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GOBIERNO DE COLOMBIA

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Health Atlas as a Policy Tool:

How to Investigate Geographic Variation and Utilize the Information for Decision-making

GOBIERNO DE COLOMBIA

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Abstract

This report concerns a series of questions and methodological challenges that should be considered in the studies of geographic variation. With in-depth discussion on its significance, history, methodological issues, and policy implications, this report will provide insights into how to investigate geographic variation and apply its results. Geographic variation studies should be a coordination of two values: integrity of the study and integration into the world.

Keywords: geographic variation, health care
JEL Codes:

Resumen

Este trabajo deja una serie de preguntas y de desafíos metodológicos, importantes de examinar en futuros esfuerzos. Por ejemplo, avanzar en un análisis más amplio de los factores subyacentes a las variaciones geográficas, que aborde de forma simultánea, desafíos metodológicos como la definición de una unidad de análisis geográfico que trascienda la división político-administrativa y la combinación y contraste de distintas fuentes de información.

Palabras clave:

Códigos JEL:

Part I. How to study geographic evaluation in health care evaluation

Introduction

Significance

Geographic variation in health care use refers to a phenomenon in which the health care use of a population varies according to the geographically defined unit (Kim et al., 2016a). In a broader and literal sense, geographic variation denotes the differing amount of health care use per population in different geographic areas. More specifically, however, it focuses on the part of variation that is not explained by population characteristics, such as demographic and health profiles. If geographic variation is not only caused by factors that are directly related with health status, that variation is likely to indicate a deviation from the optimum health care.

Geographic variation, as it is not only explained by health-related factors, indicates that the health care use of a patient may be determined by factors that are not directly connected to health status such as the location of the patient. Such possibility poses a problem in two aspects. First, it concerns effectiveness of care. Health care use that is not based on the health care need may not be in the best interests of patients. Not only may it not be the best one, but it may also be rather harmful. Health care use that deviates from the optimal use such as overuse, underuse, and misuse can cause harm or at least lessen the benefit that could have been enjoyed by the patients. Second, efficiency matters. In terms of health care input, surplus of input that would not contribute to the improvement of result reduces the efficiency of health care. Even if the input is less than the required amount, the efficiency could also decrease.

Supplier factors have been pointed out as part of factors that could affect geographic health care use regardless of population characteristics. The impact of supplier factors on health care use have been extensively investigated, not only in geographic variation studies (Birkmeyer et al., 2013; Birkmeyer et al., 1998; Glover, 1938; McPherson et al., 1982; Welch et al., 1993; Wennberg et al., 1973; Wennberg, 2014), but also in studies examining supplier or supply-induced demand theory (Anderson et al., 1981; Bickerdyke et al., 2002; Dranove, 1988; Evans, 1974; Labelle et al., 1994; Shain et al., 1959). As revealed in the previous studies, supplier factors could exert a strong influence on health care use.

Supplier factors can be explained in two aspects: quantitative and qualitative ones. First, the quantity of health care supply may influence health care use. The number of physicians (Black et al., 1995; Milcent et al., 2009) and number of hospital beds (Fisher et al., 2000; Wennberg, 1987) have turned out to influence health care use, contributing to geographic variation. Second, in terms of qualitative aspect, suppliers may affect health care use. This can be explained by the traits of the health care service (uncertainty) and health care supplier (profit motive or enthusiasm).

Uncertainty has been considered an inherent trait of medicine (Logan et al., 1996). Due to biological variability of the recipients and various options of treatment brought about along with advances of health care technology, uncertainty has remained an essential characteristic of health care. Uncertainty is related to the variability of practice styles, which are known to contribute to geographic variation (Coyte et al., 2001; Keller et al., 1998; Tu et al., 2012; Wennberg et al., 1982; Wright et al., 1999). Meanwhile, the health care supplier, as an entity who seeks its own profit, cannot be considered immune to profit-seeking. Such interest issue can appear most explicitly in the form of inducement as argued in the supplier induced demand theory. The profit-seeking is likely to work as a driving force for decisions to be made in uncertain situations, which is quite common in the field of health care. And health care suppliers are likely to be enthusiastic about implementing new treatments or procedures. This enthusiasm may be attributed to the health care suppliers' goodwill towards patients or an inquisitive mind about new technologies. However, the enthusiasm cannot be considered unrelated to the profit motive as the enthusiasm can lead to more aggressive service provision. Therefore, the traits of health care and health care suppliers, uncertainty, self-interest and enthusiasm, are related to one another and play roles in health care decision-making.

Given the characteristics that affect health care use, investigation of geographic variation of health care should be performed through the following stages: description, identification, and implementation. Accurate description of geographic variation can help recognize where variations exist, how large the variations are, and what potential sources of the variations are. The underlying causes of geographic variation should be identified when the description is accurate. Studying geographic variation would offer evidence of arbitrary features inherent in health care, which are dependent on supply or supplier characteristics. Based on such identification, measures could be established to correct unusual variation. The measures to correct geographic variation would involve policy changes and efforts for clinical improvement.

Investigating geographic variation is pursuing improvement of health care from the perspective of population. Describing geographic variation would provide information on the efficiency and effectiveness of health care. Identifying the factors of geographic variation would give specific grounds for improving health care. In conclusion, studying geographic variation is an effort to search for an optimal health care for a population in terms of its amount or its quality.

History

The Formative Years

J. Alison Glover in 1938

James Alison Glover's "The Incidence of Tonsillectomy in School Children", which was published in the *Proceedings of the Royal Society of Medicine* in 1938, is regarded as a pioneering work in geographic variation study. In this article, Dr. Glover calculated annual rates of tonsillectomy for elementary school children in England and Wales according to school districts, and he attempted comparisons of rates by period and area. And he revealed that there was a large variation in the tonsillectomy rates among school districts in London. The fundamental results of the article are summarized as follows (Glover, 1938).

1) There was a rapid rise in the incidence of tonsillectomy among school children after the beginning of the twentieth century, while the benefits of tonsillectomy were still unclear.

2) There were extreme variations in tonsillectomy rates among school districts. (Ratio of the maximal to average rate: more than 3. Ratio of the maximal to minimal rate: more than 10)

3) Geographical distribution of tonsillectomy incidences in elementary school children disclosed no correlation between the rate of incidence and demographic or environmental factors.

4) The only plausible explanation for the variation is likely to be the variation of medical opinion on the indications for operation.

Glover, through his historical and geographical analysis, raised a question about the appropriate amounts of health care use, which had been accepted as they

were given until then. The significance of his work lies not only in describing geographic variation but also in uncovering the factors that could affect variation. Geographic variation is one phenomenon that might appear as a result of inappropriate use of health care. By describing how the incidence of tonsillectomy varies according to school districts, Glover showed that health care use could deviate from its expected or desirable amount and presented the factor of variation as a research issue.

John E. Wennberg in 1973

For decades after Dr. Glover's 1938 article, the significance of geographic variation was not recognized and the topic remained rarely explored. It was not until John Wennberg and Alan Gittelsohn published "Small Area Variation in Health Care Delivery" in *Science* in 1973 that geographic variation received the attention of the public and academia. Wennberg and Gittelsohn extended Glover's theory on tonsillectomy to hospital discharge and other common surgical procedures and attempted more elaborate analyses.

Vermont, where Wennberg performed his pioneering study, was a state with a population of 444,000 in 1970 composed of 251 towns. Wennberg grouped the towns in Vermont into 13 hospital service areas surrounding the hospital based on the pattern and frequency of the residents' inpatient care (Wennberg et al., 1973). The population of each hospital service area was allocated to an identifiable supply of health care resources (Goodman, 2009). Based on the hospital service area, he measured geographic variation in age-adjusted utilization rates, and indices of manpower, facilities, and expenditures. As the measures of hospital utilization, hospital discharge rates for all causes, and broad classes of diagnoses, per capita number of days spent in a hospital, and rates of nine frequently performed surgical procedures were included.

Wennberg first described the variation in hospital resources and expenditure (Table 1). Hospital resources, such as per capita number of hospital beds and personnel, showed over 50% variation. Variation in hospital expenditure was about double. In the case of nursing homes, the variation reached over five-fold. Given that the population of the hospital service areas were homologous, as shown by the variation in the percentage of the population over 65 years (from 8.9 to 13.4), the variation in health care resources and expenditure was not likely to be distorted by the age structure. In terms of utilization, hospital days and hospital discharges varied over 50% across hospital service areas.

And in most of the surgeries which were investigated, differences were over twofold. Tonsillectomy rates varied more than tenfold.

Based on the information on hospital resources and utilization, Wennberg investigated the relationship among those indicators. He argued that any reasonable explanation for the variations in health care input and utilization was not found. Hospital expenditure showed no significant correlation with age-adjusted mortality, and there was little correspondence between physician input and health care need, such as would be indicated by the age structure of the population. Meanwhile, the correlation between the surgery rate and the input of physicians performing surgery was positive. In terms of diagnostic procedures, the utilization rates were positively correlated with the supply of the physicians who mainly perform the procedure. Wennberg concluded that the variation in health care utilization might be explained more by behavioral and distributional differences rather than by differences in illness patterns (Wennberg et al., 1973). In addition, he argued that there was considerable inequality in the health care resources among areas and that such variations could be attributed to the payment system and policies that failed to take account of actual needs of the population. He concluded that the health policy should give consideration to the actual health care needs, which were measured by the population-based analysis.

Table 1.

Variation in resources and utilization indicator

		Lowest	Highest	Highest to lowest
Resources	Beds per 10,000 persons			
	Hospitals	34	59	1.7
	Nursing homes	9	65	7.2
	Personnel per 10,000 persons			
	Full Time Equivalent(FTE) physicians	7.9	12.4	1.6
	Hospitals personnel	68	128	1.9
	Nursing homes personnel	8	52	6.5
Expenditures	Expenditures per capita			
	Hospitals	58	120	2.1
	Nursing homes	5	26	5.2
Utilization	Utilization rate per 1000 persons (age-adjusted)			
	Hospital days	1015	1495	1.5
	Hospital discharges	122	197	1.6
	Hospital discharges due to surgical procedure	36	69	1.9
	Surgery rate per 10.000 persons (age-adjusted)			
	Tonsillectomy	13	151	11.6
	Appendectomy	10	32	3.2
	Hemorrhoidectomy	2	10	5.0
	Hernioplasty (Male only)	29	48	1.7

Prostatectomy (Male only)	11	38	3.5
Dilation and curettage (Female only)	30	141	4.7
Hysterectomy (Female only)	20	60	3.0
Cholecystectomy (Female only)	17	57	3.4
Mastectomy (Female only)	12	33	2.8
Varicose veins (Female only)	6	28	4.7

Source: Adapted from Wennberg et al. Science 1973; 182(4117), 1102-1108.

This study offers several points of significance. First, it presented the importance of population-based approach in both research and policies, which would make it possible to accurately measure health care need and use. Second, it established a methodology of analyzing the health care use of a population by assigning the population to the area that corresponded to the population's actual health care use. This method, referred to as small area analysis, has remained an essential tool for geographic variation study. Third, this study established the concept of geographic variation and let its existence be recognized by the public. Fourth, it raised a concern about geographic variation by showing that there was no reasonable explanation for the phenomenon. And finally, it cast light on geographic variation as an issue to be constantly investigated and addressed as long as it remains.

The Evolution Period

Initially, Wennberg's work was not received well by academics, often subjected to rejection and criticism. As the ignorance and denial of geographic variation turned into recognition of and concern for it, geographic variation established itself as an issue that attracted the attention of numerous researchers and later be the basis of many national initiatives.

Through the studies in the 1970s, Wennberg and his colleagues revealed wide variations in per capita numbers of hospital beds and personnel and noted the correlation between supply of resources and health care use. While studying variations for common surgical procedures, they found that the degree of variation differed among procedures depending on the characteristic of a given procedure (Wennberg, 2008). In a study performed in Maine in 1975, they showed that there were distinct variations in rates of surgeries among the adjacent areas and that the variations tended to persist over time (Wennberg et al., 1975). This variation, which would be primarily attributable to variation in local medical opinion, was named "Surgical Signature" due to its sharp difference that would make it possible to identify a community only through the pattern of surgery rates (McAfee, 1987; Wennberg, 2008). Interpreting the

"Signature" through physician input has become the measure of success in the study of geographic variation (McAfee, 1987).

