against women has also been found in other clinical areas, including hip and knee replacement (Judge et al., 2010), adjuvant radiation for rectal cancer (Baxter et al., 2005), surgery for medullary thyroid cancer (MTC) (Panigrahi et al. 2010), and polypectomy during colonoscopies (Hilsden, 2004). Conversely, some find that men are discriminated against, for example in cataract surgery (Javitt et al., 1995).

A *patient's financial ability* to access care can also be influenced by socioeconomic factors (Roos & Mustard, 1997). Gilligan, Kneusel, Hoffmann, Greer, and Nattinger (2002), using data for the United States, find significant persistent variation in the use of breast-conserving treatment (BCT) by county income between 1983 to 1996; women living in lower-income counties are less likely to receive "complete" BCT (which, in addition to surgery also includes radiotherapy and lymph-node dissection). This evidence has been confirmed in other studies using U.S. data (Lazovich, White, Thomas, & Moe, 1991; Samet, Hunt, & Farrow, 1994), and Spanish data (Ridao-Lopez et al., 2011), but not in all studies on this procedure (see for example Polednak, 1997). With regards to other clinical settings, Carlisle et al. (1995) finds significant variation for eight common surgical procedures across small areas in Los Angeles County with differing income and ethnicity. The effect of income is stronger than ethnicity, in particular on coronary angioplasty and carotid endarterectomy. Similar results for coronary angiography have been found in Canada (Alter et al., 2003), for knee and hip replacements in the United Kingdom (Judge et al., 2010), cataract surgery in the United States (Javitt et al., 1995), and laparoscopic hysterectomy in the United States (Jacoby et al., 2009).

The income effect is reinforced by evidence suggesting that *insurance coverage and deprivation* have an impact on practice variation (Bisset & Russell, 1994; Griggs et al., 2009; Cave, 1995; Stafford, 1990). However, Roos and Mustard (1997) find no impact of income for 10 out of 12 common surgical procedures in Canada, and for the United Kingdom, and Kee et al. (1993) find no difference in coronary catheterization and angiography between areas of varying deprivation, measured by a composite score.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Bederman et al. (2011) find that surgeries for degenerative diseases of the lumbar spine were higher in Canadian counties with lower income.

Other important patient-level determinants include education, unemployment, and marital status. Coyte et al. (2001), using the discharge data of over 70,000 children and adolescents in Ontario, Canada, found that higher rates of pediatric middle-ear surgery occurred in counties with higher percentages of high-school graduates. For Spain, Ridao-Lopez et al. (2011) find significantly higher rates of conservative BCT in areas with both higher income and education levels.

Even *marital status* of patients has been linked with practice variations. Potosky et al., (2004) showed that 59% of married patients receive the recommended therapy non-small-cell lung cancer therapies, as opposed to only 38% of single patients. The authors speculate that married patients receive better “social support,” which in turn influences patients’ preferences for this therapy. An alternative explanation could be differences in insurance coverage for single and married individuals, and associated financial incentives, which may affect both patients and physicians’ treatment choices.

Agency theory (Jensen & Meckling, 1976) postulates that as agents to their patients, doctors might consider patient preferences in their decision leading to (warranted) practice variation. However, in the context of imperfect agency, the degree to which *patient preferences* are incorporated into treatment decisions can lead to unwarranted variation. For instance, procedure rates for preference-sensitive conditions, such as back pain, breast cancer, and benign prostatic hyperplasia, tend to vary considerably more than rates of other interventions (Arriagada et al., 1996, Green, 1996, Wennberg, 2002, Poggi et al., 2003). Hawker et al. (2001) showed that both patients’ willingness to undergo hip and knee arthroplasty and clinical need for this procedure (defined by the clinical indications) are associated with surgical rates, implying that patient-related demand factors impact on practice variations alongside clinical indications and other factors. Garg et al. (2002) find that 2% of Medicare AMI patients refuse angiography, and, not surprisingly, the authors identify this as a major predictor of underuse of the procedure. Neither study could establish why patient preferences differ, but Mancuso et al. (1996) modeled the role of patient preferences more explicitly. The study assessed the determinants of practice variation in the context of total hip and knee arthroplasties in academic medical centers in New York City and McGill, using a sample of 50 orthopedic surgeons. They argue that two types of patient characteristics can influence surgeons’ decisions for treatment: psychological and functional. With respect to the former, the authors find that poor motivation, limited cooperation, and hostile personality would render the majority of surgeons skeptical about performing arthroplasties. With respect to functional characteristics, a patient’s desire to be independent and return to work as well as the desire to perform sports would impact doctors’ decisions to perform arthroplasties.

The role that patients’ preferences might play in decision-making is likely to be greater in the context of adoption of innovative treatments. The uncertainty about what constitutes best practice tends to be higher at the early stages of an innovation diffusion process,

Variations in the Adoption of Healthcare Innovation? A Literature Review

where conclusive clinical evidence to support dominance of one treatment option over another is scant. In this context, decision aids are designed to aid patients in making decisions about specific treatments and medical procedures. This collaborative process allows patients' preferences and values to be reflected in the choice of the treatments they receive, instead of them relying solely on physicians' opinions. Research has shown that patient decision aids can effectively increase patient awareness of the expected risks, benefits, and likely outcomes of different treatment alternatives (Kaplan & Frosch, 2005; Lurie, Bell, & Weinstein, 2009). As Lurie et al. put it, ". . . the 'right rate' for most procedures is the one resulting from a fully informed patient population fully engaged in the decision-making process" (Lurie et al., 2009). Although evidence on the effect of decision aids on variation in procedure rates is limited, several randomized trials across different geographies have demonstrated significant reductions in surgery rates when such aids have been utilized (Kennedy et al., 2002; Auvinen et al., 2004; Whelan et al., 2004).

Physician-Level Factors

In a seminal paper, Wennberg and Gittelsohn (1973) suggest that "provider characteristics" are a major source of practice variation; this line of thought eventually led to Wennberg's well-known "*practice style theory*" (Wennberg, 1984), in which he concludes that unexplained variation in utilization stems from doctors themselves and what they believe constitutes appropriate care. However, Wennberg does not identify the specific aspects of physician characteristics or behavior that may underpin such variations and therefore does not offer much guidance for empirical investigation and policy interventions. While several empirical studies have tested Wennberg's practice style theory (Westert, Nieboer, & Groenewegen, 1993; Escarce, 1993), it has proven difficult to find indicators for physician attitudes, beliefs and behavior. Therefore, the vast majority of the empirical literature relies on the residual method approach toward the measurement of "practice style," first proposed by Long (2002). This approach consists of measuring the role that exogenous determinants (including patient agency constraints, organizational constraints, and environmental constraints) play in clinical practice—i.e., "induced variation"—and attributing the remaining residual variance to differences in physicians' practice styles—i.e., "unexplained" or "innate" variance. Several of these studies make use of small area analysis methodologies to control for factors which influence healthcare utilization, attributing observed differences between small areas to practice style. These studies further look at correlations between practice variation and physician characteristics.

The validity of this empirical approach to assessment of "practice style" relies on researchers' ability to observe and control for all important aspects of exogenous constraints affecting physician practice, allowing them to attribute any variance left unidentified to "innate variance," regardless of its true nature. However, this approach, as Folland and Stano (1990) point out, leads inevitably to the problem that supporting evidence of the "practice style theory" is indirect, either in the form of a correlation between utilization rate and physician's discretion regarding indication of treatment, or

Variations in the Adoption of Healthcare Innovation? A Literature Review

observations of unexplained residual (innate) variance in treatment, after adjustments for patient and hospital characteristics have been made. There is no sound basis for the claim that residual variance should be attributed entirely to physician style, just as there is no evidence to support the opposite. Therefore, using residual variance as evidence for the validity of the “practice style theory” is rather questionable, and it should merely be considered an “upper bound” for the proportional input of practice style factors (Folland & Stano, 1990). Moreover, most studies have been criticized for using aggregated data across physicians and, therefore, for being unable to fully distinguish demand factors from supply factors that affect variation (Grytten & Sørensen, 2003; Stano, 1985; Folland & Stano, 1990).

A better empirical strategy might be to make use of patient-level data to better disentangle supply- from demand-side factors. Some studies also make use of panel data linking patient characteristics with doctor characteristics to assess the dynamics of practice style and its determinants (Grytten & Sørensen, 2003; Epstein & Nicholson, 2009; Currie, MacLeod, & Van Parys, 2016; Molitor, 2018). Some contributions exploit variation in doctor migration to identify the role of physician-level factors such as preferences and learning play in explaining practice variation and physician behavior (Grytten & Sørensen, 2003; Epstein & Nicholson, 2009; Currie et al., 2016; Molitor, 2018). Grytten and Sørensen (2003) for instance, present evidence that supports the “practice style theory” for primary physician services in Norway, showing that physician-specific effects account for more than 50% of the variation in expenditure for laboratory tests, in expenditure for consultations, and in expenditure for specific procedures. The authors further show inertia in the change of practice styles for those physicians that change municipality. Epstein and Nicholson (2009), making use of patient- and physician-level data for C-sections in the United States find also evidence for the existence of practice style. The authors find that practice style changes over time and that it is shaped by learning and peer effects. Molitor (2018), using data for U.S. cardiologists, finds that physicians’ decisions are affected by practice style; however, the effect is smaller than that of environment-specific factors.

In what follows we will discuss the main findings of the empirical literature, that shows that several physician factors correlate with practice style, namely: (i) socio-demographic characteristics; (ii) training and work-related characteristics; (iii) behavioral attitudes, mainly with respect to uncertainty and enthusiasm.

Socio-Demographic Characteristics

With respect to physician socio-demographic characteristics, there is limited evidence on the role of physician age, gender, and ethnicity as determinants of practice variation. Harris et al. (2009) administered a survey on the management of patients with mitral regurgitation to a sample of 1,076 physicians, predominantly from the United States and Canada, and found no effect of *physician gender* on physician practice patterns. Similar evidence was found by a survey administered to 392 orthopedic surgeons in Ontario to assess the physician factors that impacted their decisions regarding knee replacements. The authors found the age and gender of the physician to be unrelated to the variation in

Variations in the Adoption of Healthcare Innovation? A Literature Review

decision-making in this context. A study by Yiannakoulias et al. (2009) found that *physician age* was not a significant predictor of cerebrovascular disease (CVD) entropy in the province of Alberta, Canada in 2006. However, age and gender have been found to correlate more strongly with practice variation in other areas. Wright et al. (1999) found that male physicians had a higher propensity to carry out knee-replacement surgery. Using hospital and physician-level data for Ontario between 1996 and 1999, Coyte et al. (2001) found that male physicians were more likely to refer patients for myringotomy with insertion of tympanostomy tubes than female physicians. Finally, Yiannakoulias et al. (2009) found that physician gender was a significant predictor of CVD entropy.

This strand of the literature also suggests that the *characteristics of the physician in relation to those of the patient* might impact practice variation. Geller, Burns, and Brailer (1996) found that female physicians were more likely to perform hysterectomies than male physicians. Similarly, female physicians were more likely to see female patients, have longer visit durations, and were more likely to perform prevention procedures for female patients and make some follow-up arrangements and referrals. Yiannakoulias et al. (2009) showed that CVD entropy was lower for physicians with a higher proportion of patients of the same sex than for those with lower proportions of patients of the same sex. Roos (1984) investigated hysterectomy across Manitoba, Canada, and found fivefold variation across hospital areas, showing that rates were higher in regions with a higher proportion of immigrant population. In addition, Roos (1984) found some indication of the potential impact of “hysterectomy-prone practice style” but could not present reliable evidence due to the lack of suitable data. These findings are consistent with substantial evidence from the literature on the role of doctor–patient relationship and on physicians and medical communication (Roter, Lipkin, & Korsgaard, 1991; Roter, Hall, & Aoki, 2002; Franks & Bertakis, 2003).

Training and Work-Related Characteristics

Characteristics of the *medical school* attended (for example, size, specialty of affiliated hospitals, and adequacy of teaching staff, funding, etc.), and country of training are all attributes that shape an individual physician’s practice patterns. For example, Coyte et al. (2001) found that Canadian counties with a greater proportion of referring physicians trained in North America were more inclined to perform myringotomy with insertion of tympanostomy tubes, compared to physicians that were not trained there.

Physician *experience and workload* also seems to correlate with the likelihood of performing certain treatments. Geller et al. (1996) showed that physicians with more years of experience were more likely to perform hysterectomies using a sample of 339 physicians in Arizona. Finally, Salopek et al. (1995) reported that the likelihood of performing an initial biopsy on patients suspected to have malignant melanoma was inversely related to dermatologists’ years of experience. Wright et al. (1995) found that in Ontario, orthopedic surgeons who had carried out a high volume of knee-replacement procedures were more likely than those with less experience to perform knee replacements.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Yiannakoulias et al. (2009) used the 2006 medical claims database of Alberta, Canada to analyze practice variation in CVD entropy. They estimated a hierarchical linear model to analyze determinants of practice variations at four levels (physician level, facility level, municipality level, and regional level). Findings indicated that workload for individual physicians (number of medical claims submitted), was positively associated with CVD entropy. However, the activity level of facilities was negatively associated with CVD entropy. The authors speculate that these apparently conflicting findings could be explained by how professional interaction is affected by physician workload; in practices where workload is high for all practitioners, there may be less interaction between physicians, leading to less collaboration in particular cases, and a reduction in variability in diagnoses.