Subsequent studies of Boston and New Haven in the 1980s also demonstrated that the care one received was largely dependent on the health care supply. Although both communities were served by the university hospitals and demographically similar, the services they received showed a stark contrast: there was nearly a 100% gap between the two communities in expenditures per head for inpatient care and the chance to undergo surgery. This difference was traced to the different preferences for a treatment by physicians in each region (Wennberg et al., 1987). Wennberg and his colleagues continued to conduct studies for various types of medical care and the broader population. Their efforts finally resulted in the establishment of Dartmouth Atlas Project in 1992, which would perform extensive state-wide studies of geographic variation, covering health care access, quality, outcome, and supply across the US.

Studied most actively in the US, geographic variation was also widely investigated in other developed countries. While the majority of studies were performed in the UK, Canada, and Austrailia (Figure 1), the amount of literature has been on the rise for decades in most developed countries (Figure 2). Major clinical conditions including cancer, cardiovascular, gynecological, musculoskeletal, and respiratory diseases have been covered (Corallo et al., 2014).

Figure 1.

Published studies of geographic variation by country (2000-2010)
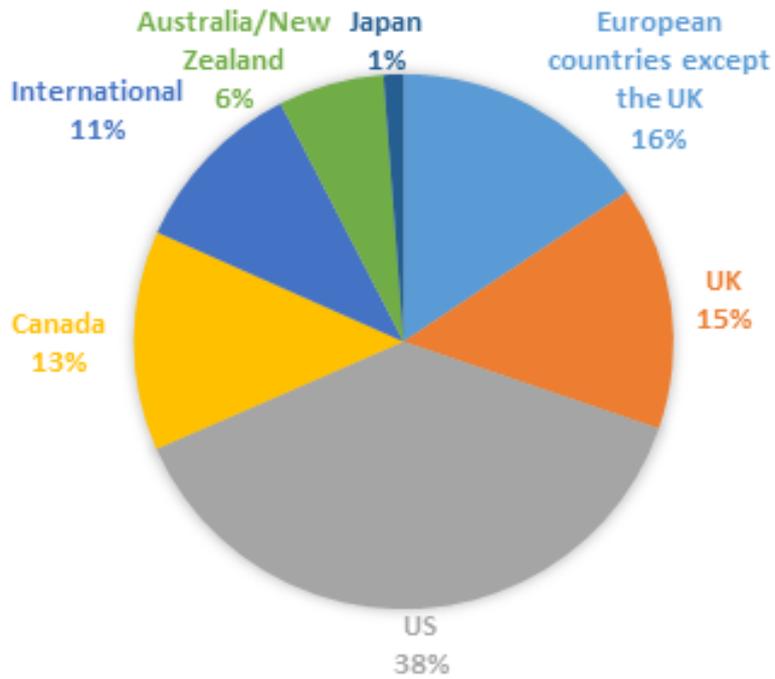
Source: Adapted from Corallo et al. Health Policy 2008; 114(1), 5-14

Figure 2.

Published studies of geographic variation by country (2000-2010)
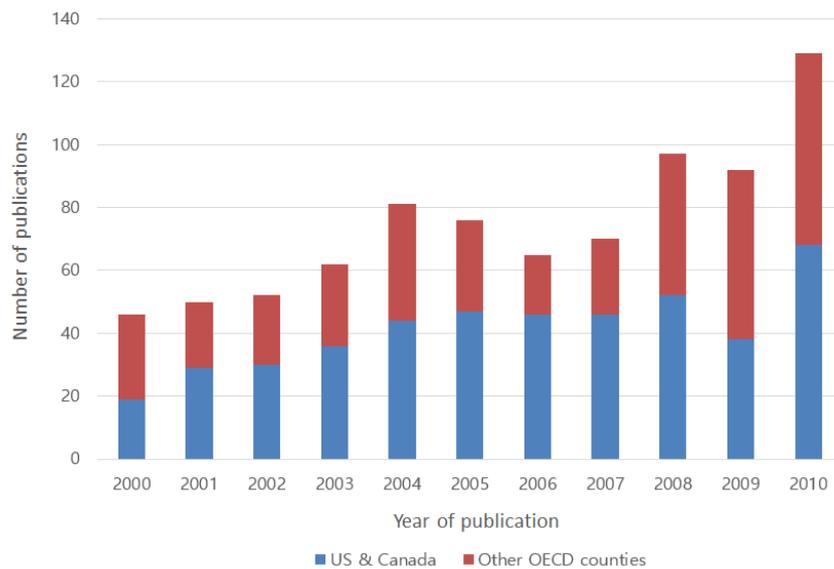
Source: Adapted from Corallo et al. Health Policy 2008; 114(1), 5-14

The studies have dealt with the variation of hospital admissions (Purdy et al., 2011a), physician visits (Long et al., 1999), diagnostic testing (Coburn et al., 2008; Coory et al., 2002; Niemann et al., 2000; You et al., 2008), surgical procedures (Farrow et al., 1992; Javitt et al., 1995), drug prescription (Curtis et al., 2006; McDonald et al., 2012), and health care spending (Fisher et al., 2003). According to the studies, geographic variation is not explained by the difference in patient characteristics such as patients' preference or need (Ozegowski et al., 2014; Schäfer et al., 2012; Volinn et al., 1992; Wennberg, 1987). The number of beds (Fisher et al., 2000; Purdy et al., 2011b; Wennberg, 1987), number of physicians (Black et al., 1995; Milcent et al., 2009), practice style (Coyte et al., 2001; Keller et al., 1998; Santora et al., 2003; Symons et al., 2002; Tu et al., 2012; Wennberg et al., 1982; Wright et al., 1999), and access to health care (Coughlin et al., 2008; Khan et al., 2010; Sherman, 2010) were found to partially explain the variation. However, a considerable part of geographic variation still remains unexplained (Newhouse et al., 2013; OECD, 2014).

The Era of Healthcare Atlas

Since the 1990s, national initiatives for atlases for health care utilization have been launched mainly in North American and European countries (Figure 3). The atlases have provided comprehensive information about health care from various dimensions including individual hospitals, local markets, and regions. Their subjects embrace an extensive range of topics such as health care utilization, clinical conditions, medical procedures, medical resources, expenditure, access, and outcome. Starting from the form of published materials, some of these atlases have progressed to interactive web-based tools, allowing comparison and analysis of variation among different regions.

The atlases have facilitated nation-wide and long-term analyses of variation. However, the ultimate goal of an atlas is, by posing a problem on the efficiency, effectiveness, and equity of the current health care system, to offer policy implications for quality improvement and decision-making. In that sense, the atlas may be considered as an accumulation of organized efforts to elucidate and improve geographic variation.

Figure 3.

The first publication of atlas by country and year
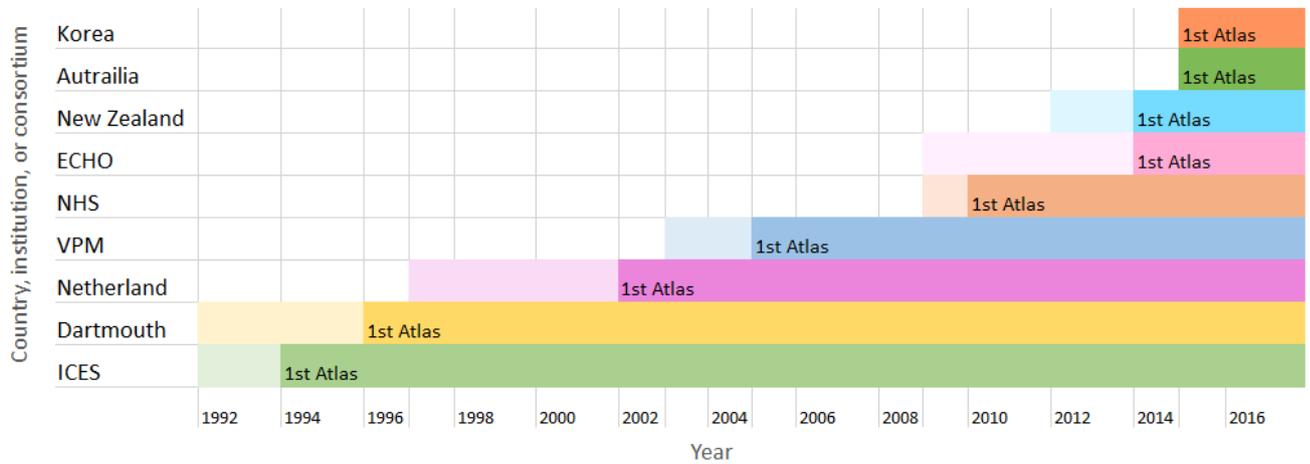
Source: ICES, Institute for Clinical Evaluative Sciences; VPM, Variaciones en la Práctica Médica; NHS, National Health Service; ECHO, European Collaboration for Healthcare Optimization Period between project initiation and the first publication was marked with lighter color.

Beyond National Boundaries

Even though a variation raises a question about the right amount of care, it does not give an answer to what the right amount is, and there is no established norm for the acceptable degree of variation. This problem is inherent in geographic variation study, which is normally performed without an appropriate measure to judge the degree of variation, and therefore, should be addressed to ensure the arguments concerning geographic variation become more convincing. Comparison of geographic variation among countries could be useful for addressing this problem.

In 2009, the European Collaboration for Healthcare Optimization (ECHO) was launched to assess healthcare system performance across Europe on the basis of a common knowledge infrastructure. Based on the achievements of the Dartmouth Atlas of Healthcare and the Spanish Atlas of Variation in Medical Practice, the ECHO Atlas aimed to measure geographic variation among the European countries (Bernal-Delgado et al., 2015). In addition, the Organisation for Economic Cooperation and Development published a report which presented information on geographic variation across countries in 2014. Although assuring comparability of geographic unit and homogeneity of data infrastructure remains to be resolved, international comparison will continue to be the future direction in geographic variation study.

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Types of Care

To better understand implications of variations of a certain health care use, two frameworks on typology of care have been developed. The first one was developed by the Dartmouth Institute for Health Policy and Clinical Practice in the United States while the other was proposed by the European Collaboration for Health Optimization, which is based on the work in the Atlas of Variations in Medical Practice in Spanish National Health System (Atlas VPM). According to these two frameworks, the available evidence on risks and benefits of different procedures influences medical opinions and patient preferences, and then may change the utilization rates (OECD, 2014).

Dartmouth Atlas

Dartmouth's framework is based on the concept of unwarranted variation. "Unwarranted variation" refers to a geographic variation in health care which cannot be explained on the basis of illness, medical evidence, or patient preference (Wennberg, 2010). The concept was derived from the geographic variation research performed by Wennberg and his colleagues, who identified three categories of care to explain unwarranted variation (Wennberg et al., 2002). The three categories of care, which are effective, preference-sensitive, and supply-sensitive care, are linked to underuse, misuse, and overuse respectively.

Effective Care

Effective care is defined as interventions in which the benefits far outweigh the risks; in this case the "right" rate of treatment is 100% of patients defined by evidence-based guidelines to be in need, and unwarranted variation is generally a matter of underuse (Wennberg, 2011). Effective care includes services whose effectiveness has been proven in clinical trials or well-designed cohort studies and whose use does not involve substantial trade-offs that depend on patient preferences (Wennberg, 2002).

In the case of effective care, virtually all patients who are eligible for treatment should be treated; failure to treat represents underuse (Wennberg, 2002). Effective care indicators, which are based on Health Plan Employer Data and Information Set (HEDIS), include vaccination for pneumococcal pneumonia; mammography screening for breast cancer and screening for colon cancer; eye examinations for diabetics; and, for heart attack victims, the prescription of aspirin therapy, beta-blockers, angiotensin converting enzyme (ACE) inhibitors and early reperfusion with thrombolytic agents, or percutaneous transluminal coronary angioplasty (PTCA) (Wennberg et al., 2002).

The underuse of effective care is universal. The Dartmouth Atlas reported systematic underuse for each of 11 examples of effective care (Wennberg, 2002). According to a study that investigated the health care use of adults in 12 metropolitan areas in the United States, participants were found to receive about half of recommended care in major acute and chronic conditions (McGlynn et al., 2003). In addition, the level of spending on health care in a community is uncorrelated with the incidence of effective care (Atlas, 2007a). Rather, the spending is inversely correlated with the likelihood of receiving recommended care (Atlas, 2007a). The most important factor for the variation in effective care is likely to be the discontinuity of care (Atlas, 2007a) and the lack of infrastructure to ensure compliance with evidence-based standards of practice (Wennberg et al., 2002).