Finally, the *department* where a physician works, specifically inpatient or emergency, has also been shown to affect physician decision-making and practice variation. Bhargavan et al. (2010) observe variation in imaging tests in the diagnosis of pulmonary embolism across emergency patients and inpatients. Patients seen in both the emergency and inpatient department were more likely to undergo imaging tests, compared to patients seen only in inpatient departments. The authors speculate that emergency physicians might demand more diagnostic tests because they need to make treatment decisions quickly; the workload in the emergency department is often higher, because of a higher volume of patients and greater patient complexity and urgency in receiving treatment; also, in emergency settings, there is often incomplete knowledge about patients' medical history.

Behavioral Attitudes

Uncertainty and Decision-Making: The Theory

Uncertainty in the diagnosis and in treatment outcomes have also been identified as important in the definition of "practice style" and consequently as one of the main predictors of practice variation. Phelps and Parente's (1990) study attempts to shed some light on the theory of "practice styles" with an economic model of practice variation which places particular emphasis on physicians' behavior; the authors demonstrate that welfare loss increases with the gap between quantity consumed by fully informed individuals and those without full information. They describe this source of variation as ". . . the economics of information, not one of irrationality or market failures" (Phelps, 1995).

Davis, Gribben, Scott, and Lay-Yee (2000) attempted to understand physicians' behavior in the context of the *environment* they were working in by analyzing the role the healthcare facility and the wider healthcare system play in physicians' decision-making. They developed the "supply hypothesis" as integration of "the observation that features of supply in medical care markets appear to play a powerful role in shaping patterns of utilization." They analyzed three key conceptual dimensions of clinical decision-making in a fee-for-service setting; namely, physician agency, clinical ambiguity, and income incentives. Of the three dimensions examined, physician agency and clinical ambiguity

Variations in the Adoption of Healthcare Innovation? A Literature Review

show significant effect in influencing inter-practitioner variation, while income incentives (measured by request for follow-up visits) do not seem to induce any detectable variation, suggesting a “clinical” rather than “economic” interpretation of medical practice variation. The *Diffusion Theory* (Phelps, 1995; Phelps, 1992; Birkmeyer et al., 1998; Griggs et al., 2009) builds on this insight, and recognizes that as more knowledge is disseminated among physicians, less uncertainty remains in their clinical judgment, which ultimately diminishes variation in their practice patterns.

Uncertainty and Decision-Making: Empirical Evidence

Uncertainty regarding treatment effectiveness and lack of consensus about what constitutes “best practice” across clinicians have both been empirically identified as possible determinants of practice variation in several clinical areas (Eddy, 1984; Andersen et al., 1987; Barron & Kazandjian, 1992; Cave, 1995; Wright et al., 1995; Weinstein, Lurie, Olson, Bronner, & Fisher, 2006; Harris et al., 2009). For a sample of 234 orthopedic surgeons in Ontario, Wright et al. (1995) assessed the agreement on indications for knee replacement and their views on their perceptions regarding the usefulness of several treatments for knee osteoarthritis. The authors show that there is clear disagreement among surgeons in the indication and effectiveness of several treatments (Wright et al., 1995). A carefully designed study by Ayanian, Landrum, Normand, Guadagnoli, and McNeil (1998) shows that the views of physicians on the appropriateness of coronary angiography after AMI for 20 common indications agree very closely with an expert panel, but the authors concede that this result may reflect the availability of acknowledged guidelines for this procedure and may not be generalizable to other important procedures. Katz et al. (2005) investigated the role of surgeon’s attitudes and beliefs in driving geographical variation in mastectomy, radiation therapy, and breast-conserving surgery (BCS) and found that high-volume surgeons more frequently endorse clinical guidelines that favor BCS, and that variation in surgeon opinion reflects clinical uncertainty about the benefits of alternative treatments.

The uncertainty about what constitutes best practice tends to be higher at the early stages of an innovation diffusion process, where conclusive clinical evidence to support dominance of one treatment option over another is scant. The large gray area of “clinical discretion” within which surgical decisions are made has indeed been identified as a source of unwarranted variation in medical decision-making and therefore will naturally impact the decision of adopting a new treatment. For instance, in a study evaluating 13 surgical procedures across different hospitals in Colorado (United States), 97% of the reviewed cases were at best aligned with published surgery indications and at worst were deemed reasonable by external expert review (Elliott, Kahn, & Kaye, 1981). As Birkmeyer et al. (2013) suggest: “procedure rates can vary substantially without surgeons breaking the rules of scientific evidence or infringing upon clinical guidelines.”

Finally, the introduction of a medical innovation can lead to variation simply by increasing the number of available alternative *treatment options* generating further uncertainty, or result in disagreement among physicians about whether the new procedure or technology should replace existing ones (Birkmeyer et al., 2013; Escarce, 1996; Wilson, 2006). In

some cases, physicians' disagreement is about the indications for surgery in light of a new technology, which can not only result in surgical variation but also an overall increase in surgical rates (Birkmeyer et al., 2013). For example, the rates of cholecystectomy in the United Kingdom and the United States increased significantly after the introduction of laparoscopic surgery in the 1990s, despite the lack of new evidence indicating surgery thresholds (Rutledge, Fakhry, Baker, & Meyer, 1996; McMahon, Fischbacher, Frame, & MacLeod, 2000). Practice variation due to variance in innovation adoption can also stem from differences in physicians' access to information, training and usage-related costs, and exposure to manufacturers' promotion efforts (Escarce, 1996; Wilson, 2006).

Enthusiasm and Decision-Making

The extent to which uncertainty impacts decision-making is mitigated by the level of *enthusiasm* with respect to a treatment. This is another factor that might explain practice variation and adoption of innovation. Chassin's (1993) "enthusiasm hypothesis" explains geographic differences in utilization by suggesting that "differences are caused primarily by the variability in the prevalence of physicians who are 'enthusiasts' about the use of the services whose use varies." Most empirical studies in this area have several limitations. First, results may be affected by sampling bias in that physicians who choose to participate in a survey are more enthusiastic toward the specified area of clinical care, thus leading to over-representation of the general propensity to perform the procedure. Further, without data on the number of patients treated by the physicians it is hard to establish the relative significance of each individual physician's response to the overall extent of observed practice variations. Therefore, the evidence that follows must be interpreted in light of these caveats.

Despite these caveats, the enthusiasm hypothesis has been identified as one of the factors associated with the variation of surgical rates in Ontario for degenerative diseases of the lumbar spine (Bederman et al., 2011), and myringotomy with insertion of tympanostomy tubes (Coyte et al., 2001). In a well-designed study that makes use of a rich dataset on patients' and physicians' characteristics, Currie et al. (2016) find further evidence in line with the enthusiasm hypothesis. The authors show that practice variation is characterized by differences across physicians' responsiveness to patients' characteristics and aggressiveness in the treatment of AMI in the United States. She further shows that aggressiveness and responsiveness vary with age, gender, and training. Bloor et al. (1978) report that higher tonsillectomy rates are found among more aggressive surgeons who, in turn, give more importance to physical examination than elements of the patient's medical history, such as the number of previous tonsillitis episodes.

Studies have identified physicians' *specialty* as a physician-related factor that affects clinical judgments (Salopek et al., 1995; Capper & Canter, 2001; Sawka et al., 2007; Harris et al., 2009; Bhargavan et al., 2010). Specialty also affects choice between medical and surgical treatments for the same conditions. For example, dermatologists who perform surgical procedures are more enthusiastic about conducting the relevant pre-surgery diagnostic biopsies than non-surgical dermatologists (Salopek et al., 1995).

Variations in the Adoption of Healthcare Innovation? A Literature Review

Sawka et al. (2007) asked individual physicians from the United States and Canada to recommend treatment using radioactive iodine remnant ablation for a sample case of thyroid carcinoma; they found that non-academic affiliation and surgical specialty are significant factors in predicting physician response. Possible explanations may be the unavailability of an imaging facility in a non-academic setting, and differences in opinion about risks and benefits of remnant ablation across surgeons and endocrinologists. Harris et al. (2009) investigated the timing of surgical treatment of asymptomatic patients with severe mitral regurgitation and found significant differences in opinion in cardiology versus cardiothoracic surgery specialties, with surgeons more prone to surgery. Bhargavan et al. (2010) found differences across specialties regarding the usage of clinical tests. Finally, Garg et al. (2002) and Borowsky et al. (1995) found that AMI patients treated by generalist physicians rather than cardiologists were less likely to receive coronary angiography, but do not further explain this finding.

Lastly, studies have identified other physician-related factors that affect clinical judgments, including site of practice (Bhargavan et al., 2010), place of education and training (Wright et al., 1999; Coyte et al., 2001), board qualification (Nickerson, Colton, Peterson, Bloom, & Hauck, 1976, Chuah, Lee, Wirtzfeld, & Pollett, 2010), years of experience (Verstappen et al., 2004; Chuah et al., 2010), compliance to guidelines (Chassin et al., 1986), and workload (Yiannakoulis et al., 2009).

Networks and Collaboration

In healthcare, *networks*, both at the individual and at the organizational level, can foster the diffusion of information, the adoption of new practices, and standardization of healthcare provision. Even though the literature above suggests that where a physician works and with whom she collaborates affects her decisions, the literature on the role of networks in the adoption and diffusion of healthcare innovations is scant. The healthcare literature on networks has focused on collecting data at the individual level in teams of physicians and nurses. The literature has focused on either the characterization of networks, the factors associated with interactions between healthcare professionals that shape the structure of such networks, network positions, or their consequences (Tasselli, 2014). This literature covered some of the ways in which relationship networks can influence both healthcare outcomes and diffusion of innovations.

Many studies characterize individual networks and its dynamics by measuring communication or information flows between doctors. The structure of communication networks is highly influenced by the tendency of people to prefer to interact with others similar to themselves, on dimension such as gender, age, seniority, or profession (Chase, 1995; Cott, 1997; Creswick & Westbrook, 2006; Creswick, Westbrook, & Braithwaite, 2009; MacPhee, 2000; MacPhee & Scott, 2002; Webster, Grusky, Podus, & Young, 1999). Seniority and professional background also affect networks between physicians in a team (West, Barron, Dowsett, & Newton, 1999), with homophily often playing a strong role. This potentially means that information and advice flow mainly in groups segregated by specialty or seniority. This might impair diffusion of information in some cases, leading to redundant information being shared within a mostly closed group. This segregation might

Variations in the Adoption of Healthcare Innovation? A Literature Review

explain differences in adoption of innovation. Indeed, evidence suggests that individuals that are homophilous with adopters (i.e., have similar characteristics, such as educational and professional background) are more likely to adopt innovations.

Team characteristics along with leader characteristics, such as gender of the clinical lead, influence the network structure of the team, for example, through centralization (Keating, Ayanian, Cleary, & Marsden, 2007). Centralization might delay diffusion of information and practices that do not originate with (or are not championed by) a central actor. Conversely, centrality of key actors in the network is usually favorable to information diffusion through this network, provided that the central individuals are supporting the diffusion (Becker, 1970; Cott, 1997; Creswick & Westbrook, 2006; Lewis, Baeza, & Alexander, 2008; Mendel, Damberg, Sorbero, Varda, & Farley, 2009; West, Barron, Dowsett, & Newton, 1999; Peng, Lo, Lin, & Yu, 2006). These network configurations have also been shown to help achieve good health outcomes (Cunningham et al., 2012).

Brokers, who are defined as individuals connecting other individuals who are otherwise unconnected, help the diffusion of critical information, so does hierarchical structure in the network (Heng, McGeorge, & Loosemore, 2005; West & Barron, 2005; Rangachari, 2008). This can potentially foster faster diffusion of innovative practices. Density in healthcare networks favors lower variability in performance but sometimes leads to less efficient information acquisition/diffusion through network ties (Fattore, Frosini, Salvatore, & Tozzi, 2009; West & Barron, 2005; West et al., 1999; Ormrod, Ferlie, Warren, & Norton, 2007; Mendel et al., 2009). There is additional evidence that how practice diffuses in a network is influenced by the professional affiliations of the network members. Ferlie, Fitzgerald, Wood and Hawkins (2005) study the barriers to adoption of innovation in the NHS and find that boundaries between professional communities, both social and cognitive, can strongly retard the spread of an innovation, hinting that in multi-professional organizations, managing disciplinary boundaries is essential to favor the adoption of specific innovations.

There is a debate around the drivers of innovation adoption in healthcare networks to determine whether *contagion or imitation* have more influence on diffusion. This debate dates back to the seminal work by Coleman, Katz, and Menzel (1957), who found that contagion led to diffusion (new adopters of a treatment were linked to doctors that had adopted) and continued with several reanalyses of their dataset (Burt, 1987; Marsden & Podolny, 1990; Strang & Tuma, 1993; Van den Bulte & Lilien, 2001), who found that structural equivalence (similarity of position) might be driving diffusion more than contagion. The structure of the network at the individual level has been shown to impact the diffusion of social norms (Srivastava & Banaji, 2011). Certain individuals in the network will play the role of gatekeepers due to their position within the structure, for example because they occupy a brokerage position in this network (Fleming & Waguespack, 2007; Lingo & O'Mahony, 2010).

Brokers connect otherwise unconnected individuals and therefore control, to a point, the information flows between the two regions of the network they connect. Should the

Variations in the Adoption of Healthcare Innovation? A Literature Review

individuals acting as a broker resist change, they are likely to delay diffusion of information and slow down the adoption of a new practice. Indeed, for the information to reach the group that is on one side of the brokers from the group on the other side will require an alternative route through the network. While brokers can delay information diffusion, other individuals have positions that can help diffusion. Central individuals with many connections are prime targets to help gather support for the introduction of new practices, as their numerous connections place them in a good position to spread information about the new norm (Borgatti, 2005; Godart, Shipilov, & Claes, 2014). One can therefore imagine that, in trying to introduce new guidelines, health systems could benefit from targeting specific individuals as “champions” following an assessment of their networks. Similarly, bringing brokers on board can help lift a hurdle for the diffusion of a new practice.

Social networks also seem to influence choice of treatment and quality of care, through social influence (Burke, Fournier, & Prasad, 2003) and through greater access to information about innovations (Carpenter et al., 2011; Hollingsworth et al., 2015). Pollack, Weissman, Bekelman, Liao, and Armstrong (2012) show, through creating networks of shared patients in the case of prostate cancer treatment, that treatment choice depends on which subgroup doctors are members of once one controls for both patients and physicians’ characteristics.

At the institutional level, there is mixed evidence about the benefits of association with institutions that disseminate best practices, with some studies showing increase in the uptake of innovative practices and others showing little or no increase in uptake (Tan et al., 2015; Meyer et al., 2013; Carpenter et al., 2012; Barocas et al., 2013; Miller, Murtagh, Suh, Knapp, Dunn, & Montie, 2010; Miller et al., 2011).

In summary, even though there is no consistent evidence on the exact magnitude or extent of influence that physicians have on practice variations, there is plenty of evidence to show that physician characteristics and network collaboration can play an important role in medical practice variations in certain clinical areas, particularly where there is uncertainty or disagreement about best-practice treatments, or where patient preferences, and their interpretation by the treating physician, play an important role. Networks of collaboration influence diffusion and adoption of innovations, even if the mechanisms behind the diffusion (contagion or imitation) are often hard to disentangle. Therefore, while it is common for health systems to foster the adoption of innovation through one-size-fits-all interventions (such as the standardization of training and/or through best-practice clinical guidelines), our results suggest that heterogeneity of physician characteristics and their networks might hinder the effectiveness of these interventions.

Provider-Level Factors

The vast majority of studies that assess the role that organizational characteristics play in determining practice variation and adoption and diffusion of innovation tend to use

Variations in the Adoption of Healthcare Innovation? A Literature Review

aggregate data at provider level. They usually have few controls for patient need and physician characteristics and therefore fail to disentangle the effect of organizational characteristics on clinical practice and adoption of innovation from the effect of demand-side and practice style factors. One notable exception is the study by Molitor (2018) which found that the effect of organizational-level characteristics in explaining practice variation is twice the size of physician-specific factors. Yet the author does not identify which organizational factors play a role, and the evidence remains mostly descriptive in nature.

Within this largely descriptive body of literature, there is abundant empirical evidence that differences in *hospital organizational characteristics* are associated with variation and adoption of innovation. Studies have identified type of hospital (Blais, 1993; Weiner, Starfield, Powe, Stuart, & Steinwachs, 1996; Spencer et al., 2008; Willens et al., 2009), location (urban or rural) (Gatsonis, Epstein, Newhouse, Normand, & McNeil, 1995; Nattinger, Gottlieb, Hoffman, Walker, & Goodwin, 1996; Byles, Mishra, & Schofield, 2000; Hilsden, 2004; Garreau et al., 2005; Yiannakoulias et al., 2009; Bhargavan et al., 2010), size and capacity (Kimberly & Evanisko, 1981; Castle, 2001; Goes & Park, 1997; Nystrom, Ramamurthy, & Wilson, 2002; Brown & Barnett, 1992; Burns, Chilingirian, & Wholey, 1994; Nattinger et al., 1996; Fritsche et al., 2000; Verstappen et al., 2004; Baicker, Buckles, & Chandra, 2006; Xirasagar, Lin, & Liu, 2006; Ketcham, Baker, & MacIsaac, 2007; Chen, Zhang, Sun, & Mueller, 2009; Yiannakoulias et al., 2009; Lurie & Weinstein, 2001; Goes & Park, 1997; Nystrom et al., 2002), age of the hospital (Kimberly & Evanisko, 1981), organizational slack (Nystrom et al., 2002), availability of resources and certain procedures (Santos-Eggimann et al., 1989, Every et al., 1993; Gatsonis et al., 1995), existence of a trauma center (Davis, Localio, Stafford, Helfaer, & Durbin, 2005), and functional differentiation (Kimberly & Evanisko, 1981, Burns & Wholey, 1993). All of these have been shown to result in systematic variations in the availability of medical treatments or diagnostic tools, mix and number of clinical staff, financial incentives, and other factors that cause practice patterns that are not explained by other causes at the patient and physician level.

Variation in the *availability of diagnostic and therapeutic technologies* have been shown to affect variations in procedures ranging from Cesarean delivery, cardiac procedures (including catheterization, percutaneous coronary angioplasty, and coronary artery bypass graft surgery), treatment for breast cancer or prostate cancer (Lazovich et al., 1991; Every et al., 1993; Mirvis & Graney, 1999; Garg et al., 2002; Baicker et al., 2006; Nambudiri et al., 2012) and thrombolysis (Pilote et al., 1996). Studies find that the in-hospital availability of cardiac procedures (cardiac catheterization, bypass surgery, and angioplasty) strongly influences their use for AMI patients, for example in hospitals in New England, United States (Wennberg et al., 1997), in New York State (Blustein, 1993) for patients from the US Veterans Health Administration (VA) (Mirvis & Graney, 1999), and, in the case of coronary angiography, in Medicare AMI patients (Gatsonis et al., 1995; Garg et al., 2002), and in AMI patients admitted to hospitals in Seattle (Every et al., 1993). Nambudiri et al. (2012) show that VA medical centers with limited access to external beam radiotherapy had lower radiotherapy rates for treating prostate cancer

Variations in the Adoption of Healthcare Innovation? A Literature Review

patients. Studies on VA data are not without limitations; for example, VA patients may be systematically different from other patient populations, which limits generalizability of results (Nambudiri et al., 2012); further, VA patients could have received medical attention in non-VA centers, with the effect that procedure rates are underestimated. Pilote et al. (1996), using data on over 20,000 thrombolysis patients, show that availability of angiography and revascularization, aside from, perhaps surprisingly, younger age, was a major determinant of its use.

Urbanization of the area in which a hospital is located affects population density, and can impact on the availability of facilities and supply and mix of clinical staff. Urbanization has been proven a determining factor in the accessibility of medical services such as breast-conserving treatment (BCT) (Nattinger et al., 1996), but seems less important for the availability of some other procedures, for example endoscopy (Hilsden, 2004). Economies of scale may determine that procedures which have comparably higher requirements with regards to equipment, facilities, and supply and qualification of medical staff are concentrated in urban metropolitan areas where there is a large enough population and a higher demand for such procedures. However, Weinstein et al. (2004) analyzed Medicare rates for surgery to treat degenerative diseases of the hip, knee, and spine across U.S. regions over a decade, and observed an inverse association between population density and spine surgery rates, but no significant association between supply of surgeons and surgery rates. They further found that rates were highly variable among regions, and that these variations were surprisingly persistent over time.

Differing characteristics of the surgeon population across urban and rural areas may also result in practice variations; for example, Yiannakoulis et al. (2009) analyzed variations in diagnostic practice style associated with cerebrovascular disease in the province of Alberta, Canada. They found that physicians working in rural and urban municipalities had different practice style patterns even after controlling for the types of facilities they work in, their professional medical specialization, and their workload. They speculate whether the notably higher proportion of foreign-trained practitioners in rural areas, and their unique practice patterns, may account for part of the variation between rural and urban municipalities.

A number of studies show that *practice or facility size* have significant impact on physician behavior and practice variations. Baicker et al. (2006) used the National Center for Health Statistics (NCHS) that contains linked data on birth and infant death to identify factors that contribute to risk-adjusted county Cesarean rates and found that provider density and hospital capacity account for around 9% of the variation in these rates. Goes and Park (1997) and Nystrom et al. (2002), using panel data for U.S. hospitals, found that larger hospitals were more innovative than smaller hospitals. Castle (2001) found similar evidence for nursing homes, with nursing homes with a higher number of beds being more likely to adopt innovation at early stages of the diffusion process. Angst et al. (2010) studied the diffusion of electronic records in U.S. hospitals from 1975 to 2005 and found that the size and age of a hospital make it more prone to

Variations in the Adoption of Healthcare Innovation? A Literature Review

being influenced to adopt, while younger hospitals are more influential (infectious). They also found that status increases influence, and so does spatial proximity.

Lu et al. (2015) assessed what hospital characteristics that correlate with innovation adoption behavior using patient-level data for the provision of percutaneous coronary interventions in Taiwanese hospitals. The authors showed that smaller hospitals and those located close to an early adopter tended to adopt the innovation later. A higher proportion of physicians practicing in larger facilities appears to decrease practice variations overall (Burns et al., 1994; Yiannakoulis et al., 2009), possibly because increased communication among staff in larger facilities results in treatment decisions that are more in line with universally acknowledged best practice (Verstappen et al., 2004; Xirasagar et al., 2006; Ketcham et al., 2007). Ketcham et al. (2007) demonstrate that communication among doctors is associated with improved patient outcomes. They find that Medicare patients with AMI treated by solo physicians are less likely to receive cardiac catheterization and angioplasty within a day of admission and more likely to die than other patients in the same hospital. However, reduced variation can also be seen as loss of autonomy and may not necessarily be beneficial in terms of accommodating patient preferences and encouraging innovation.

Burns and Wholey (1993), using a panel of 1375 non-federal general hospitals in the United States, followed between 1961 and 1978, found that *functional and task diversity* correlates with adoption of innovation in hospitals. Functional differentiation—measured as the extent to which a hospital is divided into different sub-units—has also been found to be correlate with the adoption of 12 technological innovations and 8 administrative innovations in U.S. hospitals, after controlling for leadership and contextual differences across hospitals.

Lastly, *hospital policies, incentives and regulations* play a significant role in unifying clinical practice. A recent study from Gauld, Horwitt, Williams, and Cohen (2011) investigated the strategies employed by 710 U.S. hospitals to reduce unwarranted practice variation and found that methods to modify variation include (in descending order of effectiveness judged by hospital representatives) benchmarking, clinical-practice guidelines, blinded report cards, opinion leader education, pay for performance, unblinded report cards, and patient engagement. Guadagnoli et al. (2001) found geographic variation of angiography in Medicare patients to be associated with higher degree of discretion in the indications of a specific treatment, suggesting the need for clinical trials that can provide convincing guidelines for physician practice. Keller, Soule, Wennberg, and Hanley (1990) found that practice variation in orthopedic procedures can be reduced through data feedback. Marciniak et al. (1998) showed that feedback of the Cooperative Cardiovascular Project data to hospitals and coordination between referral networks improved care in four states in the United States.

In the context of imperfect agency, heterogeneity in financial incentives faced by physicians might explain clinical-practice variation. Howard, David, and Hockenberry

(2017) exploit an “informational shock” in the United States to show that physicians’ treatment decisions are affected by ownership and financial incentives.

Health System and Ecosystem Factors

Patients, physicians, and providers interact within an *ecosystem* and therefore their actions are inevitably influenced by the institutional and contextual environment of the health system and more generally the society within which they exist. The ecological approach to the assessment of practice variation highlights the importance of the contextual environment and the interdependence of the different stakeholders within the health system as a key determinant of practice variation and adoption of innovation. Two recent frameworks explore the contextual determinants of practice variation (Gillick, 2009; Burke et al., 2010) within its broader context. Burke et al. (2010) focuses on the social interaction among local physicians, namely productivity spillover and conformity pressure, providing a theoretical framework in which both patient characteristics and local social influence are taken into consideration.