Preference-Sensitive Care

Preference-sensitive care is clinical services where for many patients at least two valid alternative treatment strategies are available (Wennberg et al., 2002). One example is the use of lumpectomy or mastectomy for treating early stage breast cancer. Another example is the treatment of early stage prostate cancer, for which the treatment options include surgery, various forms of radiation, and watchful waiting (Wennberg, 2002).

Back surgery, of which indication is not yet well established, also belongs to preference-sensitive care. In Figure 4, compared with the case of hip fracture, where patients' preferences and those of their surgeons are essentially the same, the rates of back surgery, hip replacement, and knees surgery vary remarkably (Atlas, 2007b). This reflects the fact that there is less consensus among physicians about the indications of these procedures.

Preference-sensitive care often involves significant trade-offs affecting the patient's quality and/or length of life (Atlas, 2007b). Decisions about those services reflect patients' personal values and preferences, and should be made

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only after patients have enough information to make an informed choice (Atlas, 2007b).

In terms of unwarranted variation, preference-sensitive care is related with misuse. Misuse results from the failure to accurately communicate the risks and benefits of the alternative treatment, and the failure to base the choice of treatment on the patient's values and preference (Atlas, 2007b). Although the treatment choice should depend on informed patients' making decisions based on the best clinical evidence, in practice, choices appear to be determined largely by local medical opinion (Wennberg et al., 2002). As in the case of Wennberg's study of Boston and New Haven, variations in medical opinion among the faculties of academic medical centers can create wide variations in the risk for elective surgery in the population they service (Wennberg, 2002). Still, treatment patterns for preference-sensitive care conditions show striking differences among regions (Wennberg et al., 2002).

Figure 4.

Rates of four orthopedic procedures among Medicare enrollees in 306 hospital referral regions (2002-03)
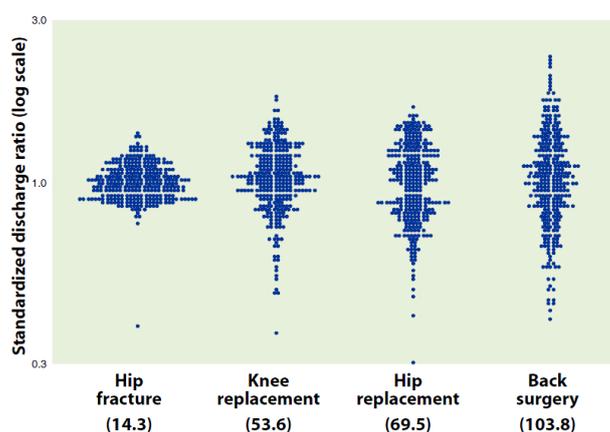
Source: Reprinted from Dartmouth Atlas Project Brief. 2007.

Supply-Sensitive Care

Supply-sensitive care includes a group of services that are directly related to the supply of physicians, health care facilities, and medical equipment (Wennberg, 2011). It is care whose frequency of use is not determined by well-articulated medical theory, much less by scientific evidence (Atlas, 2007c). For each of these services, the per capita quantity of health care resources allocated to a given population largely determines the frequency of use (Wennberg, 2002).

Services that belong to the category of supply-sensitive care are often overused, and, as a result, the geographic variation in the use of supply-sensitive care appears very large (Atlas, 2007c). Most of this variation arises from the frequency with which patients with chronic diseases use consultations, diagnostic tests, referrals to medical specialists, hospitalizations, and stays in intensive care units use (Wennberg, 2002). For example, patients with chronic diseases such as diabetes, congestive heart failure, cancer, and obstructive pulmonary disease who live in regions with more doctors per capita will have more consultations and diagnostic tests. If they live in regions with more beds they will experience more hospitalizations and stays in intensive care units (Figure 5) (Kim et al., 2016b; Wennberg, 2002).

Figure 5.

Correlation between hospital beds per 1,000 and discharges per 1,000 (2010-2014) among the Korean population
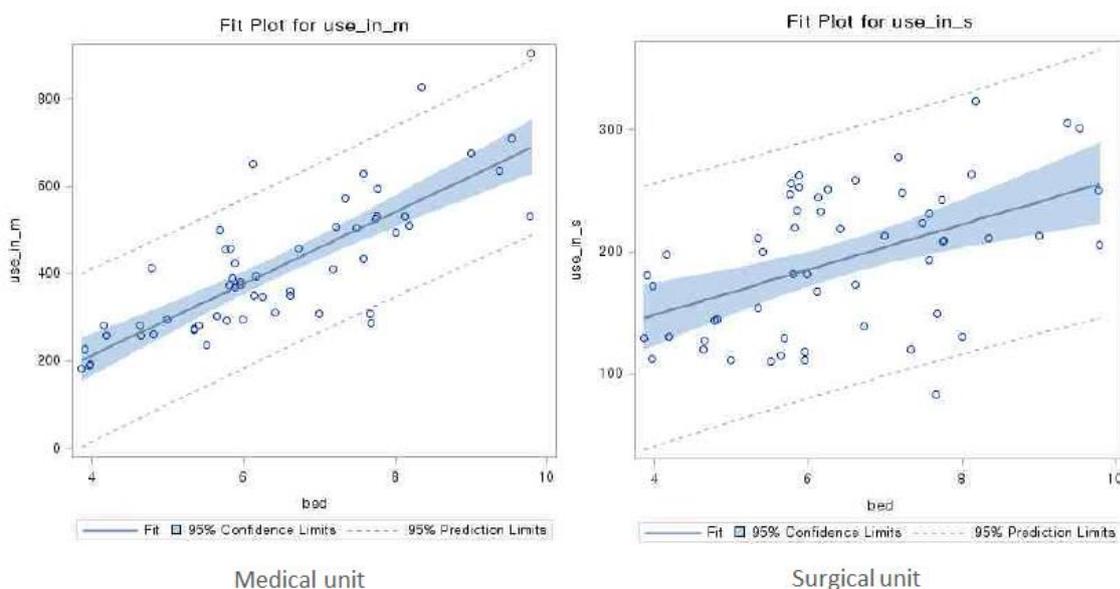
Source: Adapted from Kim et al. National Health Insurance Korea 2016.

In the US, supply-sensitive care accounts for most of the two-fold regional variation in total per capital spending on patients aged 65 and over (Wennberg, 2011). Greater intensity of care definitely incurs more cost; however, evidence of its positive effect on the outcome is absent. Compared to regions with less care intensity, patients with hip fractures, a heart attack, or a colectomy for colon cancer had higher mortality rates and worse quality care in regions with greater care intensity (Atlas, 2007c).

ECHO

The framework proposed by the ECHO is based on the work performed by the Atlas VPM. The health care system in Spain differs from that in the U.S., on which Dartmouth Atlas is based on. For example, the Spanish health care system is a highly regulated system with universal mandatory coverage for a very comprehensive benefits basket. The general practitioners act as gate-keepers, and patients have limited choices for providers (Bernal-Delgado et al., 2014). The structure of incentives for payers, providers and patients is also different. Given the diversity of the health care system and its components, it is not appropriate to apply a framework of a specific atlas to the other health care environments, because it cannot be universal from its birth. This concern applied to the case of the atlas VPM. As the framework of the Dartmouth Atlas is less suitable for describing Spanish health care system, where patients' choice for physicians is limited, the Atlas VPM re-defines categories of care according to the effectiveness of care (Bernal-Delgado et al., 2014).

Effective Care

Effective care is procedures or activities with proven effectiveness for any patients (OECD, 2014). Acute Myocardial Infarction (AMI) admissions, surgery in breast cancer, hip fracture repair, and colectomy in colorectal cancer are included in effective care (Bernal-Delgado et al., 2014). The indications for this category of care are beyond controversy. Therefore, if there are no barriers to access, the utilization rates and variations can be considered an accurate reflection of the demographic characteristics of populations.

Effective care with uncertain marginal benefits

This category of care includes procedures or activities whose risk-benefit balance depends on patients characteristics (OECD, 2014). The marginal benefits of health care services belonging to this category usually concern the

patients outside the eligible group. Percutaneous Coronary Intervention (PCI) in AMI, knee-replacement, carotid endarterectomy, and C-sections are the examples of effective care with uncertain marginal benefits (Bernal-Delgado et al., 2014).

Lower-value care

Procedures or activities with no evidence-based effectiveness belong to lower-value care (OECD, 2014). Spinal fusion, prostatectomy in prostate cancer, tonsillectomy in children aged 15 and younger, and non-conservative surgery in breast cancer for women 50-69 years old can be classified as the lower-value care (Bernal-Delgado et al., 2014). In the Spanish health care system, where there is a lack of financial barriers to the more cost-effective alternatives and physicians have no incentives to induce unnecessary services, variations in lower-value care are likely to have two factors: Different styles of practice and differential adoption of more cost-effective alternatives across areas (Bernal-Delgado et al., 2014).

National health atlas project

Significance

Health atlases are effective monitoring and evaluation tools in studying the distribution and use of medical resources from a geographical perspective. They can be helpful not only in understanding our healthcare system, but also in the setting of direction and the mapping of future investment plans to improve health and health systems across the nation. Health atlases allow for a deeper comprehension of the numerous unwarranted variations which cannot be explained "on the basis of variation of disease, patient preference, or medical science across geographical areas" (Wennberg, 2014), but rather, by the disparities in health system performance. The construction of a health atlas plays a significant role in reducing such variations that often challenge the establishment of absolute health equity, and helps policymakers facilitate a more scientifically evidence-based, systematic health care system.

Drawing a global picture of the variations in national health systems and their respective performances is crucial in identifying benchmarks in quality and efficiency. This report therefore aims to provide a sustained measurement of health system performance (i.e. variation) to track the effects of policy changes and clinical improvement efforts, which will be useful when objectively assessing Colombia's current situation and assisting developing plans at the regional and global level. A regional and more detailed overview of the main agendas that major countries have set in their foundation and development of their own health atlas will be elaborated on throughout the report. Data from the main critical areas of the health system development, including differences in health system infrastructure, regional variations, and financial and human resources are individually presented.

The data collected in the course of this report have a number of limitations. These should be kept in mind when viewing the results. While best attempts have been made to obtain information from countries on all variables, some could not provide specific details on a few issues. The most common reason for the missing data is that such data simply do not exist within the countries. Most of the nations that have built and/or are building a health atlas are high-income countries like the United States, the United Kingdom (England), and Spain. For the vast majority of countries, there was almost no information available.

The Health Atlas Project is an ongoing activity around the world and as more accurate and comprehensive information covering all aspects of health resources become available and the concepts and definitions of resources become more refined, it is hoped that the database will also become better organized and more reliable. The information provided in the profile should be viewed as the best information available from all sources combined.

Case Study (1) – United States

Background

The Dartmouth Atlas Project began in 1993 as a study of health care markets in the United States, measuring variations in health care resources and their utilization by geographic areas: local hospital market areas, regional referral regions, and states. More recently, the research agenda has expanded to reporting on the resources and utilization among patients at specific hospitals. DAP research uses very large claims databases from the Medicare program and other sources to define where Americans seek care and what kind of care they receive and to correlate increasing expenditures and supply of health providers and services with health outcomes.

Selected Content

The original data come from the Centers for Medicare and Medicaid Services (CMS) administrative and claims data and the U.S. Census population data.

- The database contains information on Medicare spending and on Medicare utilization of selected services, providers, and facilities by state, local, and regional market areas; by selected subpopulations of Medicare beneficiaries, including decedents and chronically ill beneficiaries; and by providers. The database also allows users to compare quality measures across hospitals

- Multi-centers around end-of-life care as a main indicator, as it provides insight into important drivers of total costs and overall regional healthcare quality

- End-of-life care represents a substantial fraction of all health care costs, and therefore, it ensures comparability, as these patients all have the same outcome

Methodology

Indicators are created from Medicare claims and administrative data. The percentage of Medicare deaths occurring in a hospital was computed using "death in a hospital" (discharge status B in the Medicare Provider Analysis and Review (MEDPAR) file) as the numerator event. For the percentage of Medicare deaths who were admitted to an intensive care unit (ICU) in the last 6 months of life, the numerator event was "death in a hospital with admission to an ICU within 6 months of the death date", using MEDPAR files. Rates were age, sex, and race adjusted and were expressed as a percentage of deaths. Medicare decedents are identified by their ZIP code of residence. Total ICU days measures intensive care days (which includes medical, surgical, trauma, and burn care) and coronary care days to produce a total ICU days. Intermediate care or step-down units are also included.