Conversely, Gillick’s (2009) framework employs the “ecosystem” approach to explaining geographic variation in physician test-ordering behavior. With data on physician-administered imaging tests in Florida, Gillick highlights that the interacting components of a medical ecosystem includes that of patient–physician relationship, impact of local community characteristics (e.g., hospitals, medical schools, supply of malpractice lawyers, health plans), and on a larger scale, societal factors such as drug companies, media, congress, and medical device-makers, etc. The model stresses the interdependence of each component, hence any change imposed on a single component of the ecosystem may bring about compensatory changes in another aspect. This means that policymakers must embed these spillover effects in policy design and consider multiple levels of interventions should they wish to achieve major changes in physician practice pattern. Gillick’s model, although difficult to test empirically, emphasizes that the healthcare system is constructed from much more than the adopters and end users of innovation, i.e., just hospitals, doctors, and patients. System-level factors can work on multiple levels to influence physician- and patient behavior, and impact on observed practice patterns (Riley et al., 2008; Busato, Widmer, & Matter, 2011; Ridao-Lopez et al., 2011).

The position of a hospital within the healthcare system is also likely to influence practice. Compagni, Mele, and Ravasi (2015) studied the diffusion of robotic surgery in Italy from 1999 to 2010 and found that peripheral hospitals sometimes take up the role of innovation champions in the search for social status. When their efforts are successful, they become “exemplary users” and the advocacy work they do to promote the new practice strengthens isomorphic diffusion, even when uncertainty about the benefits of the innovation remains.

Another important system-level factor is the *financing of healthcare*. Prospective payments have been found to affect the adoption and diffusion of innovation in hospitals.

Variations in the Adoption of Healthcare Innovation? A Literature Review

However, the evidence on the direction of the effect is mixed (Sorenson et al., 2015). With a sample of 2,558 U.S. hospitals over a 10-year period, Cromwell and Kanak (1982) show that rate-setting prospective payments programs negatively correlate with the adoption and diffusion of innovation in different settings (e.g., intensive care, open-heart surgery, social work, physical therapy, and electroencephalogram). However, the authors suggest that the effect is significant for prospective payments that are mandatory and with a broad payer scope. Looking at the same setting and exploiting variation of prospective payment policies across U.S. states, Romeo, Wagner, and Lee (1984) found that the effect on adoption and diffusion of innovation of prospective payment policies depended on the innovation and incentive structure inherent to each policy. Castle (2001) found that prospective financing was negatively related with the likelihood of early adoption of innovation in 162 U.S. nursing homes.

Healthcare financing is particularly important if it affects out-of-pocket costs for patients and expected reimbursement of physicians (Busato et al., 2011). Long (2002) and Gillick (2009) have both emphasized the importance of patients' health insurance arrangements in determining physician behavior in their theoretical models. A number of empirical studies investigate the impact of financing arrangements by comparing practice patterns for patients with private or private supplementary insurance, with patients that mainly rely on publicly provided funding (Pilpel, Fraser, Kosecoff, Weitzman, & Brook, 1992; Laouri et al., 1997; Shorten & Shorten, 2000; Busato et al., 2011). The studies reviewed here focus on patients that are treated in the same hospitals, in order to isolate the impact of financing arrangements from ownership status of hospitals. Shorten and Shorten (2000) analyzed 2028 women who underwent vaginal delivery during a 12-month study period in a large public hospital in South Wales, Australia. Of those, 723 were privately insured but chose treatment in a public hospital. Privately insured women are twice as likely to experience episiotomy as publicly admitted women, even after controlling for clinical and other factors. There is no evidence that privately insured women have better outcomes overall; in fact, they are more likely to experience third-degree tears. The authors did not investigate the underlying reasons for different practice patterns but speculated that insurance type affects the mix of obstetricians and midwives involved during labor and birth, with private patients receiving a relatively greater input from obstetricians. This in turn may impact on the type of treatment received, because obstetricians and midwives have different clinical background, education, and experiences. Shorten and Shorten (2000) does not mention whether obstetricians have any financial advantages in treating private patients.

Griggs et al. (2009) investigated how patients' insurance coverage may play a role in the financial incentives driving physician behavior in the USA. They studied 1051 women diagnosed with ductal carcinoma *in situ* between 1985 and 2000 with data from 2 tumor registries. After controlling for clinical, pathological, treatment, and demographic characteristics, they found a significantly increased rate of lymph-node dissection for patients with more comprehensive insurance coverage. For Switzerland, Busato et al. (2011) found a higher rate of orthopedic surgery in patients with supplementary private health insurance in comparison to patients without insurance. They speculate that the

Variations in the Adoption of Healthcare Innovation? A Literature Review

additional payment that physicians and hospitals receive for treatment of patients with supplementary cover may explain these results. These results could be due to sample selection; patients are more likely to take out private insurance if they have a greater medical need and a greater likelihood to require surgical treatment. However, the evidence points to the contrary: private health insurance is more likely to be purchased by individuals with, on average, “higher education, better self-perceived health status, fewer work related musculoskeletal problems, a healthier lifestyle and usually high health insurance deductibles” (Busato et al., 2011), all of which are characteristics likely to result in lower medical need.

Riley et al. (2008) have compared diagnosis and treatment patterns for several cancers in Medicare managed care and fee-for-service sectors. The authors found significant variation among plans and highlight the plan-benefit structure as one potential determinant of their findings. However, also in this contribution, their findings could be due to sample selection.

System-level factors beyond the healthcare system may impact on practice variations for certain procedures. Wasiak, Pransky, and Yao (2006) demonstrate that variations in surgical treatment of work-related carpal-tunnel syndrome are significantly associated with different United States workers’ compensation jurisdictions, and associated levels of compensation.

Another system-level factor that can affect decision-making—including the adoption of innovation—is *competition*. As postulated by economic theory, competitive firms will have a stronger incentive to adopt innovation as the benefit from doing so—greater market power—is greater in competitive than non-competitive markets (Arrow, 1962; Fudenberg & Tirole, 1985). In healthcare this effect can arise from competition among both hospitals and physicians. The first is more relevant in public health systems like the NHS, whereas in private health systems such as that of the United States, and in social health insurance systems such as that found in Germany, both hospital- and individual-led competition are prevalent. For instance, Propper and Söderlund (1998) found that price competition between NHS hospitals in the internal market in the 1990s had some effect on prices and costs. Yet, Propper, Burgess, and Gossage, (2008) also show that while some quality measures, such as waiting times fell, others, such as mortality rose, which indicates that price competition may compromise service quality unless safeguards are in place. While there is little research on the effect of competition among physicians on the adoption and diffusion of innovation, competition in other care settings has been found to play a role in decision-making. Healthcare providers (hospitals, clinics, clinical practices, and nursing homes) located in more competitive markets have been found to be more likely to adopt innovation, speeding up the process of its diffusion (Escarce, Bloom, Hillman, Shea, & Schwartz, 1995; Hamilton & McManus, 2005; Callaway & Ghosal, 2012; Sethi, Henry, Hevelone, Lipsitz, Belkin, & Nguyen, 2013). Hamilton and McManus (2005) analyzed how competition between fertility clinics in the United States affected the diffusion of a new technology for infertility treatment. The authors showed that an increase in competition was associated with a 19% increase of the likelihood of a clinic adopting the fertility

Variations in the Adoption of Healthcare Innovation? A Literature Review

innovation. Competition has also been found to increase the likelihood or early adoption of innovation in nursing homes (Castle, 2001).

Geographic differences in clinical practice and adoption of innovation can also be related to *regional differences in the way healthcare provision is organized*, even within the same country. For example, Bhargavan et al. (2010) study the frequency of use of imaging tests in the diagnosis of pulmonary embolism in the fee-for-service population in the United States and find that utilization is particularly low in California compared to other states. The Kaiser-Permanente health maintenance organization plays a particularly prominent role in healthcare in California, and the authors speculate that the parsimonious care patterns of Kaiser-Permanente spill over into the general practice patterns in the region. But even without organizational influences of this nature, there may naturally exist a faster diffusion of practice style or information among physicians practicing in proximity to each other. Strategies that adjust the organizational structure of medical practice can indeed help to reduce variation. For instance, implementing gatekeeping systems and financial incentives that encourage better coordination of primary care may slow growth in costs and improve care (Busato, Matter, Kunzi, & Goodman, 2012).

Lastly, other important factors impacting on physician behavior include drug companies and device manufacturers, evidence and guidelines, and regulation related to malpractice policies (Cabana et al., 1999; Gillick, 2009; Sherer & Coogan, 2015; Frakes, 2013). Frakes (2013) assesses the impact of evidence-based national malpractice standards on practice variation for several procedures and showed that national standards led to a reduction of between 30% and 50% in the gap between state-utilization rates and the respective national mean. However, the impact of evidence will differ according to provider characteristics such as ownership and incentives (Howard et al., 2017).

Discussions and Conclusions

Variation in innovation adoption and medical practice occurs at multiple levels, from patients, through physicians and their formal and informal networks, to provider and health system level. The phenomenon suggests uneven diffusion of new technologies and procedures, with potential manifestation of inefficiency and inequity in medical resources access and utilization. As this literature review shows, there are a myriad of factors involved in medical practice variation and in the adoption and diffusion of innovation. Traditionally, the literature has focused on patient and provider characteristics as main determinants of practice variation. Patients living in different geographic areas, patients consulting different doctors in the same area, or even patients of the same doctor but with differing socio-demographic characteristics or insured under different schemes may experience differential health service in terms of type and volume. Many studies of practice variation use aggregate provider-level data, and therefore necessarily focus on the many provider-level factors that are sources of practice variations. Studies have found that these include organizational characteristics, location, rurality, size, availability of treatment and diagnostic tools, and skill mix of medical staff.

Variations in the Adoption of Healthcare Innovation? A Literature Review

More recent empirical evidence indicates that physicians' characteristics—such as socioeconomic profile, training, and work-related characteristics—and the environmental constraints shaping their behavior are equally influential components of practice variation. Among these, physician-related socio-psychological and behavioral factors underpinning practice variation (e.g., attitudes toward risk and innovation adoption) remain under-researched and deserve consideration. Such characteristics of physicians are termed “practice style,” and although considered a major source of practice variation, have proven difficult to investigate empirically.

Formal and informal networks between physicians may play an important role in innovation adoption; brokers link otherwise unconnected physicians and may be an important influencing role because they either resist or foster adoption.

Lastly, features of healthcare systems—for example, public coverage of healthcare expenditure, cost-based reimbursement, and service-delivery organization—are generally associated with higher utilization rates and adoption of innovation.

Overall, due to data and methodological limitations, there is little evidence on the causal impact of each these factors and on their relative importance in explaining adoption and diffusion patterns of innovation. Further, even though it is now widely established that variation accruing on aspects beyond patients' clinical characteristics can lead to inefficiency and inequity, little has been suggested on implementable instruments that are effective in identifying and measuring unwarranted variation in clinical practice and innovation diffusion.

Of course, higher rates of innovation adoption might not necessarily result in better outcomes. Ultimately the impact on outcomes will depend on the benefits associated with specific innovations. Given the generalized political agenda of cost containment, high rates of utilization of expensive innovations are more likely to be frowned upon than lower rates of utilization. Hence, a question that has been repeatedly investigated is: “are high rates too high?” (Volinn, Diehr, Ciol, & Loeser, 1994). As discussed here, most researchers agree that the appropriateness of practice should not be determined by the rate of practice (Chassin et al., 1987; Casparie, 1996; Fisher et al., 2003), and several studies have found that higher rates of utilization result in no apparent benefit regarding patient outcomes (Shorten and Shorten, 2000; Baicker et al., 2006; Song et al., 2010).

Assuming equal access for all patients as equity principle, the “right rate” for a particular procedure should be set in accordance with the “need” for it, as measured by the proportion of patients who are eligible for the procedure. To establish eligibility, one must first define the diagnostic criterion qualifying an individual as a recipient of the procedure in question. In the absence of reliable evidence and appropriate indicators that measure the value of an innovation, to judge “appropriateness” of a certain procedure rate simply by comparing it to other rates is, as Chassin et al. (1986) point out, “both uninformed and dangerous. It is uninformed because at present we have no clinical data that would allow us to judge the difference in appropriateness of the use of any particular procedure between high-use and low-use areas. It is dangerous because such an

Variations in the Adoption of Healthcare Innovation? A Literature Review

assumption will surely result in policies that restrict access to care. Thus, if the assumption is wrong, patients will suffer." Therefore, as a way forward, health systems ought to invest in new processes to assess and monitor unwarranted variation.

The measurement of welfare losses due to unwarranted variation can be instrumental for the implementation and acceptability of such processes. Even though it has been established theoretically that variation in medical care results in welfare loss (Phelps & Parente, 1990; Phelps, 1995), we are still far from having a clear understanding of the welfare implications of unwarranted variation. To quantify the extent of welfare loss, one must consider the implications of variation in terms of content and quality of care. One questionable proposition from the early literature on practice variation, as Folland and Stano have noted, is that "variation across areas reflects inappropriate use" (1990). If all variation in practice patterns were inappropriate, then it should hold that levels of intensity are either positively associated (in areas of underuse), or negatively associated (in areas of overuse) with procedure rate, rather than remaining consistent through all rates of intensity. Chassin et al.'s (1987) study assumes similar levels of "appropriateness" of the same procedure across different sites (geographic areas of high, low, and average use of these procedures), therefore implying that attributes of variation must be divided into those that are justified and those that are not. Wennberg was first in terming the "inappropriate aspects" of variation in a contextual format, namely "unwarranted variation" i.e., "those that cannot be explained by type or severity of illness or by patient preferences" (Wennberg, 2002). Wennberg's approach of distinguishing between warranted and unwarranted variations, though widely accepted, fails to address the lack of scientific basis in designating each service a matching category, hence the question of whether higher rates in a procedure imply beneficial utilization or improper overuse remains, more often than not, unanswered. The same issue lodges in many other studies that have demonstrated the existence of variation in treatment by measuring it with compliance to clinical guidelines or trial evidence, which unfortunately, are all subject to errors of their own. Uncertainty in clinical practice (Eddy, 1984) notwithstanding the choice of methods employed to assess the appropriateness of diagnostic and therapeutic procedures may well influence the result of assessment (Casparie, 1996). Identification of a golden standard must be guaranteed before the "inappropriateness" of variation in a specific procedure can be established, and appropriateness ought to account for "patient preferences" with respect to treatment options. There are numerous ways in which patient preferences can be elicited, and yet health researchers are still far from reaching a uniform decision as to which technique is most valid. Once appropriateness of diffusion levels is identified, health systems should invest in the policy amenable factors that foster its diffused use in the targeted populations.

The standard indications (e.g., degree of functional limitation) are usually constructed based on observed outcomes of clinical trials or expert panel consensus (Casparie, 1996). However, expert panel judgments are largely associated with the personal experience of panel members, hence, the resulting guidelines depend upon members' understanding of all existing clinical evidence, but more importantly, on their own experience in embedding

Variations in the Adoption of Healthcare Innovation? A Literature Review

innovations into practice. Second, and more importantly, the clinical understanding of the precise indications for a procedure is affected by the level of uncertainty inherent to our limited understanding of the functioning mechanisms of the human body. This level of uncertainty leaves space for subjectivity in the assessment of the benefits and risks of embedding an innovation into medical practice, which can potentially lead to inadequate levels of innovation diffusion into health systems. These high levels of discretion in decision-making make it difficult to diffuse innovation in areas where it would present significant benefits to the population. It is therefore imperative to understand the determinants of decision-making in those areas where there exists a high level of discretion with regards to medical practice.

Although research shows that some strategies aimed at reducing variation in medical decision-making, (e.g., use decision aids, benchmarking, clinical-practice guidelines) are bearing fruit (Marciniak et al., 1998; Guadagnoli et al., 2001; Lurie et al., 2009; Gauld et al., 2011), there are still pervasive unwarranted differences in healthcare delivery. Evidence-based understanding of the barriers to innovation adoption, which can lead to persistent practice variation, inefficiency, is critical to develop effective interventions seeking to encourage the uptake and diffusion of new medical technologies and procedures.

In conclusion, the research focus on the drivers of practice variation has shifted from disease and need prevalence to the role physician practice style and environmental constraints play on physician behavior. Yet, despite 75 years of research and growing awareness of this issue among clinicians and policymakers, given the myriad of possible influencing factors, much more research is needed before we can reach a clear and comprehensive understanding of the determinants of variation in medical decision-making, and in turn the strategies to effectively address the resultant healthcare disparity. Future efforts should focus on developing evidence-based guidelines to reduce clinical uncertainty, identifying the exogenous factors causing medical variation and devising strategies to modify these factors.

Acknowledgments

This project is part of the Health Foundation's Efficiency Research programme. The Health Foundation is an independent charity committed to bringing about better health and healthcare for people in the UK. We are thankful for their financial support. We thank Eliana Barrenho and Carol Propper for their comments.

References

Alfredsson, J., Sederholm-Lawesson, S., Stenstrand, U., & Swahn, E. (2009). Although women are less likely to be admitted to coronary care units, they are treated equally to men and have better outcome: A prospective cohort study in patients with non ST-elevation acute coronary syndromes. *Acute Cardiac Care*, 11(3), 173–180.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Alter, D. A., Naylor, C. D., Austin, P. C., Chan, B. T., & Tu, J. V. (2003). Geography and service supply do not explain socioeconomic gradients in angiography use after acute myocardial infarction. *Canadian Medical Association Journal*, 168(3), 261-264.

Andersen, T. F., Blais, R., Bredesen, J., Jorgensen, T., Loft, A., Madsen, M., Mooney, G., & T. Sejr, T. (1987). Coping with regional variations: The case of surgery in Denmark. *International Journal of Health Planning Management*, 2(4), 253-264.

Angst, C. M., Agarwal, R., Sambamurthy, V., & Kelley, K. (2010). Social contagion and information technology diffusion: The adoption of electronic medical records in U.S. hospitals. *Management Science*, 56(8), 1219-1241.

Arriagada, R., Le, M., Rochard, F., & Contesso, G. (1996). Conservative treatment versus mastectomy in early breast cancer: Patterns of failure with 15 years of follow-up data. Institut Gustave-Roussy Breast Cancer Group. *Journal of Clinical Oncology*, 14, 1558-1564.

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In National Bureau of Economic Research, *The rate and direction of inventive activity: Economic and social factors*. Princeton, NJ: Princeton University Press,

Auvinen, A., Hakama, M., Ala-Opas, M., Vornanen, T., Leppilahti, M., Salminen, P., & Tammela, T. L. J. (2004). A randomized trial of choice of treatment in prostate cancer: The effect of intervention on the treatment chosen. *BJU International*, 93(1), 52-56.

Ayanian, J. Z., Epstein, A. M. (1991). Differences in the use of procedures between women and men hospitalized for coronary heart disease. *The New England Journal of Medicine*, 325, 221-225.

Ayanian, J. Z., Landrum, M. B., Normand, S.-L. T., Guadagnoli, E., & McNeil, B. J. (1998). Rating the appropriateness of coronary angiography—Do practicing physicians agree with an expert panel and with each other? *The New England Journal of Medicine*, 338(26), 1896-1904.

Baicker, K., Buckles, K. S., & Chandra, A. (2006). Geographic variation in the appropriate use of cesarean delivery. *Health Affairs (Millwood)*, 25(5), w355-367.

Barnato, A. E., Lucas, F. L., Staiger, D., Wennberg, D. E., & Chandra, A. (2005). Hospital-level racial disparities in acute myocardial infarction treatment and outcomes. *Medical Care*, 43(4), 308.

Barocas, D. A., Liu, A., Burks, F. N., Suh, R. S., Schuster, T. G., Bradford, T., . . . Miller, D. C. (2013). Practice based collaboration to improve the use of immediate intravesical therapy after resection of nonmuscle invasive bladder cancer. *Journal of Urology*, 190(6), 2011-2016.

Barron, M., & Kazandjian, V. A. (1992). Geographic variation in lumbar diskectomy: A protocol for evaluation. *QRB. Quality Review Bulletin*, 18(3), 98-107.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Baxter, N. N., Rothenberger, D. A., Morris, A. M., & Bullard, K. M. (2005). Adjuvant radiation for rectal cancer: Do we measure up to the standard of care? An epidemiologic analysis of trends over 25 years in the United States. *Diseases of the Colon and Rectum*, 48(1), 9–15.

Becker, M. H. (1970). Factors affecting the diffusion of innovation among health professionals. *American Journal of Public Health*, 60, 294–304.

Bederman, S. S., Coyte, P. C., Kreder, H. J., Mahomed, N. N., McIsaac, W. J., & Wright, J. G. (2011). Who's in the driver's seat? The influence of patient and physician enthusiasm on regional variation in degenerative lumbar spinal surgery: A population-based study. *Spine (Phila Pa 1976)*, 36(6), 481–489.

Bhargavan, M., Sunshine, J. H., Lewis, R. S., Jha, S., Owen, J. B., & Vializ, J. (2010). Frequency of use of imaging tests in the diagnosis of pulmonary embolism: Effects of physician specialty, patient characteristics, and region. *American Journal of Roentgenology*, 194(4), 1018–1026.

Birkmeyer, J. D., Sharp, S. M., Finlayson, S. R. G., Fisher, E. S., & Wennberg, J. E. (1998). Variation profiles of common surgical procedures. *Surgery*, 124(5), 917–923.

Birkmeyer, J. D., Reames, B. N., McCulloch, P., Carr, A. J., Campbell, W. B., & Wennberg, J. E. (2013). Understanding of regional variation in the use of surgery. *Lancet*, 382(9898), 1121–1129.

Bisset, A. F., & Russell, D. (1994). Grommets, tonsillectomies, and deprivation in Scotland. *BMJ*, 308(6937), 1129–1132.

Blais, R. (1993). Variations in surgical rates in Quebec: Does access to teaching hospitals make a difference? *Canadian Medical Association Journal* 148(10), 1729–1736.

Bloor, M. J., Venters, G. A., & Samphier, M. L. (1978). Geographical variation in the incidence of operations on the tonsils and adenoids. An epidemiological and sociological investigation (part II). *Journal of Laryngology and Otology* 92(10), 883–895.

Blustein, J. (1993). High-technology cardiac procedures: The impact of service availability on service use in New York State. *Journal of the American Medical Association*, 270(3), 344–349.

Borgatti, S. P. (2005). Centrality and network flow. *Social Networks*, 27(1), 55–71.

Borowsky, S. J., Kravitz, R. L., Laouri, M., Leaks, B., Partridge, J., Kaushik, V., . . . Brook, R. H. (1995). Effect of physician specialty on use of necessary coronary angiography. *Journal of the American College of Cardiology*, 26(6), 1484–1491.

Braveman, P., Egerter, S., & Williams, D. R. (2011). The social determinants of health: Coming of age. *Annual Review of Public Health*, 32, 381–398.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Brown, L. J., & Barnett, J. R. (1992). Influence of bed supply and health care organization on regional and local patterns of diabetes related hospitalization. *Social Science & Medicine* 35(9), 1157–1170.

Burke, M. A., Fournier, G., & Prasad, K. (2003). Physician social networks and geographical variation in medical care. Brookings Institute, Center on Social and Economic Dynamics. Working Paper 33.

Burke, M. A., Fournier, G. M., & Prasad, K. (2010). Geographic variations in a model of physician treatment choice with social interactions. *Journal of Economic Behaviour and Organization* 73(3), 418–432.

Burns, L. R., & Wholey, D. R. (1993). Adoption and abandonment of matrix management programs: Effects of organizational characteristics and interorganizational networks. *Academy of Management Journal*, 36, 106–38.

Burns, L. R., Chilingirian, J. A., & Wholey, D. R. (1994). The effect of physician practice organization on efficient utilization of hospital resources. *Health Services Research Journal*, 29(5), 583–603.

Burt, R. S. (1987). Social contagion and innovation: Cohesion versus structural equivalence. *American Journal of Sociology*, 92(6), 1287–1335.

Busato, A., Matter, P., Kunzi, B., & Goodman, D. (2012). Geographic variation in the cost of ambulatory care in Switzerland. *Journal of Health Services Research and Policy*, 17(1), 18–23.

Busato, A., Widmer, M., & Matter, P. (2011). Variation in incidence of orthopaedic surgery between populations with basic or basic plus supplementary health insurance in Switzerland. *Swiss Medical Weekly*, 141, w13152.

Byles, J. E., Mishra, G., & Schofield, M. (2000). Factors associated with hysterectomy among women in Australia. *Health & Place*, 6(4), 301–308.

Cabana, M. D., Rand, C. S., Powe, N. R., Wu, A. W., Wilson, M. H., Abboud, P. C., & Rubin, H. R. (1999). Why don't physicians follow clinical practice guidelines? A framework for improvement. *Journal of the American Medical Association*, 282(15), 1458–1465.

Caldon, L. J., Walters, S. J., Reed, J. A., Murphy, A., Worley, A., & Reed, M. W. (2005). Case-mix fails to explain variation in mastectomy rates: Management of screen-detected breast cancer in a UK region 1997–2003. *British Journal of Cancer*, 92(1), 55–59.

Callaway, B., & Ghosal, V. (2012). Adoption and diffusion of health information technology—The case of primary care clinics. CESifo Working Paper Series 3925, CESifo Group Munich.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Capper, R., & Canter, R. J. (2001). Is there agreement among general practitioners, paediatricians and otolaryngologists about the management of children with recurrent tonsillitis? *Clinical Otolaryngology and Allied Sciences*, 26(5), 371–378.

Carlisle, D. M., Valdez, R. B., Shapiro, M. F., & Brook, R. H. (1995). Geographic variation in rates of selected surgical procedures within Los Angeles County. *Health Services Research Journal*, 30(1), 27–42.