Used Indicators

- Medicare Reimbursements - Medicare spending has a more than a two-fold difference among hospital referral regions. Spending also varies from state to state, and from one hospital to another, even among hospitals within the same region. Most of this variation is not due to differences in the price of care in different parts of the country, but rather, due to differences in the volume, or the amount of inpatient care delivered per patient.

- Post-Acute Care - Improving care coordination after discharge from the hospital is important to patients, to hospitals and to Medicare. Without high-quality care coordination, patients can bounce from home to the emergency room and back into the hospital, sometimes repeatedly. Better care coordination promises to reduce readmission rates and improve patients' lives while reducing costs.

- Hospital Use - Most hospitalizations are for conditions that have high or very high patterns of variation in their discharge rates. Medical discharges are more variable than surgical discharges. For medical

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conditions, the majority of variation is associated with hospital capacity (as measured by the per capita supply of hospital beds).

- Medical Discharges - For patients with medical conditions, geography matters; patients with medical conditions receive very different care depending upon where they live. Why does care vary so much? The most obvious explanation might seem to be regional differences in how sick patients are. But the prevalence and severity of illness accounts for remarkably little of the variation in care.

- Surgical Procedures - Most patients defer to their physicians when it comes to deciding what care they receive. When it comes to elective surgery, physician opinion can vary widely as to when the treatment is necessary, and which patients are appropriate. Consequently, the frequency of discretionary surgery such as knee or hip replacement or back surgery also varies remarkably from one region to another.

- Quality / Effective Care - Effective care consists of evidence-based interventions where the benefits so far exceed the harms that all patients in need should receive the service. Life-saving drugs following a heart attack are an example. Variations in the use of such treatments among eligible patients reflect a failure to deliver needed care, or underuse.

- End-of-Life Care - Modern technology has vastly extended the ability to intervene in the lives of patients, most dramatically so when life itself is at stake. But the capability to intervene is not uniformly deployed, and health care providers do not share a uniform propensity to hospitalize dying patients or to use technology at the end of life. The American experience of death varies remarkably from one community to another.

- Care of Chronic Illnesses in Last Two Years of Life - Caring for people with chronic disease accounts for more than 75% of health care spending. As chronic disease progresses, the amount of care delivered and the costs associated with this care increase dramatically. Patients with chronic illness in their last two years of life account for about 32% of total Medicare spending, with much of it going toward physician and hospital fees associated with repeated hospitalizations.

- Cancer Screening - Recommendations about screening for cancer have shifted over the last decade to ensure that people who are unlikely to experience benefit—but may experience harm—from screening do not get screened. For older adults, this shift has translated into guidelines

that indicate an age above which screening is not recommended. Making the decision to cease screening may be challenging for clinicians and patients.

- Demographics of the Medicare Population - These measures examine the demographics of older adults, including age, race, enrollment status, and other characteristics, to understand who are the older adults of today in the United States.

- Interactions with the Healthcare System - Older adults are more likely than ever to experience frequent, complex interactions with the health care system involving an expanded cadre of providers. Providers may be unaware of the other health care activities in which an older person may be involved. Understanding how care for older adults is organized and delivered can shed light on whether care could be delivered more efficiently from the patient's point of view.

- Prescription Drug Use in Medicare Part D - Prescription medications are an increasingly important component of health care. Many drugs are highly effective at treating or preventing disease, while others have benefits that are less clear and may be outweighed by potential adverse effects. Regional variation in the use of prescription drugs suggests that these benefits and risks are not uniformly delivered to Medicare patients.

- Variation in the Care of Surgical Conditions - These indicators were created for a series of six Dartmouth Atlas reports that examine unwarranted variations in U.S. surgical care. The topics include surgical treatments for obesity, cerebral aneurysms, diabetes/peripheral artery disease, spinal stenosis, organ failure (transplantation), and prostate cancer.

- Children's Healthcare - This section examines small area variations in children's health care in Northern New England for ambulatory physician services, hospitalization, common surgery, imaging, and outpatient prescription fills. The measures are presented by hospital service area and pediatric surgical area, revealing the care provided by specific hospitals and their medical staffs.

- Hospital & Physician Capacity - Regional variation in hospital and physician capacity reveals the irrational distribution of valuable and expensive health care resources. Capacity strongly influences both the quantity and per capita cost of care provided to patients. Better planning

of future growth in capacity can help build a more effective and affordable health care system.

Case Study (2) – United Kingdom (England and Wales) : the Environment and Health Atlas for England and Wales

Background

Small Area Health Statistics Unit, or SAHSU (based at Imperial College), published an environment and health atlas for England and Wales on 24 April 2014. The atlas maps the spatial variation between areas for both long-term risks of 14 health conditions and levels of five environmental agents at a very high spatial resolution. These maps have been developed as a resource for the public, researchers and anyone working in public health and policy to better understand the geographic distribution of environmental agents and health conditions in England and Wales. Fourteen health conditions are mapped at small-area (census ward) level. They show relative risks (the risk in a census ward relative to the risk in England and Wales) averaged over a 25-year period (1985-2009) where possible. Maps are presented separately for males and females. These are adjusted for age, deprivation and chance fluctuations due to small numbers. The health maps produced were developed specifically for the Atlas. Unlike most other UK atlases (e.g. at district, NHS board or primary care trust level), this atlas provides health maps at census ward level (average population 6,000), giving a high degree of spatial resolution to better show geographical variability. Further information on NHS performance data and current projects to reform NHS is provided through the King's Fund website. Small Area Health Statistics Unit, or SAHSU (based at Imperial College), is the supplier of the atlas.

Selected Content

The database contains superficial statistics and information on lung cancer, breast cancer, prostate cancer, skin cancer, bladder cancer, leukemia, brain cancer, liver cancer, mesothelioma, heart disease, COPD, kidney disease, stillbirths, and low birth weight by age, sex, and region. Each set of maps are presented with a short explanatory text to aid interpretation. Comparison of patterns seen in the environmental exposure and health outcome maps can

suggest hypotheses about possible associations, but cannot prove or disprove causation, which requires information from external studies. The text highlights authoritative reviews and relevant major studies to help interpret any patterns seen in the maps.

Used Indicators

- Cancers including lung cancer, breast cancer, prostate cancer, skin cancer, bladder cancer, leukemia, brain cancer, liver cancer, mesothelioma

- Heart disease

- COPD

- Kidney disease

- Child and maternal health including stillbirths and low birth weight

Case Study (3) - Spain: the Atlas of Variations in Medical Practice in the Spanish National Health System (Atlas VPM)

Background

The Atlas VPM started in the early 2000s in collaboration with the regional health authorities in Spain to acquire hospital data at the patient level. These data were then amassed into a central database and then an online analysis tool was built as a front-end to the database. This meant that policymakers, managers and other stakeholders could go directly to the Atlas website and conduct research on key issues more quickly and efficiently by themselves. The adopted conceptual framework attaches each indicator to two informative attributes: its value and its variation across the territory. The value-attribute informs a judgement as to whether utilization reaches an acceptable level using "standard" expectation as a reference. The variation-attribute signals whether the systematic differences observed across territories are unwarranted and, thus, need to be tackled. Population characteristics must be ruled out as the source of variation using the appropriate statistical treatment.

The Spanish National Health Service differs from the one depicted in the Atlas of Dartmouth. In the Spanish context, while the effective care category has been proven quite suitable, supply and especially preference-sensitive category are more problematic. Providers' choice is limited in Spain, and patients-doctors agency relationship is essentially biased towards the side of professional "preferences" rather than patients' preference. Thus, rather than taking "prior" stakes as the underpinning factors and solutions, the Atlas framework has chosen to re-define relevant care categories in reference to their proven effectiveness, leaving the door open for contextual analysis to reveal the drivers of utilization and variation across the territory. Therefore, the categories adopted in Atlas VPM have been:

- Effective care – proven effectiveness for any patient.

- Effective care with uncertain marginal benefit (benefit-risk balance) in non-average patients – patients for whom there is insufficient evidence of effectiveness.

- Lower-value care – no evidence about its effectiveness.

There is a total of eight atlases published by the SNS. The selected topics are as follows:

- Atlas 1. Variability in orthopaedic and trauma surgery. Hip fracture, knee replacement, and hip replacement.

- Atlas 2. Variability in general surgery interventions in the Spanish National Health System.

- Atlas 3. Variability in pediatric hospitalizations for selected diagnoses and surgical procedures.

- Atlas 4. Variability in hospitalization for cardiovascular problems and procedures in the National Health System.

- Atlas 5. Variability in the rate of hospitalizations for mental health problems in acute hospitals.

- Atlas 6. Variability in hospitalisations due to onclolgical surgery in the National Health System. In this Atlas, we describe the differences across surgery utilisation in the treatment of 9 cancer types: breast, bladder, colorectal, prostate, uterus, larynx, lung, stomach and esophagus, between the years 2005 and 2007.

- Atlas 7. Variability in hospitalizations of older people in the National Health System.

- Atlas 8. Variability in potentially avoidable hospitalizations related to chronic diseases.

Overall, the Atlas VPM revealed unwarranted variations in general surgery, orthopaedics, paediatric hospitalizations, cardiovascular procedures, mental health hospital care, oncologic surgery, avoidable hospitalizations, c-section rates, and patient safety or mortality in cardiovascular procedures.

Population Covered

The Atlas VPM database contains information on each of the publicly funded hospital admissions in the country, which amounts to around 5 millions per consolidated year (it includes all items in the national hospital discharges dataset: demographics, diagnoses, procedures, type of admission, type of discharge, relevant date, etc.). Each admission is assigned to the patient's place of residence (each one of the 199 administrative healthcare areas across the 17 Autonomous Communities, for a total population of some 46 million inhabitants). For the purpose of this exercise, admissions in 2008 and 2009 were pooled accounting for 2 million admissions per year.

Methodology

- Value-attribute - It is measured calculating and mapping out procedure utilization rates and ratios for each of the 199 healthcare areas existing in the SNS. Age and sex standardized utilization rates are used as the basic measure of exposure to care for the population living in each area. Depending on the type of procedure analyzed (effective, uncertain marginal benefit, or lower value) high levels of exposure could be interpreted either as good or liable for improvement.

- Variation-attribute - A crude measure of the magnitude of variation is the ratio of variation or extremal quotient (EQ5 –95) comparing utilization rates in the areas in the 95th and 5th percentile of the distribution. Along the same lines, the interquartile ratio (IQ75–25 or rate in the 75th to rate in the 25th percentile) would represent the variation within the central part of the distribution of rates. However, these measures cannot rule out chance as an alternative explanation for the differences detected. Thus, two other statistics are estimated: the classical Component of Systematic Variation (CSV) and the Empirical

Bayes statistic (EB). Both are based on the relationship between observed and expected cases for each healthcare area although the EB offers more robust estimations for small populations and low utilization rates.

- Analyzing main underlying causes - Notwithstanding the ecological nature of Atlas VPM data and the informative flaws when using real-life information sources, it is possible to provide insight on some relevant factors likely to influence variation. Atlas VPM uses different methods to explore underlying factors. Contingent on the rationale (i.e. "causal model") of each indicator, and on the data availability some of them are systematically used, whereas other requires specific research.

- Burden of disease - At population level, age, sex, and in some procedures, social deprivation (see later) are considered as proxies of burden of disease in the 199 healthcare areas of the Spanish SNS. However, when posssible (essentially contingent on the existence and quality of data) other proxies are used with a view of accounting for the actual prevalence or incidence of a particular event of interest.

- Social deprivation - Concentration curves and concentration indices (with their respective 95% confidence intervals) are frequently drawn and estimated. Average household income for each one of the 199 healthcare areas is usually analyzed as a proxy of social gradient. When utilization is biased against less affluent areas (pro-rich difference in effective care), models are estimated in order to determine whether income in the areas is an independent factor.

- Supply - Supply is usually studied in the Atlas VPM in order to explain whether the existence of specific services or the number of resources per capita within an area affects variation.

- Concentration of population 30 minutes away from a specialized service - The concentration of population around specific services tends to explain both wealth and supply when it comes to studying elective surgery. Although 80% of the Spanish population lives less than 30 min away (time-distance) from an acute-care hospital, some specific studies might benefit of particular analysis.

Used Indicators

The Atlas VPM is analyzing unwarranted variations in:

- general surgery

- orthopaedics

- paediatric hospitalizations

- cardiovascular procedures

- mental health hospital care

- oncologic surgery

- avoidable hospitalizations

- c-section rates

- and patient safety or mortality in cardiovascular procedures.

Comparative analysis

The three territories mentioned above—the United States, the United Kingdom, and Spain—are all well known for their successful creation of a national atlas project. The most glaring common factor is that they are all of high income, which we can comprehend as the representation of fiscal or infrastructural resource sufficiency in implementing the project per se. On a more fundamental ground, however, the style and structure of the three respective projects differ formidably from one another. The United States focuses on the interactions between numerous and diverse indicators as well as health care determinants to draw an elaborate and comprehensive picture of its healthcare system. The heath atlas efforts in the US have mostly been led by a private institution, Dartmouth, which can be seen as a coherent reflection of its hybrid medical system and the consequently large influence bestowed to private medical suppliers. The United Kingdom and Spain, on the other hand, pursue the project on a more public level as can be related to their exertion of universal healthcare, collaborating with the government and national institutes to expand on their respective findings. These findings originate from typical information drawn from general indicators multi-centering around the most frequently occurring illnesses and/or performed surgical procedures. Insight on the

possible underlying factors and implications in policymaking are provided through a division of work with diverse national institutes, as stated above.

Though rather subjective, the latter can be understood as more credible, and moreover, better fit for Colombia's commencement of the Atlas Project. Despite it being the pioneering as well as the most fruitful (on a short-term basis and with respect to the recent project initiations) project in creating a healthcare database on the distribution and utilization of medical resources, the Dartmouth Atlas Project (DAP) has had its own problems too large to overlook. The main issue was that the underlying methodology of the Dartmouth studies is highly questionable from a scientific standpoint, and that, as an examination of the Dartmouth Atlas shows, the conclusions the Dartmouth researchers draw from the data they collected are built into the premises they employ. In turn, the Dartmouth Institute wholly rebutted the allegations and defended its work, even challenging each criticism in a pdf statement online. The question that comes into mind, as this report is concerned, is not whether the work structure of the DAP is efficient or not; rather, it is about how a monopoly of work can be problematic. It can be understood how the division of work through an integrative collaboration among credible institutions can lead to more scientific and objective analyses. This style of work is closely related to that of U.K. and Spain—territories that adopt a universal healthcare system and pursue the Atlas Project on a more public level, as does Colombia.

This does not conclude, however, that the Atlas Projects of U.K. and Spain is without flaw. According to From Data to Decisions: Exploring How Healthcare Payers Respond to the NHS Atlas of Variation in Healthcare in England (L. Schang et al, 2014), six Primary Care Trusts (PCTs) viewed the NHS Atlas (England) as having organizational constraints to be put to practice. In other words, the Atlas Project should not only be credible from a scientific standpoint, but also applicable; awareness of data, acceptance of data, perceived applicability of the data, ability to use the data, current use of the Atlas, challenges in using the Atlas, and enabling factors for coordinating further analysis and action should all be significant factors to consider when initiating the Atlas Project.

Table 2.
Structural Comparison of Health Atlases, by Nation

	The United States	*The United Kingdom (England and Wales)*	*Spain*
health system	a "hybrid system"	a universal system	a universal system
level of income	high income	high income	high income
main problem	high cost of medical care	weak demonstration of medical care quality mainly due to overuse of low-value care	inequity of geographical, socio-economical, and structural distribution of various healthcare networks and resources
Atlas objectives	defining where Americans seek care, what kind of care they receive; correlating increasing expenditures and the supply of health providers and services with health outcomes.	to help in development of hypotheses to understand and explain variability in disease risk that may relate to the environment, lifestyle factors and/or location.	to compare healthcare geographically – region by region – with a view to giving powerful feedback to policy decision-makers and managers nationwide.
how the Atlas is run	focuses on the interactions between diverse indicators and healthcare determinants (monopoly of work)	utilizes typical findings based on general indicators (*i.e* the rate of stillbirths or a specific type of cancer in a region by age and gender) and leaves analysis to other national institutions (division of work)	utilizes typical findings based on general indicators multi-centering around surgical procedures and provides insight on possible underlying factors; analysis is carried out in collaboration with the government (division of work)
how the Atlas is provided	via web. Links to previous reports are also provided.	via web. Links to previous reports are not provided. Print versions of the Atlas can be purchased with email contact to SAHSU.	via web. Links to previous reports and related papers are also provided.

Setting the Right Agenda

The system-wide efforts to measure and monitor unwarranted variation across the territory are very valuable not only in the case of the USA and the DAP, but also in the context of the European National Health Services. As outlined in the introduction of this chapter, the wealth of having a regional Health Atlas allows meaningful benchmarking tailored at policy-relevant levels of analysis and using the focused action as a lever to enhance the system performance. A sustained initiative able to monitor variations over time and investigate the factors underpinning them is a powerful tool in supporting evidence-based policymaking and evaluating the impact of implemented measures.

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Nevertheless, there are several issues that should be taken into account to realize the full potential of the newly immerging Colombian Health Atlas Project:

1) The conceptual framework used in analyzing data and interpreting the results should be divided and yet collaborative among several institutions.

2) This should also fit the stakeholders' structure of incentives and organizational conditionings built into the institutional arrangements in Colombia. The following results' relevance for action and local acceptability can be improved.

3) Variation analysis is a monitoring tool rather than a firm diagnosis. It helps to guide further investigation by focusing scrutiny on geographical units showing unexpected behavior and on technologies.

4) Sophisticating the modelling of clinical practice variation phenomena, introducing innovative probabilistic and multi-level methods, and appropriate statistical treatment of some of the main hindrances is necessary. The final goal of strengthening the analytical apparatus is to enhance the reliability of the results and thus improve the quality of the decisions that could be made based on these results:

- The value of variation studies will depend on the specificity of the models analyzing underlying factors. There is no general causal model explaining variation. Conversely, underlying factors may be different or affect variation across procedures and contexts differently.

- Good models support suitable attribution of responsibility to different decision-making levels. The decisions can be backtracked and their specific impact on the observed variations carefully explored in conjunction with other factors.

- From a performance measurement perspective, eliciting interdependence across areas allows to flag the relative weight of within vs. neighborhood factors in the production of unwarranted variations, and therefore, to better focus healthcare policies and planning, in the more flexible real-world context.

- Overall, it is recommended that the Atlas focus on geographics/demographics, racial and socioeconomic status, chronic illnesses, obesity, smoking, alcohol consumption, mental illness, and maternal and child death.

Defining geographic units of analysis

Why it is critical

How to define geographic units of analysis is critical in the study of geographic variation in health care. The significance of geographic units in investigating geographic variation can be explained by three aspects: measurement, interpretation, and policy implications.

First, in terms of measurement of geographic variation, the way of organizing geographic units affects the measurement of geographic variation. Different ways of organizing geographic units may lead to inconsistent results among studies (Volinn et al., 1994). This discordance is related to the way of assigning a health care use to a certain geographic unit. In addition, concerning the effects of characteristics of geographic units, population size of a geographic unit (OECD, 2014), and the number of geographic units may influence geographic variation (Jackson et al., 2010). Heterogeneity in the size and the number of geographic units could produce extra variation (Thygesen et al., 2015), which may exaggerate the degree of deviation, and thus, the liability of health care suppliers in a certain geographic unit.

Selecting geographic units is crucial in terms of the analysis and interpretation of geographic variation in health care. As one of the purposes of studying geographic variation is to identify provider factors in variation, geographic units should be able to describe the health care use of the residents with accuracy (Kim et al., 2017). Ideally, a geographic unit of analysis should be completely self-sufficient in health care use in order that geographic health care use can be attributed to the health care suppliers in that area (Kim et al., 2017). Studies based on geographic units, that do not delineate geographic patterns of health care use accurately, may lead to an erroneous attribution of health care use to health care suppliers.

Lastly, defining geographic units is important in regard to the policy implications of geographic variation studies. The significance of geographic variation lies not only in the accurate description of the phenomenon, but ultimately, in the implementation of the results in the real world. Therefore, if

geographic units used in a research are not consistent with the units in which policies are actually implemented, the study result may of little use in the practical aspects, however accurately it describes the variation.

According to the discussions above, the conditions required for geographic units can be summarized in two aspects: "intrinsic" and "extrinsic" relevance (Kim, 2016). Intrinsic and extrinsic relevance may be referred to, respectively, as the integrity of the study per se and the integration of the study into the real world. Intrinsic relevance concerns measurement issues: accurately describing the health care use in geographic units and minimizing the extra variation caused by the characteristics of geographic units. Extrinsic relevance, on the other hand, concerns implementation issues: the probability of persuading healthcare stakeholders and practically applying the studies of geographic variation. Geographic units should be determined with consideration of those two facets of relevance.

How to define geographic units

Two geographic units

Research on geographic variation has been performed with two kinds of geographic units: units organized for the purpose of variation analysis and administrative areas. The former (subsequently referred to as service areas), designated as hospital service areas at the beginning (Wennberg et al., 1973), have been organized based on coverage areas of hospitals. Service areas, such as hospital and health service area and hospital referral regions, have been widely used to investigate geographic variation of health care (Klauss et al., 2005).

Although a considerable part of geographic variation studies were performed according to administrative areas, service areas have been a fundamental tool in the geographic variation study since its inception. As studies for geographic variation started not only for the purpose of description but for the identification of the factors, organization of service areas in a way that is the most appropriate for identifying the underlying causes of geographic variation has remained a matter of interest for researchers.

According to Garnick et al. (Garnick et al., 1987), three empirical approaches have been used to define service areas:

1) Geopolitical boundaries

   This approach is based on the predetermined areal units like administrative areas; therefore, it is practical and comparable. However, the large size gap among geopolitical areas can be a disadvantage to statistical analysis.

2) Distances among hospitals

   In this approach, service areas are delineated based on distances among hospitals by locating each hospital according to its geographical position, and the number of hospitals within a given radius are determined. However, the appropriate radius may differ for different services and the "distance" may not be the only factor that would determine the health care use of a population.

3) Patient origin (Patient travel from residence to the hospital)

   This approach is used if data are available on where patients live and are hospitalized. Patient-origin areas are based on two concepts proposed by Griffith: a measure of relevance as the proportion of patients from a community who go to a given hospital and a measure of commitment as the proportion of a hospital's patients who come from a given community. While this method can depict the health care use of populations more accurately, it requires extensive data manipulation and must be updated frequently to reflect changes in patterns of hospital care.

Compared to thirty years ago, when the patient data were hard to acquire, it became relatively easier to gain patient data linked to the address of their own residence and their hospital. In addition, due to the development of the geographic information system, accurate and comprehensive measurement of geographical position became possible. Meanwhile, administrative areas still remain as a reference point for defining geographic areas.

Therefore, nowadays, it is difficult to separate the three approaches from each other. As the geographic variation studies developed, geographic unit of analysis tended to be organized in consideration of those three approaches. Still, used not only in large-scale projects such as the Dartmouth Atlas Project, service areas are also being used in many studies as an attempt to accurately reflect the health care use pattern of a population (Kim et al., 2016a; Klauss et al., 2005; Thygesen et al., 2015).

However, when it comes to service areas, it still remains a challenge to make the study results better recognized by health care stakeholders and the general public, who are accustomed to thinking and making a plan based on the already established administrative areas. Service areas, being ad-hoc units, may lack stability and be of limited use for policy. In addition, despite an attempt to accurately describe the health care use of a population, services areas do not completely reflect the health care use of a population. This problem is inevitable in the present day where transportation is readily available and patients can freely choose a hospital.

Administrative areas, due to the convenience of data manipulation, policy making, and health care provision, have been extensively used for geographic variation studies. According to a systematic review of geographic variation, covering more than 800 publications issued between 2000 and 2011 in OECD countries, more than 70 percent of the research was conducted using administrative areas, while only 8 percent adopted service areas such as primary care service areas, health service areas, hospital referral regions, and market based regions (Corallo et al., 2014).

However, administrative areas may be incomplete as a unit of analysis for geographic variation studies. Administrative areas, as they are not established solely for the purpose of health care use, may not be consistent with actual health care use. This inconsistency can be explained in two aspects. First, it is health care use happening outside the region. In this point of view, the credibility of the attribution of health care use to health care suppliers in a geographic unit can become an issue. Second, the width of the coverage area differs according to the procedure. In case of services that are performed in the tertiary hospitals, the coverage area is broader compared to services provided in private clinics or small hospitals. The administrative areas are less likely to reflect those characteristics of the health care services in study. Given the ultimate purpose of geographic variation studies, which is to identify supplier factors of an unwarranted variation and provide evidence to correct the deviation, the discrepancy between administrative areas and areas of actual health care use may be a weakness for geographic research.