Carpenter, W. R., Reeder-Hayes, K., Bainbridge, J., Meyer, A.-M., Amos, K. D., Weiner, B. J., & Godley, P. A. (2011). The role of organizational affiliations and research networks in the diffusion of breast cancer treatment innovation. *Medical Care*, 49(2), 172–179.

Carpenter, W. R., Meyer, A. M., Wu, Y., Qaqish, B., Sanoff, H. K., Goldberg, R. M., & Weiner, B. J. (2012). Translating research into practice: The role of provider-based research networks in the diffusion of an evidence-based colon cancer treatment innovation. *Medical care*, 50(8), 737–748.

Casparie, A. F. (1996). The ambiguous relationship between practice variation and appropriateness of care: An agenda for further research. *Health Policy* 35(3), 247–265.

Castle, N. G. (2001). Innovation in nursing homes: Which facilities are the early adopters? *Gerontologist*, 41, 161–72.

Cave, D. G. (1995). Small-area variations in the treatment of prevalent medical conditions: A comparison of three cities in the Northeast. *Journal of Ambulatory Care Management*, 18(3), 42–57.

Chase, S. K. (1995). The social context of critical care clinical judgment. *Heart & Lung*, 24(2), 154–162.

Chassin, M. R. (1993). Explaining geographic variations: The enthusiasm hypothesis. *Medical Care*, 31(5 Suppl), YS37–44.

Chassin, M. R., Brook, R. H., Park, R. E., Keesey, J., Fink, A., Kosecoff, J., . . . Solomon, D. H. (1986). Variations in the use of medical and surgical services by the Medicare population. *The New England Journal of Medicine*, 314(5), 285–290.

Chassin, M. R., Kosecoff, J., Park, R. E., Winslow, C. M., Kahn, K. L., Merrick, N. J., . . . Brook, R. H. (1987). Does inappropriate use explain geographic variations in the use of health care services? A study of three procedures. *Journal of the American Medical Association*, 258(18), 2533–2537.

Chen, L. W., Zhang, W., Sun, J., & Mueller, K. J. (2009). The magnitude, variation, and determinants of rural hospital resource utilization associated with hospitalizations due to ambulatory care sensitive conditions. *Journal of Public Health Management and Practice*, 15(3), 216–222.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Chuah, T. K., Lee, T., Wirtzfeld, D., & Pollett, W. (2010). Management of primary rectal cancer by surgeons in Atlantic Canada: Results of a regional survey. *Canadian Journal of Surgery*, 53(6), 396-402.

Clarke, K. W., Gray, D., Keating, N. A., & Hampton, J. R. (1994). Do women with acute myocardial infarction receive the same treatment as men? *BMJ*, 309(6954), 563-566.

Coleman, J. S., Katz, E., & Menzel, H. (1957). The diffusion of an innovation among physicians. *Sociometry*, 20(4), 253-270.

Comin, D., & Hobijn, B. (2010). An exploration of technology diffusion. *American Economic Review*, 100(5), 2031-2059.

Compagni, A., Mele, V., & Ravasi, D. (2015). How early implementations influence later adoptions of innovation: Social positioning and skill reproduction in the diffusion of robotic surgery. *Academy of Management Journal*, 58(1), 242-278.

Cott, C. (1997). We decide, you carry it out: A social network analysis of multidisciplinary long-term care teams. *Social Science & Medicine*, 45(9), 1411-1421.

Coyte, P. C., Croxford, R., Asche, C. V., To, T., Feldman, W., & Friedberg, J. (2001). Physician and population determinants of rates of middle-ear surgery in Ontario. *Journal of the American Medical Association*, 286(17), 2128-2135.

Cromwell, J., & Kanak, J. R. (1982). The effects of prospective reimbursement programs on hospital adoption and service sharing. *Health Care Financing Review*, 4(2), 67-88.

Creswick, N., & Westbrook, J. I. (2006). The medication advice-seeking network of staff in an Australian hospital renal ward. *Studies in Health Technology and Informatics*, 130, 217-231.

Creswick, N., Westbrook, J. I., & Braithwaite, J. (2009). Understanding communication networks in the emergency department. *BMC Health Services Research Journal*, 9(1), 247.

Cunningham, F. C., Ranmuthugala, G., Plumb, J., Georgiou, A., Westbrook, J. I., & Braithwaite, J. (2012). Health professional networks as a vector for improving healthcare quality and safety: A systematic review. *BMJ Quality and Safety*, 21(3), 239-249.

Currie, J., MacLeod, W. B., & Van Parys, J. (2016). Practice style and patient health outcomes: The case of heart attacks. *Journal of Health Economics*, 47, 64-80.

Davis, P., Gribben, B., Scott, A., & Lay-Yee, R. (2000). The supply hypothesis and medical practice variation in primary care: Testing economic and clinical models of inter-practitioner variation. *Social Science & Medicine*, 50(3), 407-418.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Davis, D. H., Localio, A. R., Stafford, P. W., Helfaer, M. A., & Durbin, D. R. (2005). Trends in operative management of pediatric splenic injury in a regional trauma system. *Pediatrics*, 115(1), 89–94.
- Davis, A. M., Vinci, L. M., Okwuosa, T. M., Chase, A. R., & Huang, E. S. (2007). Cardiovascular health disparities a systematic review of health care interventions. *Medical Care Research and Review*, 64(5 suppl), 29S–100S.
- Dranove, D., Ramanarayanan, S., & Rao, H. (2006). The substance of style: A study of practice styles of ob/gyn practice specialists in Florida. Kellogg School of Management Working Paper, Northwestern University.
- Eddy, D. M. (1984). Variations in physician practice: The role of uncertainty. *Health Affairs (Millwood)*, 3(2), 74–89.
- Elliott, R. V., Kahn, K. A., & Kaye, R. (1981). Physicians measure up: A study of 13 surgical procedures. *Journal of the American Medical Association*, 245(6), 595–600.
- Epstein, A. J., & Nicholson, S. (2009). The formation and evolution of physician treatment styles: An application to caesarean sections. *Journal of Health Economics*, 28(6), 1126–1140.
- Escarce, J. (1996). Externalities in hospitals and physician adoption of a new surgical technology: An exploratory analysis. *Journal of Health Economics*, 15(6), 715–734.
- Escarce, J. J. (1993). Would eliminating differences in physician practice style reduce geographic variations in cataract surgery rates? *Medical Care*, 31(12), 1106–1118.
- Escarce, J. J., Bloom, B. S., Hillman, A. L., Shea, J. A., & Schwartz, J. S. (1995). Diffusion of laparoscopic cholecystectomy among general surgeons in the United States. *Medical care*, 33(3), 256–271.
- Every, N. R., Larson, E. B., Litwin, P. E., Maynard, C., Fihn, S. D., Eisenberg, M. S., . . . Weaver, W. D. (1993). The association between on-site cardiac catheterization facilities and the use of coronary angiography after acute myocardial infarction. *New England Journal of Medicine*, 329(8), 546–551.
- Fanuele, J., Koval, K. J., Lurie, J., Zhou, W., Tosteson, A., & Ring, D. (2009). Distal radial fracture treatment: What you get may depend on your age and address. *Journal of Bone and Joint Surgery. American Volume*, 91(6), 1313–1319.
- Fattore G., Frosini, F., Salvatore, D., & Tozzi, V. (2009). Social network analysis in primary care: The impact of interactions on prescribing behaviour. *Health Policy*, 92(2), 141–148.
- Ferlie, E., Fitzgerald, L., Wood, M., & Hawkins, C. (2005). The nonspread of innovation: The mediating role of professionals. *Academy of Management Journal*, 48(1), 117–134.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Fisher, E. S., Wennberg, D. E., Stukel, T. A., Gottlieb, D. J., Lucas, F. L., & Pinder, E. L. (2003). The implications of regional variations in Medicare spending. Part 1: The content, quality, and accessibility of care. *Annals of Internal Medicine*, 138(4), 273-287.
- Fleming, L., & Waguespack, D. M. (2007). Brokerage, boundary spanning, and leadership in open innovation communities. *Organization Science*, 18(2), 165-180.
- Folland, S., & Stano, M. (1990). Small area variations: A critical review of propositions, methods, and evidence. *Medical Care Research and Review*, 47(4), 419-465.
- Franks, P., & Bertakis, K. D. (2003). Physician gender, patient gender, and primary care. *Journal of Women's Health (Larchmt)*, 12(1), 73-80.
- Frakes, M. (2013). The impact of medical liability standards on regional variations in physician behaviour: Evidence from the adoption of national-standard rules. *American Economic Review*, 103(1), 257-276.
- Fritsche, L., Vanrenterghem, Y., Nordal, K. P., Grinyo, J. M., Moreso, F., Budde, K., . . . Neumayer, H. H. (2000). Practice variations in the evaluation of adult candidates for cadaveric kidney transplantation: A survey of the European Transplant Centers. *Transplantation*, 70(10), 1492-1497.
- Fudenberg, D., & Tirole, J. (1985). Preemption and rent equalization in the adoption of new technology. *Review of Economic Studies*, 52, 383-401.
- Garg, P. P., Landrum, M. B., Normand, S. L., Ayanian, J. Z., Hauptman, P. J., Ryan, T. J., . . . Guadagnoli, E. (2002). Understanding individual and small area variation in the underuse of coronary angiography following acute myocardial infarction. *Medical Care*, 40(7), 614-626.
- Garreau, J. R., Nelson, J., Cook, D., Vetto, J., Walts, D., Homer, L., & Johnson, N. (2005). Geographic variation in sentinel node adaptation by practicing surgeons in Oregon. *The American Journal of Surgery* 189(5), 616-619.
- Gatsonis, C. A., Epstein, A. M., Newhouse, J. P., Normand, S. L., & McNeil, B. J. (1995). Variations in the utilization of coronary angiography for elderly patients with an acute myocardial infarction: An analysis using hierarchical logistic regression. *Medical Care*, 33(6), 625-642.
- Gauld, R., Horwitt, J., Williams, S., & Cohen, A. B. (2011). What strategies do US hospitals employ to reduce unwarranted clinical practice variations? *American Journal of Medical Quality*, 26(2), 120-126.
- Gelijns, A., & Rosenberg, N. (1994). The dynamics of technological change in medicine. *Health Affairs (Millwood)*, 13(3), 28-46.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Geller, S. E., Burns, L. R., & Brailer, D. J. (1996). The impact of nonclinical factors on practice variations: The case of hysterectomies. *Health Services Research Journal*, 30(6), 729-750.
- Gillick, M. R. (2009). Medicine as ecoculture. *Annals of Internal Medicine* 151(8), 577-580.
- Gilligan, M., Kneusel, R., Hoffmann, R., Greer, A., & Nattinger, A. (2002). Persistent differences in sociodemographic determinants of breast conserving treatment despite overall increased adoption. *Medical Care*, 40, 181-189.
- Glover, J. A. (1938). The incidence of tonsillectomy in school children. *Indian Journal of Pediatrics*, 5(4), 252-258.
- Glover, J. A. (2008). The incidence of tonsillectomy in school children. *International Journal of Epidemiology*, 37(1), 9-19.
- Godart, F. C., Shipilov, A. V., & Claes, K. (2014). Making the most of the revolving door: The impact of outward personnel mobility networks on organizational creativity. *Organization Science*, 25(2), 377-400.
- Goes, J. B., & Park, S. H. (1997). Interorganisational links and innovation: The case of hospital services. *Academy of Management Journal*, 40, 673-96.
- Goodman, D. C., & Green, G. R. (1996). Assessment tools: Small area analysis. *American Journal of Medical Quality*, 11(1), S12-14.
- Green, L. (1996). Geography is destiny: Where you live—Not the facts of your case—May determine what medical treatment you receive. *Mirabella November/December*, 154-158.
- Griggs, J. J., Sorbero, M. E., Ahrendt, G. M., Stark, A., Heininger, S., Gold, H. T., Schiffhauer, L. M., & Dick, A. W. (2009). The pen and the scalpel: Effect of diffusion of information on nonclinical variations in surgical treatment. *Medical Care*, 47(7), 749-757.
- Groeneveld, P. W., Heidenreich, P. A., & Garber, A. M. (2005). Trends in implantable cardioverter-defibrillator racial disparity: The importance of geography. *Journal of the American College of Cardiology*, 45(1), 72-78.
- Grytten, J., & Sorensen, R. (2003). Practice variation and physician-specific effects. *Journal of Health Economics* 22(3), 403-418.
- Guadagnoli, E., Landrum, M. B., Normand, S. L., Ayanian, J. Z., Garg, P., Hauptman, P. J., . . . McNeil, B. J. (2001). Impact of underuse, overuse, and discretionary use on geographic variation in the use of coronary angiography after acute myocardial infarction. *Medical Care*, 39(5), 446-458.
- Hannan, E. L., & Kumar, D. (1997). Geographic variation in the utilization and choice of procedures for treating coronary artery disease in New York State. *Ischaemic Heart*

Variations in the Adoption of Healthcare Innovation? A Literature Review

Disease Patient Outcomes Research Team (PORT). *Journal of Health Services Research and Policy*, 2(3), 137-143.