In addition, extra variation produced by heterogeneity in population size and number of units comes into question. The reason it becomes an issue in administrative areas is that administrative areas can be readily used for international comparison of geographic variation. While geographic variation studies have developed over the last few decades, the studies evolved from description of variation within a nation into international comparisons. A recent international comparison of geographic variation was performed by the Organisation for Economic Co-operation and Development (OECD) (OECD,

2014). The comparison was conducted mainly on the basis of administrative areas of 13 countries. Population distribution and number of geographic units used in the study showed marked variation (Kim et al., 2016a). Extra-variation will remain an obstacle to international comparison of geographic variation if not properly addressed.

Defining service areas

There has been a number of studies on how to define geographic boundaries. In terms of the methodology, hierarchical clustering, which was originally used to analyze labor market area, was applied to define a health service area (Harner et al., 1980; Taliaferro et al., 1973). Although simple, the method was intuitive and appropriate for reflecting actual health service use patterns (Kim, 2017).

The hierarchical clustering algorithm was also used in recent studies. In the Dartmouth Atlas of Health Care, hospital service areas were defined by the following three steps (Wennberg et al., 1996). 1) All acute care hospitals in the 50 states and the District of Columbia were identified from the American Hospital Association and Medicare provider files and assigned to the town or city in which they were located. 2) All 1992 and 1993 Medicare hospitalization records for each hospital were analyzed to ascertain the ZIP code of its patients. Using a plurality rule, each ZIP Code was assigned on a provisional basis to the town containing the hospitals most often used by local residents. 3) The visual examination of the ZIP Codes using a computer-generated map to make sure that the ZIP Codes included in the hospital service areas were contiguous.

Automatic Zoning Procedure (AZP) is another important method for geographic variation analysis. AZP, which is based on the iterative recombination of building block zones into output regions from an initial random aggregation (IRA), provides a means to automate the process of designing a zonal system (Kim, 2017). An essential part of the implementation of such zonal recombination is the maintenance of a contiguity matrix, allowing the identification of valid swaps between adjacent zones.

There have been attempts to define geographic units by using other clustering analysis or combination of various methods. Schortt et al. (Shortt et al., 2005) developed Synthetic Data Matrix (SDM) which combined a number of areal units created by different methodologies. And Delamater et al. (Delamater et al., 2013), employing a 2-step K-means + Ward's clustering algorithm,

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clustered facilities on the basis of similarities in patient utilization patterns and geographic location.

Statistical change detection for multi-dimensional data

An area-constructing methodology can be considered valid when it can detect statistical changes in the patients' data for health care use. If the statistical change of patients' data is consistent with the changes in the service area, which were created by the input of the patients' data, the methodology can be considered valid (Kim, 2017). The health care use data is the value denoted on geo-space which is constructed in the form of origin-destination matrix. As the origin- destination matrix can be summarized by the x and y coordinates of each origin and destination and the flow, the data can be regarded as multidimensional (Kim, 2017).

To detect the statistical change, statistical tests such as Kulldorff's spatial scan statistic (Kulldorff, 1997), Kolmogorov-Smirnov test, a distribution-free multivariate KS test (Justel et al., 1997), and the density test (Song et al., 2007b) have been used. In addition, techniques like Image Quality Assessment (IQA) and Structural Similarity Index (SSIM) could be used to address this issue (Kim, 2017).

Korean experience

Background

Recently, along with the rise of international comparison of geographic variation, there has been an attempt to build geographic units that are more homogenous in terms of the population size (Thygesen et al., 2015). This study aimed to diminish extra-variation among geographic units while maintaining policy relevance by respecting current boundaries of administrative areas. In terms of accurate measurement of variation and fair comparison of variation among different countries, the issue of how to organize new geographic units is expected to receive increasing attention.

In Korea, variation studies have been mainly performed on the basis of administrative areas. However, the fraction of the population using health care service in their own area is generally lower in Korea compared with other countries (Kim et al., 2016a). In addition, variation in population sizes of administrative areas in Korea turned out to be larger than in other countries. Such characteristics make administrative areas in Korea a less suitable option for geographic variation study.

To address the problems associated with using administrative areas for geographic variation studies, new areal units for analysis of geographic variation were developed. New areal units were organized for the following three purposes: (i) To establish areal units that cover actual health care use. (ii) To understand the pattern of health care utilization based on health care supply. (iii) To prepare the ground for monitoring and ensuring health care supply. The flow chart of this study is depicted in Figure 6 (Kim, 2017).

Figure 6.

Flow chart of developing health service areas
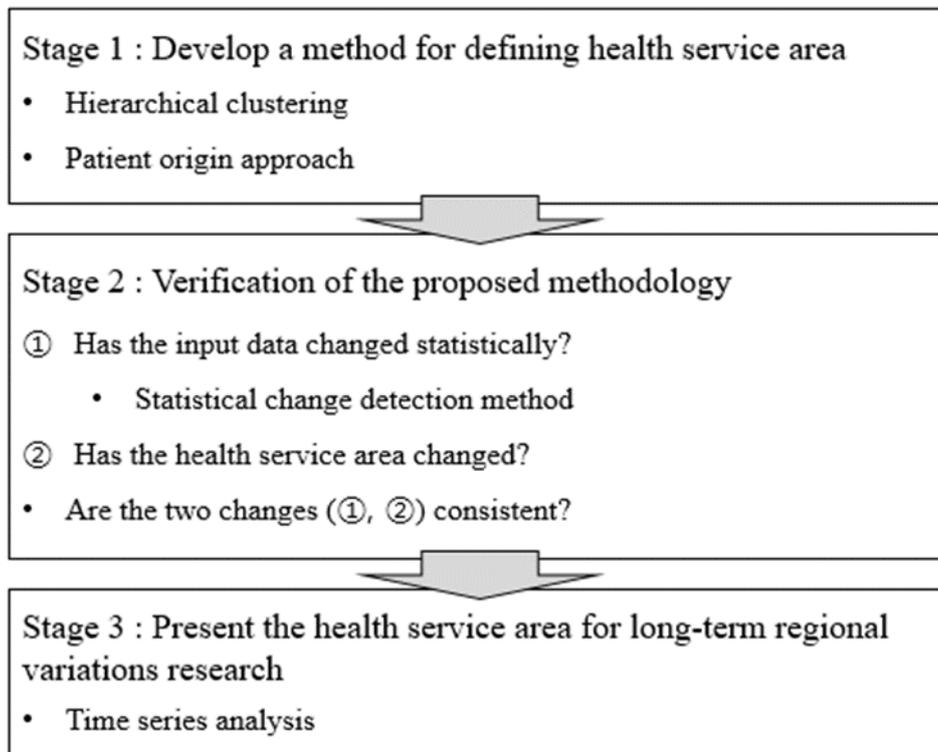
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016

Defining health service areas

Patient-origin approach

Patient-origin study, which analyzes the frequency of use of hospitals by patients according to their place of residence, was undertaken by Wennberg in his monumental study which was published in 1973 (Wennberg et al., 1973). Since then, patient-origin approach has been used in many variation studies including the Dartmouth Atlas. The Korean Atlas also adapted this methodology. In patient- origin approach, an origin destination matrix that represents patients' health care use behavior is constructed (Figure 7). Then, the relevance index and the commitment index are calculated according to the given administrative areas. The relevance index (RI) refers to the proportion of the hospitalizations that occurred within an area to the total number of hospitalizations in that area. The commitment index (CI) refers to the proportion of the hospitalizations that occurred within an area to the total number of hospitalizations of the area's residents.

Figure 7.

Patients' health care use origin destination (OD) matrix

Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Then on the basis of the multiplication of a relevance index and a commitment index, merging was performed. Merging was done on the existing administrative areas (163 districts) of Korea. To reflect both the dependence of residents' health care use on certain areas and the dependence of an area on the residents of certain areas, the multiplication of RI and CI was used. In the Dartmouth Atlas, when they organized Hospital Referral Regions (HRRs), Hospital Service Areas (HSAs) were assigned to the candidate HRRs, where most patients went for the services (Wennberg et al., 1996). In other words, only the concept of RI was applied in the Dartmouth Atlas. However, in Korea, where populations and medical resources tend to be concentrated in large cities, it is practically impossible to create health service areas with geographic continuity by using only RI. Therefore, to reflect both the relevance and commitment, the multiplication of both values was used. The rationale of using the multiplication of RI and CI is described in Figure 8.

Figure 8.

Application of RI and CI into merging
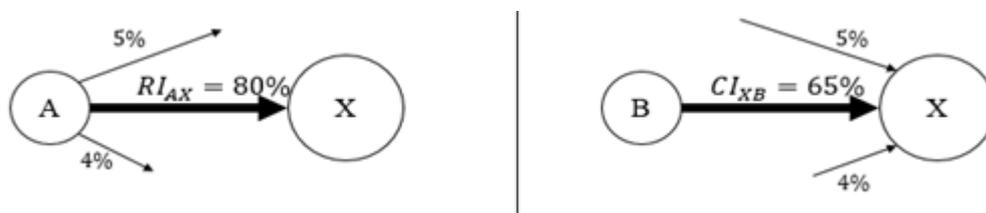
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

To select the combination of the merged areal units, three criteria were applied: (i) Minimum value of the RI of an areal unit (40%); (ii) Minimum population size of an areal unit (150 000); (iii) Maximum travel time (60 minutes). The minimum value of the RI and population size were based on the results from a previous study on organizing areal units for health care use (Park et al., 2011), where the average value of the RI of the 163 districts (si/gun) was about 40%. To ensure that the minimum RI of new areal units attained the average RI of the existing units, the minimum value of the RI was set at 40%. On the basis of the analysis of the RI and the population size of the districts, it was concluded that population size should be at least 150,000 to attain the minimum RI. Travel time refers to the time required for a car to move from one

area to another area. Based on previous studies where 60 minutes was defined as a critical period for reducing mortality in emergency medical conditions (Kim et al., 2015; Park et al., 2011), the maximum travel time was set at 60 minutes. Travel time was calculated between center points of the populations of areal units (Kim et al., 2016a). The input parameter, data, and the output parameter are described in Figure 9 (Kim, 2017).

Figure 9.

Data and parameters in Korea Health Atlas

[INPUT]

Data:

- Medical use data between administrative districts
- Population data of administrative districts
- Distance data between population centers of administrative districts

Parameter:

- Minimum population
- Minimum self-containment
- Merging distance

[OUTPUT]

- Health service areas (Cluster)
- Population size of each cluster
- Self-containment level of each cluster
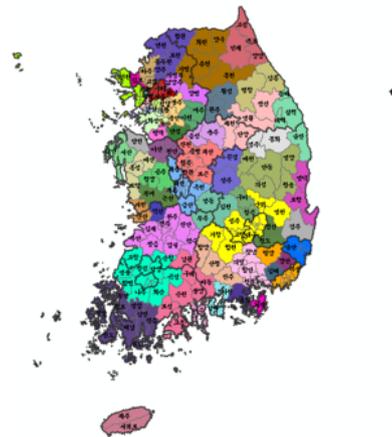
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Data description

The data for the health care use was tabulated in the origin-destination matix (Figure 10). The table in the Figure 10 shows how many patients used the health care services in which administrative areas. The total number of the administrative areas, which served as the building blocks for new geographic units, was 162. Data for hospitalization was acquired from the National Health Insurance database (2011 to 2015) (Kim et al., 2016a; Kim et al., 2016b).

Figure 10.

Origin-destination matrix
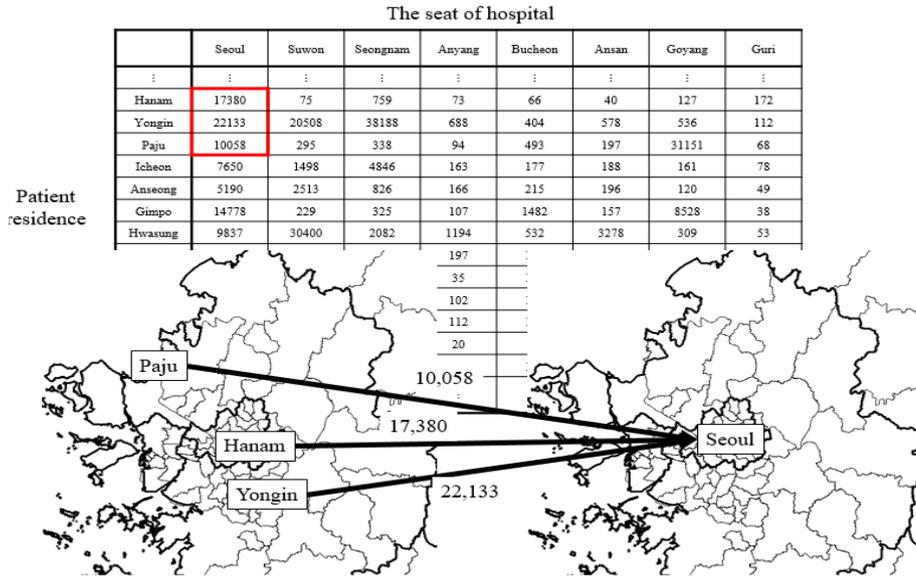
The seat of hospital

Patient residence		Seoul	Suwon	Seongnam	Anyang	Bucheon	Ansan	Goyang	Guri
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Hanam	17380	75	759	73	66	40	127	172
	Yongin	22133	20508	38188	688	404	578	536	112
	Paju	10058	295	338	94	493	197	31151	68
	Icheon	7650	1498	4846	163	177	188	161	78
	Anseong	5190	2513	826	166	215	196	120	49
	Gimpo	14778	229	325	107	1482	157	8528	38
	Hwasung	9837	30400	2082	1194	532	3278	309	53

Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

The population of each administrative area was calculated using 50m grid unit population data. The distance between administrative areas were measured as the distance between population center points of each area. The distance was calculated using the network data for traffic analysis provided by the National Transportation Database Center (Kim, 2017).

Overview of the procedure for defining health service areas

The procedure for defining health service areas is divided into three stages (Figure 11). In each stage, the building block areas merged into the seed areas, and the result was adjusted. Then, the adjusted result was used as the input building blocks in the next step (Kim, 2017).

Figure 11.

Three stages of defining health service areas
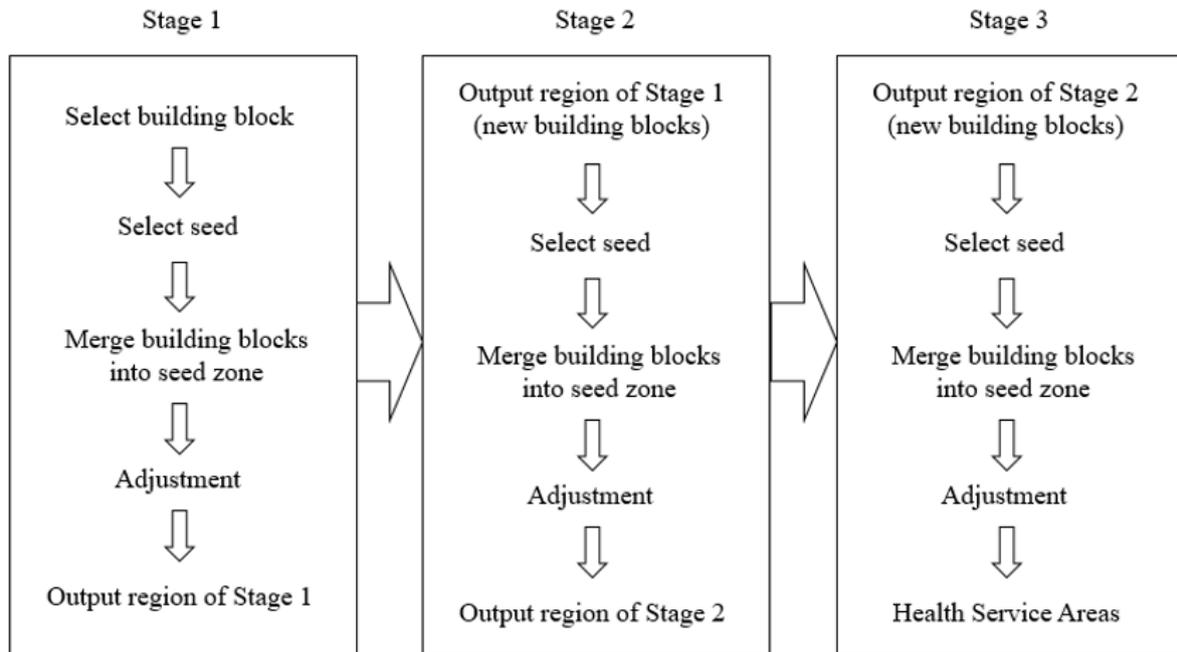
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

In Stage 1, on the basis of the initial building blocks (administrative areas: the city (Si) / county (Gun)), seeds were selected. A seed was defined as a building block that provided more than 50 health care services. Then, each building block merged into one seed region according to the merging criteria of the highest value of multiplication of RI and CI. If the distance between a building block and a selected seed region was longer than the predetermined criteria on distance, merging was not performed. Next, in the adjustment step, the population and the self-containment level of the each output region were compared with the minimum population and minimum self-containment (RI). If any of these two values were less than the criteria value, the merged area was decomposed into the initial building blocks.

The process of Stage 2 was similar to that of Stage 1. The difference from Stage 1 is the criteria value on merging distance. While the actual distance between the building block and the seed area was used in Stage 1, in Stage 2, the RI-weighted distance between the two areas was used. The concept of RI-weighted distance is shown in Figure 12 (Kim, 2017). For example, according to the equation in Figure 12, the distance between the building block *i* and an

integrated region *A* was calculated at 135. At the end of Stage 2, the second intermediate output regions for the health service area were produced.

Figure 12.

Concept of RI weighted distance

$$\mathrm{d_{iA}} = \frac{RI_{ij} \times d_{ij} + RI_{ik} \times d_{ik}}{RI_{ij} + RI_{ik}}$$
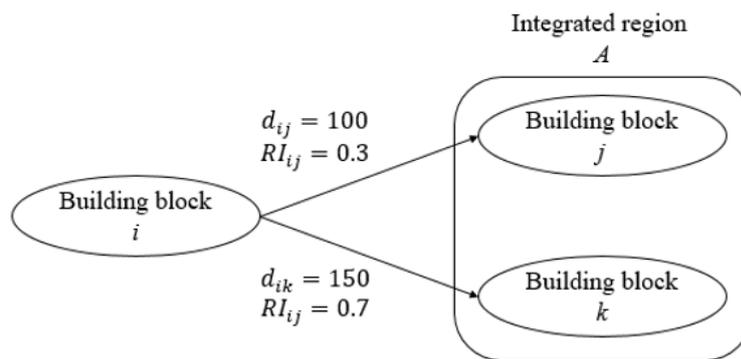
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

The merging process of Stage 3 differs from the previous two stages. In the previous two stages, each building block was merged into one seed region with the highest RI*CI of merging criteria. However, as the constraints were not met when merging into the region with the highest RI*CI, in Stage 3, the building blocks merged into the seed region with second highest RI*CI value. Also, stage 3 differs from the previous two stages in the adjustment step. In the adjustment step of previous stages, if the population and self-containment level of the created region did not meet the minimal criteria, the region was decomposed into the original building blocks. However, in Stage 3, the last stage, the decomposed blocks merged into the nearest region to obtain the geographical continuity of the health service areas (Kim, 2017).

Change detection of health care use data

The newly organized health service areas could change according to the change in patients' health care use pattern, which could be caused by factors such as policy, preference, and market environment. Therefore, the validity of the

newly organized health service area should be tested using statistical change detection. If the statistical change of the health service use data is consistent with the change in the service area, which was produced after inputting new health service use data, the proposed methodology could prove to be valid. The framework for validation is presented in Figure 13 (Kim, 2017).

Figure 13.

Framework for validation of health service area
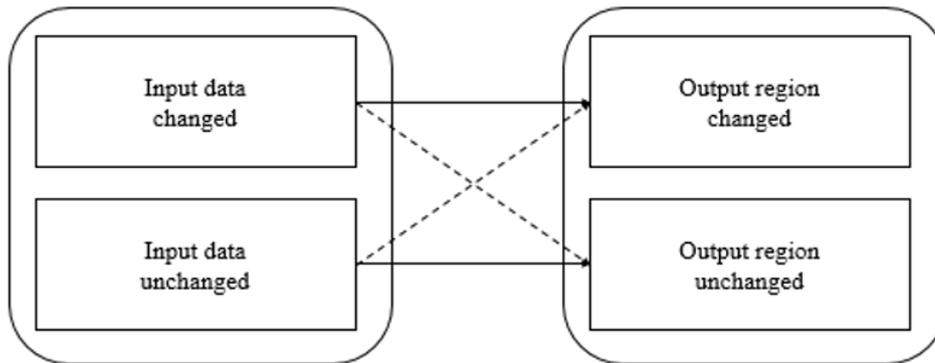
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Detecting overall changes in health care use data using the density test

To check if the newly organized health service areas were affected by the change in the patients' data, the procedure of Density proposed by Song et al. (Song et al., 2007a) was applied. Described below are the procedures of density test (Figure 13).

Figure 14.

Procedures of Density Test
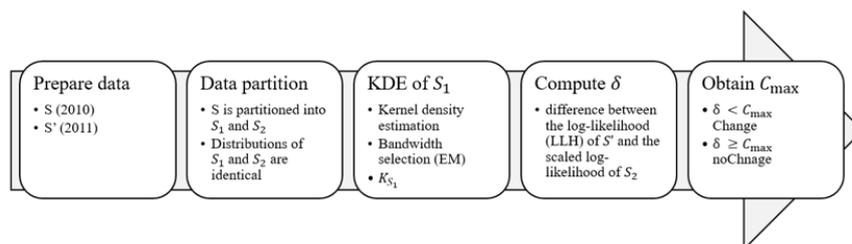
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Detecting partial changes in health care using the structural similarity index with density test

As the density test only confirmed the change of data and does not identify which part of data has changed. Structural similarity index (SSIM) was applied with the density test. The SSIM is the objective image quality index that is used in the image quality assessment (IQA). The SSIM computes the similarity of two images using average, variance, and covariance comparisons. The SSIM was calculated over a part of square block of the matrix. Then, the mean structural similarity index (MSSIM) was calculated by summing and averaging SSIM values across the whole matrix (Figure 14). How the SSIM was applied in the Korean health atlas is presented in Figure 15 and 16 (Kim, 2017).

Figure 15.

Calculation of the Mean Structural Similarity Index (MSSIM)

$$SSIM\,(a,\,b) = l(a,b) \cdot c(a,b) \cdot s(a,b)$$

$$l(a,b) = \frac{2\mu_a\mu_b + C_1}{\mu_a^2 + \mu_b^2 + C_1}$$

$$c(a,b) = \frac{2\sigma_a\sigma_b + C_2}{\sigma_a^2 + \sigma_b^2 + C_2}$$

$$s(a,b) = \frac{\sigma_{ab} + C_3}{\sigma_a\sigma_b + C_3}$$

$$MSSIM = \frac{1}{N}\sum_{i=1}^{N} SSIM\,(a_i, b_i)$$

Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Figure 16.

Example of calculating the Structural Similarity Index (SSIM)
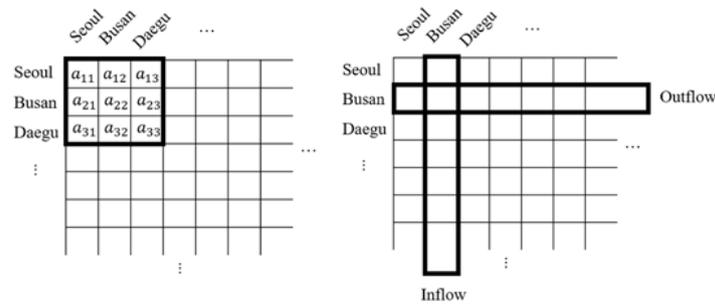
Source: Reprinted from Kim et al. Korea Advanced Institute of Science and Technology 2016.

Comparing hospital service areas and administrative areas

Through the analyses, the methodology, which was used to organize new health service areas, proved to be valid. The end result is presdented in Figure 17. These health service areas were organized based on the acute care admission data from 2011 to 2015 in Korea. From 162 administrative areas, which were used as building blocks, a total of 56 service areas were organized.

Figure 17.