Hamilton, B. H., & McManus, B. (2005). Technology diffusion and market structure: Evidence from infertility treatment markets. SSRN working paper, SSRN 813826 (2005).

Harris, K. M., Pastorius, C. A., Duval, S., Harwood, E., Henry, T. D., Carabello, B. A., & Hirsch, A. T. (2009). Practice variation among cardiovascular physicians in management of patients with mitral regurgitation. *American Journal of Cardiology*, 103(2), 255-261.

Hawker, G. A., Wright, J. G., Coyte, P. C., Williams, J. I., Harvey, B., Glazier, R., . . . Badley, E. M. (2001). Determining the need for hip and knee arthroplasty: The Role of clinical severity and patients' preferences, *Medical Care*, 39(3), 206-216.

Heng, H., McGeorge, W., & Loosemore, M. (2005). Beyond strategy: Exploring the brokerage role of facilities manager in hospitals. *Journal of Health Organization and Management*, 19(1), 16-31.

Hilsden, R. J. (2004). Patterns of use of flexible sigmoidoscopy, colonoscopy and gastroscopy: A population-based study in a Canadian province. *Canadian Journal of Gastroenterology and Hepatology*, 18(4), 213-219.

Hollingsworth, J. M., Funk, R. J., Garrison, S. A., Owen-Smith, J., Kaufman, S. R., Landon, B. E., & Birkmeyer, J. D. (2015). Differences between physician social networks for cardiac surgery serving communities with high versus low proportions of black residents. *Medical Care*, 53(2), 160-167.

Howard, D. H., David, G., & Hockenberry, J. (2017). Selective hearing: Physician-ownership and physicians' response to new evidence. *Journal of Economics and Management Strategy*, 26, 152-168.

Jacoby, V. L., Autry, A., Jacobson, G., Domush, R., Nakagawa, S., & Jacoby, A. (2009). Nationwide use of laparoscopic hysterectomy compared with abdominal and vaginal approaches. *Obstetrics & Gynecology*, 114(5), 1041-1048.

Javitt, J. C., Kendix, M., Tielsch, J. M., Steinwachs, D. M., Schein, O. D., Kolb, M. M., & Steinberg, E. P. (1995). Geographic variation in utilization of cataract surgery. *Medical Care*, 33(1), 90-105.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305-360.

Judge, A., Welton, N. J., Sandhu, J., & Ben-Shlomo, Y. (2010). Equity in access to total joint replacement of the hip and knee in England: Cross sectional study. *BMJ*, 341, c4092.

Kaplan, R. M., & Frosch, D. L. (2005). Decision making in medicine and health care. *Annual Review of Clinical Psychology*, 1, 525-556.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Katz, S., Lantz, P., Janz, N., Fagerlin, A., Schwartz, K., & Liu, L. (2005). Surgeon perspectives about local therapy for breast carcinoma. *Cancer*, *104*, 1854–1861.

Kay, V. J., Das, N., Mahmood, T. A., & Smith, A. (2002). Current practice of hysterectomy and oophorectomy in the United Kingdom and Republic of Ireland. *Journal of Obstetrics and Gynaecology*, *22*(6), 672–680.

Keating, N. L., Ayanian, J. Z., Cleary, P. D., & Marsden, P. V. (2007). Factors affecting influential discussions among physicians: A social network analysis of a primary care practice. *Journal of General Internal Medicine*, *22*(6), 794–798.

Kee, F. (1993). Referrals for coronary angiography in a high risk population. *Quality in Health Care*, *2*(2), 87–90.

Kee, F., Gaffney, B., Currie, S., & O'Reilly, D. (1993). Access to coronary catheterisation: Fair shares for all? *BMJ*, *307*(6915), 1305–1307.

Keller, R. B., Soule, D. N., Wennberg, J. E., & Hanley, D. F. (1990). Dealing with geographic variations in the use of hospitals: The experience of the Maine Medical Assessment Foundation Orthopaedic Study Group. *Journal of Bone and Joint Surgery. American Volume*, *72*(9), 1286–1293.

Kennedy, A. D. M., Sculpher, M. J., Coulter, A., Dwyer, N., Rees, M., Abrams, K. R., . . . Stirrat, G. (2002). Effects of decision aids for menorrhagia on treatment choices, health outcomes, and costs: A randomized controlled trial. *Journal of the American Medical Association*, *288*(21), 2701–2708.

Ketcham, J. D., Baker, L. C., & MacIsaac, D. (2007). Physician practice size and variations in treatments and outcomes: Evidence from Medicare patients with AMI. *Health Affairs (Millwood)*, *26*(1), 195–205.

Kimberly, J. R., & Evanisko, J. M. (1981). Organisational innovation: The influence of individual, organisational and contextual factors on hospital adoption of technological and administrative innovation. *Academy of Management Journal*, *24*, 689–713.

Klabunde, C. N., Potosky, A. L., Harlan, L. C., & Kramer, B. S. (1998). Trends and black/white differences in treatment for nonmetastatic prostate cancer. *Medical Care*, *36*(9), 1337–1348.

Kressin, N. R., Boehmer, U., Berlowitz, D., Christiansen, C. L., Pitman, A., & Jones, J. A. (2003). Racial variations in dental procedures: The case of root canal therapy versus tooth extraction. *Medical Care*, *41*(11), 1256–1261.

Laouri, M., Kravitz, R. L., French, W. J., Yang, I., Milliken, J. C., Hilborne, L., . . . Brook, R. H. (1997). Underuse of coronary revascularization procedures: Application of a clinical method. *Journal of the American College of Cardiology*, *29*(5), 891–897.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Lazovich, D., White, E., Thomas, D. B., & Moe, R. E. (1991). Underutilization of breast-conserving surgery and radiation therapy among women with Stage I or II breast cancer. *Journal of the American Medical Association*, 266(24), 3433-3438.
- Lewis, J. M., Baeza, J. I., & Alexander, D. (2008). Partnerships in primary care in Australia: Network structure, dynamics and sustainability. *Social Science & Medicine*, 67(2), 280-291.
- Lingo, E. L., & O'Mahony, S. (2010). Nexus work: Brokerage on creative projects. *Administrative Science Quarterly*, 55(1), 47-81.
- Long, M. J. (2002). An explanatory model of medical practice variation: A physician resource demand perspective. *Journal of Evaluation in Clinical Practice*, 8(2), 167-174.
- Lu, T., Huang, Y., Lee, J., Yang, L., Liang, F., Yin, W., & Kawachi, I. (2015). Characteristics of early and late adopting hospitals providing percutaneous coronary intervention in Taiwan. *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*, 4(12).
- Lurie, J. D., Bell, J. E., & Weinstein, J. (2009). What rate of utilization is appropriate in musculoskeletal care? *Clinical Orthopaedics and Related Research*, 467(10), 2506-2511.
- Lurie, J. D., & Weinstein, J. N. (2001). Shared decision-making and the orthopaedic workforce. *Clinical Orthopaedics and Related Research*, 385, 68-75.
- MacPhee, M. (2000). Hospital networking: Comparing the work of nurses with flexible and traditional schedules. *Journal of Nursing Administration*, 30(4), 190-198.
- MacPhee, M., & J. Scott, J. (2002). The role of social support networks for rural hospital nurses: Supporting and sustaining the rural nursing work force. *Journal of Nursing Administration*, 32(5), 264-272.
- Mancuso, C. A., Ranawat, C. S., Esdaile, J. M., Johanson, N. A., & Charlson, M. E. (1996). Indications for total hip and total knee arthroplasties: Results of orthopaedic surveys. *Journal of Arthroplasty*, 11(1), 34-46.
- Marciniak, T. A., Ellerbeck, E. F., Radford, M. J., Kresowik, T. F., Gold, J. A., Krumholz, H. M., . . . Jencks, S. F. (1998). Improving the quality of care for Medicare patients with acute myocardial infarction: Results from the Cooperative Cardiovascular Project. *Journal of the American Medical Association*, 279(17), 1351-1357.
- Marsden, P. V., & Podolny, J. (1990). Dynamic analysis of network diffusion processes. In J. Weesie & H. Flap (Eds.), *Social networks through time* (pp. 197-214). Utrecht, Netherlands: University of Utrecht/ISOR.
- Mayberry, R. M., Mili, F., & Ofili, E. (2000). Racial and ethnic differences in access to medical care. *Medical Care Research and Review*, 57(4 suppl.), 108-145.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- McMahon, A. J., Fischbacher, C. M., Frame, S. H., & MacLeod, M. C. M. (2000). Impact of laparoscopic cholecystectomy: A population-based study. *Lancet*, *356*(9242), 1632–1637.
- Mendel, P., Damberg, C. L., Sorbero, M. E., Varda, D. M., & Farley, D. O. (2009). The growth of partnerships to support patient safety practice adoption. *Health Services Research Journal*, *44*(2p2), 717–738.
- Meyer, A.-M., Reeder-Hayes, K. E., Liu, H., Wheeler, S. B., Penn, D., Weiner, B. J., & Carpenter, W. R. (2013). Differential receipt of sentinel lymph node biopsy within practice-based research networks. *Medical Care*, *51*(9), 812.
- Miller, D. C., Murtagh, D. S., Suh, R. S., Knapp, P. M., Dunn, R. L., & Montie, J. E. (2010). Establishment of a urological surgery quality collaborative. *Journal of Urology*, *184*(6), 2485–2490.
- Miller, D. C., Murtagh, D. S., Suh, R. S., Knapp, P. M., Schuster, T. G., Dunn, R. L., & Montie, J. E. (2011). Regional collaboration to improve radiographic staging practices among men with early stage prostate cancer. *Journal of Urology*, *186*(3), 844–849.
- Mirvis, D. M., Burns, R., Gaschen, L., Cloar, F. T., & Graney, M. (1994). Variation in utilization of cardiac procedures in the Department of Veterans Affairs health care system: Effect of race. *Journal of the American College of Cardiology*, *24*(5), 1297–1304.
- Mirvis, D. M., & Graney, M. J. (1999). Variations in the use of cardiac procedures in the Veterans Health Administration. *American Heart Journal*, *137*(4 Pt 1), 706–713.
- Molitor, D. (2018). The evolution of physician practice styles: Evidence from cardiologist migration. *American Economic Journal: Economic Policy*, *10*(1), 326–356.
- Nambudiri, V. E., Landrum, M. B., Lamont, E. B., McNeil, B. J., Bozeman, S. R., Freedland, S. J., & Keating, N. L. (2012). Understanding variation in primary prostate cancer treatment within the Veterans Health Administration. *Urology*, *79*(3), 537–545.
- Nattinger, A. B., Gottlieb, M. S., Hoffman, R. G., Walker, A. P., & Goodwin, J. S. (1996). Minimal increase in use of breast-conserving surgery from 1986 to 1990. *Medical Care* *34*(5), 479–489.
- Nickerson, R. J., Colton, T., Peterson, O. L., Bloom, B. S., & Hauck, W. W., Jr. (1976). Doctors who perform operations: A study on in-hospital surgery in four diverse geographic areas (second of two parts). *The New England Journal of Medicine*, *295*(18), 982–989.
- Nystrom, P. C., Ramamurthy, K., & Wilson, A. L. (2002). Organizational context, climate and innovativeness: Adoption of imaging technology. *Journal of Engineering and Technology Management*, *19*(3–4), 221–247.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Ormrod, S., Ferlie, E., Warren, F., & Norton, K. (2007). The appropriation of new organizational forms within networks of practice: Founder and founder-related ideological power. *Human Relations*, 60(5), 745–767.
- Panigrahi, B., Roman, S. A., & Sosa, J. A. (2010). Medullary thyroid cancer: Are practice patterns in the United States discordant from American Thyroid Association guidelines? *Annals of Surgical Oncology*, 17(6), 1490–1498.
- Peng, T.-J. A., Lo, F.-Y., Lin, C.-S., & Yu, C.-M. J. (2006). Benefiting from networks by occupying central positions: An empirical study of the Taiwan health care industry. *Health Care Management Review* 31(4), 317–327.
- Petticrew, M., McKee, M., & Jones, J. (1993). Coronary artery surgery: Are women discriminated against? *BMJ*, 306(6886), 1164–1166.
- Phelps, C. E. (1992). Diffusion of information in medical care. *Journal of Economic Perspectives*, 6(3), 23–42.
- Phelps, C. E. (1995). Welfare loss from variations: Further considerations. *Journal of Health Economics*, 14(2), 253–260.
- Phelps, C. E., & Parente, S. T. (1990). Priority setting in medical technology and medical practice assessment. *Medical Care* 28(8), 703–723.
- Pilote, L., Miller, D. P., Califf, R. M., Rao, J. S., Weaver, W. D., & Topol, E. J. (1996). Determinants of the use of coronary angiography and revascularization after thrombolysis for acute myocardial infarction. *The New England Journal of Medicine*, 335(16), 1198–1205.
- Pilpel, D., Fraser, G. M., Kosecoff, J., Weitzman, S., & Brook, R. H. (1992). Regional differences in appropriateness of cholecystectomy in a prepaid health insurance system. *Public Health Reviews*, 20(1–2), 61–74.
- Poggi, M. M., Danforth, D. N., Sciuto, L. C., Smith, S. L., Steinberg, S. M., Liewehr, D. J., . . . Altamus, R. M. (2003). Eighteen-year results in the treatment of early breast carcinoma with mastectomy versus breast conservation therapy: The National Cancer Institute randomized trial. *Cancer*, 98(4), 697–702.
- Polednak, A. P. (1997). Predictors of breast-conserving surgery in Connecticut, 1990–1992. *Annals of Surgical Oncology*, 4(3), 259–263.
- Pollack, C. E., Weissman, G., Bekelman, J., Liao, K., & Armstrong, K. (2012). Physician social networks and variation in prostate cancer treatment in three cities. *Health Services Research*, 47(1 Pt. 2), 380–403.
- Potosky, A. L., Saxman, S., Wallace, R. B., & Lynch, C. F. (2004). Population variations in the initial treatment of non-small-cell lung cancer. *Journal of Clinical Oncology*, 22(16), 3261–3268.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Propper, C., Burgess, S., & Gossage, D. (2008). Competition and quality: Evidence from the NHS internal market 1991-9*. *The Economic Journal* 118(525), 138-170.

Propper, C., & Söderlund, N. (1998). Competition in the NHS internal market: An overview of its effects on hospital prices and costs. *Health Economics*, 7(3), 187-197.

Rangachari, P. (2008). Knowledge sharing networks related to hospital quality measurement and reporting. *Health Care Management Review*, 33(3), 253-263.

Ridao-Lopez, M., Garcia-Armesto, S., Abadia-Taira, B., Peiro-Moreno, S., & Bernal-Delgado, E. (2011). Income level and regional policies, underlying factors associated with unwarranted variations in conservative breast cancer surgery in Spain. *BMC Cancer*, 11(1), 145.

Riley, G. F., Warren, J. L., Potosky, A. L., Klabunde, C. N., Harlan, L. C., & Osswald, M. B. (2008). Comparison of cancer diagnosis and treatment in Medicare fee-for-service and managed care plans. *Medical Care*, 46(10), 1108-1115.

Romeo, A. A., Wagner, J. L., & Lee, R. H. (1984). Prospective reimbursement and the diffusion of new technologies in hospitals. *Journal of Health Economics*, 3(1), 1984, 1-24.

Roos, N. P. (1984). Hysterectomy: Variations in rates across small areas and across physicians' practices. *American Journal of Public Health*, 74(4), 327-335.

Roos, N. P., & Mustard, C. A. (1997). Variation in health and health care use by socioeconomic status in Winnipeg, Canada: Does the system work well? Yes and no. *Milbank Quarterly*, 75(1), 89-111.

Roter, D. L., Hall, J. A., Aoki, Y. (2002). **Physician gender effects in medical communication: A Meta-analytic Review.** *JAMA: Journal of the American Medical Association*, 288(6), 756-764.

Roter, D., Lipkin, M., Jr., & Korsgaard, A. (1991). Sex differences in patients' and physicians' communication during primary care medical visits. *Medical Care*, 29(11), 1083-1093.

Rutledge, R., Fakhry, S. M., Baker, C. C., & Meyer, A. A. (1996). The impact of laparoscopic cholecystectomy on the management and outcome of biliary tract disease in North Carolina: A statewide, population-based, time-series analysis. *Journal of the American College of Surgeons*, 183(1), 31-45.

Salopek, T. G., Slade, J., Marghoob, A. A., Rigel, D. S., Kopf, A. W., Bart, R. S., & Friedman, R. J. (1995). Management of cutaneous malignant melanoma by dermatologists of the American Academy of Dermatology: I. Survey of biopsy practices of pigmented lesions suspected as melanoma. *Journal of the American Academy of Dermatology*, 33(3), 441-450.

Variations in the Adoption of Healthcare Innovation? A Literature Review

- Samet, J. M., Hunt, W. C., & Farrow, D. C. (1994). Determinants of receiving breast-conserving surgery: The surveillance, epidemiology, and end results program, 1983-1986. *Cancer*, 73(9), 2344-2351.
- Santos-Eggimann, B., Paccaud, F., & Gutzwiller, F. (1989). Coronary arteriography rates in Switzerland—How do they vary? *Social Science & Medicine*, 28(2), 115-120.
- Sawka, A. M., Rotstein, L., Brierley, J. D., Tsang, R. W., Thabane, L., Gafni, A., . . . Ezzat, S. (2007). Regional differences in opinions on adjuvant radioactive iodine treatment of thyroid carcinoma within Canada and the United States. *Thyroid*, 17(12), 1235-1242.
- Sethi, R., Henry, A. J., Hevelone, N. D., Lipsitz, S. R., Belkin, M., & Nguyen, L. L. (2013). Impact of hospital market competition on endovascular aneurysm repair adoption and outcomes. *Journal of Vascular Surgery*, 58(3), 596-606.
- Sherer, B. A., & Coogan, C. L. (2015). The current state of medical malpractice in urology. *Urology*, 86(1), 2-9.
- Shorten, A., & Shorten, B. (2000). Women's choice? The impact of private health insurance on episiotomy rates in Australian hospitals. *Midwifery*, 16(3), 204-212.
- Song, Y., Skinner, J., Bynum, J., Sutherland, J., Wennberg, J. E., & Fisher, E. S. (2010). Regional variations in diagnostic practices. *New England Journal of Medicine*, 363(1), 45-53.
- Sorenson, C., Drummond, M., Torbica, A., Callea, G., & Mateus, C. (2015). The role of hospital payments in the adoption of new medical technologies: An international survey of current practice. *Health Economics, Policy and Law*, 10(2), 133-159.
- Spencer, B. A., Miller, D. C., Litwin, M. S., Ritchey, J. D., Stewart, A. K., Dunn, R. L., . . . Wei, J. T. (2008). Variations in quality of care for men with early-stage prostate cancer. *Journal of Clinical Oncology*, 26(22), 3735-3742.
- Srivastava, S. B., & Banaji, M. R. (2011). Culture, cognition, & collaborative networks in organizations. *American Sociological Review*, 76(2), 207-233.
- Stafford, R. S. (1990). Cesarean section use and source of payment: An analysis of California hospital discharge abstracts. *American Journal of Public Health*, 80(3), 313-315.
- Stano, M. (1985). An analysis of the evidence on competition in the physician services markets. *Journal of Health Economics*, 4(3), 197-212.
- Strang, D., & Tuma, N. B. (1993). Spatial and temporal heterogeneity in diffusion. *American Journal of Sociology*, 99, 614-639.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Tan, H. J., Meyer, A. M., Kuo, T. M., Smith, A. B., Wheeler, S. B., Carpenter, W. R., & Nielsen, M. E. (2015). Provider-based research networks and diffusion of surgical technologies among patients with early-stage kidney cancer. *Cancer*, *121*(6), 836–43.

Tasselli, S. (2014). Social networks of professionals in health care organizations: A review. *Medical Care Research and Review*, *71*(6), 619–660.

Van den Bulte, C., & Lilien, G. L. (2001). Medical innovation revisited: Social contagion versus marketing effort. *American Journal of Sociology*, *106*, 1409–1435.

Verstappen, W. H., ter Riet, G., Dubois, W. I., Winkens, R., Grol, R. P., & van der Weijden, T. (2004). Variation in test ordering behaviour of GPs: Professional or context-related factors? *Family Practice*, *21*(4), 387–395.

Volinn, E., Diehr, P., Ciol, M. A., & Loeser, J. D. (1994). Why does geographic variation in health care practices matter? (And seven questions to ask in evaluating studies on geographic variation). *Spine (Phila Pa 1976)*, *19*(18 Suppl), 2092S–2100S.

Walker, G. M., Jr. (1979). Utilization of health care: The Laredo migrant experience. *American Journal of Public Health*, *69*(7), 667–672.

Wasiak, R., Pransky, G., & Yao, P. (2006). Geographic variation in surgical treatment for work-related carpal tunnel syndrome: Does improved return to work matter? *Work*, *26*(1), 3–11.

Webster C., Grusky, O., Podus, D., & Young, A. (1999). Team leadership: Network differences in women's and men's instrumental and expressive relations. *Administration and Policy in Mental Health*, *26*(3), 169–90.

Weiner, J. P., Starfield, B. H., Powe, N. R., Stuart, M. E., & Steinwachs, D. M. (1996). Ambulatory care practice variation within a Medicaid program. *Health Services Research*, *30*(6), 751–770.

Weinstein, J. N., Bronner, K. K., Morgan, T. S., & Wennberg, J. E. (2004). **Trends and geographic variations in major surgery for degenerative diseases of the hip, knee, & spine.** *Health Affairs (Millwood)*, *23*(Suppl Variation), Var81–89.

Weinstein, J. N., Lurie, J. D., Olson, P. R., Bronner, K. K., & Fisher, E. S. (2006). United States' trends and regional variations in lumbar spine surgery: 1992–2003. *Spine (Phila Pa 1976)*, *31*(23), 2707–2714.

Wennberg, D., Dickens, J., Jr., Soule, D., Kellett, M., Jr., Malenka, D., Robb, J., . . . Hillman, R. (1997). The relationship between the supply of cardiac catheterization laboratories, cardiologists and the use of invasive cardiac procedures in northern New England. *Journal of Health Services Research & Policy*, *2*(2), 75–80.

Wennberg, J., & Gittelsohn, A. (1973). Small area variations in health care delivery. *Science*, *182*(4117), 1102–1108.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Wennberg, J. E. (1984). Dealing with medical practice variations: A proposal for action. *Health Affairs (Millwood)* 3(2), 6–32.

Wennberg, J. E. (2002). Unwarranted variations in healthcare delivery: Implications for academic medical centres. *BMJ*, 325(7370), 961–964.

West, E., & Barron, D. N. (2005). Social and geographical boundaries around senior nurse and physician leaders: An application of social network analysis. *Canadian Journal of Nursing Research*, 37(3), 132–149.

West, E., Barron, D. N., Dowsett, J., & Newton, J. N. (1999). Hierarchies and cliques in the social networks of health care professionals: Implications for the design of dissemination strategies. *Social Science and Medicine*, 48(5), 633–646.

Westert, G. P., Nieboer, A. P., & Groenewegen, P. P. (1993). Variation in duration of hospital stay between hospitals and between doctors within hospitals. *Social Science and Medicine*, 37(6), 833–839.

Whelan, T., Levine, M., Willan, A., Gafni, A., Sanders, K., Mirsky, D., . . . Dubois, S. (2004). Effect of a decision aid on knowledge and treatment decision making for breast cancer surgery: A randomized trial. *Journal of the American Medical Association*, 292(4), 435–441.

Willens, H. J., Gomez-Marin, O., Heldman, A., Chakko, S., Postel, C., Hasan, T., & Mohammed, F. (2009). Adherence to appropriateness criteria for transthoracic echocardiography: Comparisons between a regional department of Veterans Affairs health care system and academic practice and between physicians and mid-level providers. *Journal of the American Society of Echocardiography*, 22(7), 793–799.

Wilson, C. B. (2006). Adoption of new surgical technology. *BMJ*, 332(7533), 112–114.

Wright, J. G., Coyte, P., Hawker, G., Bombardier, C., Cooke, D., Heck, D., . . . Freund, D. (1995). Variation in orthopedic surgeons' perceptions of the indications for and outcomes of knee replacement. *Canadian Medical Association Journal*, 152(5), 687–697.

Wright, J. G., Hawker, G. A., Bombardier, C., Croxford, R., Dittus, R. S., Freund, D. A., & Coyte, P. C. (1999). Physician enthusiasm as an explanation for area variation in the utilization of knee replacement surgery. *Medical Care*, 37(9), 946–956.

Xirasagar, S., Lin, H. C., & Liu, T. C. (2006). Do group practices have lower caesarean rates than solo practice obstetric clinics? Evidence from Taiwan. *Health Policy Plan* 21(4), 319–325.

Yiannakoulias, N., Hill, M. D., & Svenson, L. W. (2009). Geographic hierarchies of diagnostic practice style in cerebrovascular disease. *Social Science and Medicine*, 68(11), 1985–1992.

Variations in the Adoption of Healthcare Innovation? A Literature Review

Marisa Miraldo

Business School, Imperial College London

Katharina Hauck

School of Public Health, Imperial College London

Antoine Vernet

The Bartlett School of Construction and Project Management, University College London

Ana Wheelock

Faculty of Medicine, Imperial College London