New areal units organized for geographic variation study in Korea
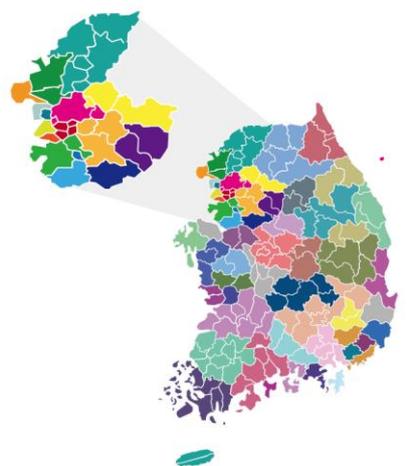
According to a study, which attempted to compare the new units, which were developed in the similar way with the units described above, to the administrative areas, the variation of both population size and procedure rates generally decreased in new areal units (Figure 18,19).

Figure 18.

The distributions of the populations in the administrative areas (districts) and new areal units
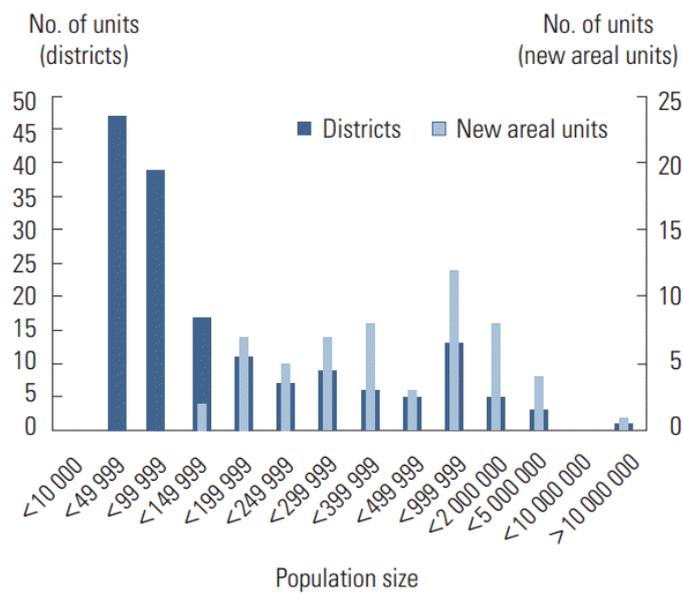
Figure 19.

The kernel density function for age–sex standardized rates of the eight
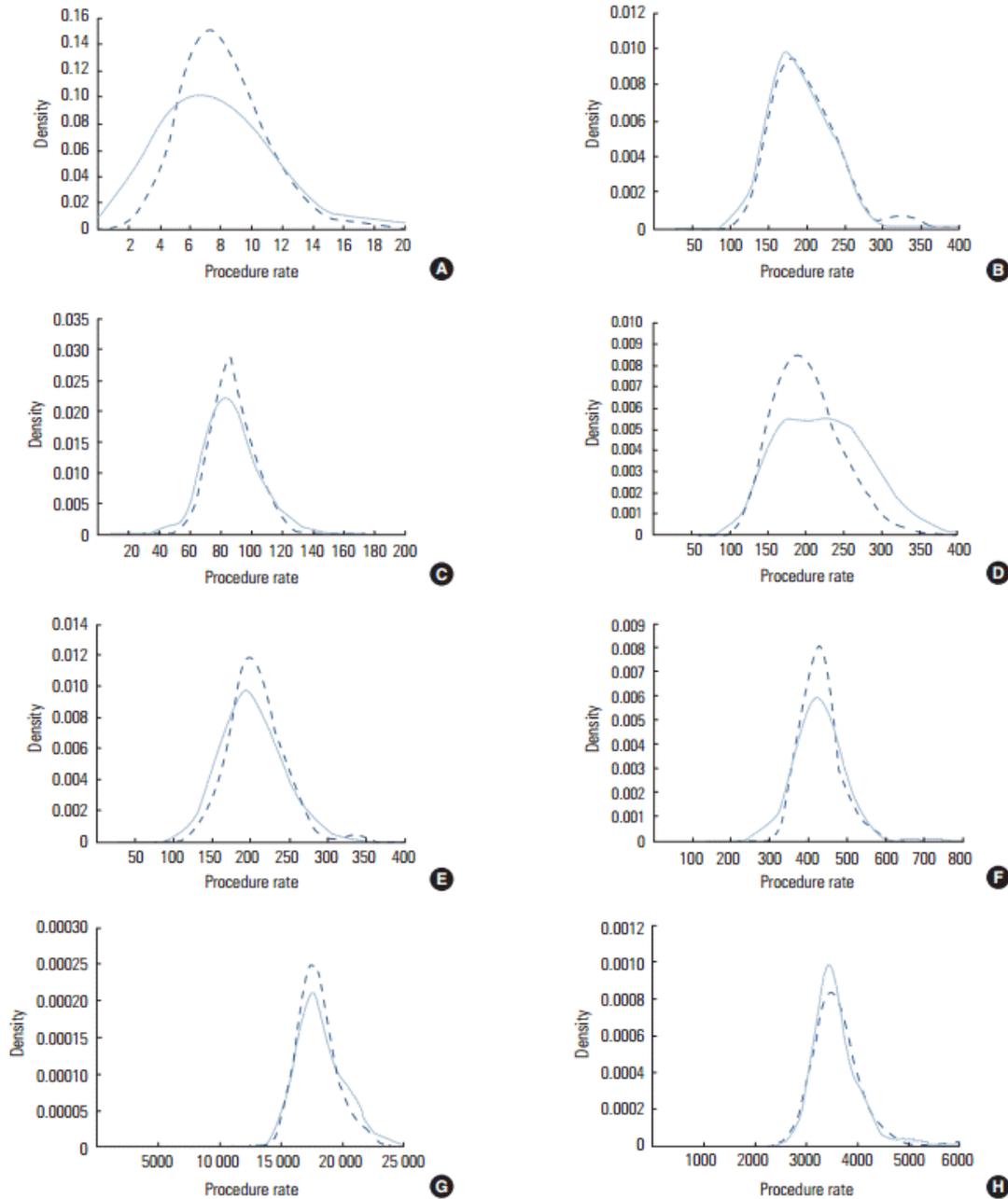
Source: Repirnted from Kim et al. J Prev Med Public Health 2016; 49(4): 233.
A: coronary artery bypass graft surgery, B: percutaneous transluminal coronary angioplasty, C: surgery after hip fracture, D: knee-replacement surgery, E: hysterectomy, F: caesarean section, G: computed tomography scan, and H: magnetic resonance image scan procedures in the administrative units (districts) and the new areal units. Solid lines represent the rate distribution

in the administrative units (districts) and dotted lines represent the rate distribution in the new areal units.

However, interestingly, the change of systemic component of variation, which was a measure to investigate true variation (variation across areas), was ambiguous between new areal units and administrative areas (Kim et al., 2016a). This result suggests that the new areal units concern the population size and the variation of population sizes among geographic units, but not the structure of population within a geographic unit (Kim, 2016). Developing areal units that accurately describe health care use and establishing the units as a basis for policy implementation remain work in progress in Korea.

Methodology

Measures of variation

Extremal Quotient (EQ)

The extremal quotient (EQ) is defined as the ratio of the highest geographic unit rate to the lowest geographic unit rate of interventions. The EQ is commonly used because of its ease of use and intuitiveness. Given that the EQ is prone to be affected by extreme values, ratio of the 90th percentile to the 10th percentile or ratio of the 95th percentile to the 5th percentile of the distribution can be used instead to lessen the impact of the extreme values.

Coefficient of Variation (CV)

The coefficient of variation (CV) is the ratio of the standard deviation to the mean of procedure rates in given geographic units. It measures the amount of variability. As the CV is unitless, it is insensitive to the scale and can be used to compare the data that have different units or different sizes of means.

Systematic Component of Variation (SCV)

The systematic component of variation is the estimate of systematic part of variation (variation across regions) which was separated from the random part of variation due to age and sex (variation within regions). Since proposed by Mcpherson et al. in 1982 (McPherson et al., 1982), the SCV was utilized in various research with some modifications (Murthy et al., 2003; OECD, 2014; Rodríguez-Martínez et al., 2013; Westerling, 1995). Figure 20 is the formula for the SCV presented by Mcpherson.

Figure 20.

Formula for the systematic component of variation (SCV)

$$SCV = \frac{1}{N}\left\{ \sum_{k=1}^{i} \frac{(O_i - Ei)^2}{E_i^2} - \sum_{k=1}^{i} \frac{1}{E_i} \right\}$$

Source: Adapted from Mcpherson et al. New England Journal of Medicine, 307.

Empirical Bayes Methods

Empirical Bayes methods are procedures for statistical inference in which the priori distribution is estimated from the data. There are two kinds of empirical Bayes methods: while parametric approach specifies a parametric family of prior distributions, the non-parametric approach leaves the prior completely unspecified (Casella, 1985). Empirical Bayes estimation is known to be useful in the context of Geographical Information Systems for Spatial Epidemiology, where large amounts of data are managed and the algorithms used must be rapid and not very computer-intensive (Gómez-Rubio et al., 2006). Empirical Bayes estimation has been used for analyzing geographic variation in procedure utilization (Gatsonis et al., 1993) as well as disease risk (Aylin et al., 1999; Bernardinelli et al., 1992),

Standardization

Variation studies involve comparing health care related rates (mortality, morbidity, and procedure utilization rates) among two or more populations. If populations differ in regard to characteristics that affect the rate that is to be investigated, a comparison of the crude rates would be misleading. Therefore, characteristics that could affect the rate under study should be considered before making comparisons. Standardization is a method to take the differences into consideration. If the rates are calculated based on the specific characteristic(s), they are called specific rates. Age and sex are two of the most common variables used for standardization (Naing, 2000).

Direct Standardization

Direct standardization is a method to calculate a rate according to a reference (standard) population. This method is used to remove the effect of the population structure on the rate when the rate of a population under study should be compared with the other population or the whole population in general (for example, a nation or a continent). In a direct standardization, the rate is calculated according to the reference population which is stratified according to the variables such as age and sex. For example, we calculate the rate in each group of variable stratified by the variables, and by applying the rate to the reference population, we recalculate the number of outcome. Using the newly calculated number of outcome and the reference population, we can calculate a standardized rate. The reference population varies according to the object of comparison. In case of a comparison within a country, the whole population of the country in a specific period is used. And the total sum of the populations of geographic units thatare to be compared can be used as a reference population.

Indirect Standardization

Indirect standardization produces a rate for the study population which would be expected if the disease experience of the study population were identical to that of a standard population (Lengerich, 2017). It is commonly used to study whether a certain population has a higher mortality than a similar population that is not engaged in the risk under study such as occupational exposure (Gordis, 2009). In an indirect standardization, the age-specific rates for a known population are applied to each age group in the population under study to calculate the expected number of outcome. And the expected number of outcome is compared with the observed number of outcome. Standardized mortality ratio (SMR) is a measure derived from the indirect standardization. SMR is defined as an observed number of deaths per year divided by an expected number of deaths per year.

Comorbidity risk adjustment

Comorbidity refers to any medical conditions existing in a patient who has the index disease under study. Comorbidity is associated with worse health outcomes, more complex management, and the increased health care costs (Valderas et al., 2009). If there are differences in the baseline health status between patients, mortality or other outcomes predicted on the basis of the currently available data would become less accurate. Therefore, such differences should be adjusted. Measuring comorbidity is an important method for risk adjustment. Several indices have been developed to classify comorbidities.

Charlson Comorbidity Index

The Charlson comorbidity index is a method of predicting mortality by classifying or weighting comorbid conditions which might alter the risk of mortality for use in longitudinal studies (Charlson et al., 1987). It was developed based on medical record review. In Charlson index, weights for 19 major comorbid conditions are assigned according to the number and seriousness of comorbidities. The weight is approximately equal to the one-year relative risk of death for that condition, and the index score, the sum of assigned weights, indicates a measure of the burden of the comorbid disease (D'hoore et al., 1993). Several variations of the Charlson comorbidity index including the Charlson/Deyo, Charlson/Romano, Charlson/Manitoba, and Charlson/D'hoore have been developed.

Table 3.

Weighted index of comorbidity

Assigned weights for diseases	Conditions
1	Myocardial infarct
	Congestive heart failure
	Peripheral vascular disease
	Dementia
	Chronic pulmonary disease
	Connective tissue disease
	Ulcer disease
	Mild liver disease
	Diabetes
2	Hemiplegia
	Moderate or several renal disease
	Diabetes with end organ damage
	Any tumor
	Leukemia
	Lymphoma
3	Modearte or severe liver disease
6	Metastatic solid tumor
	AIDS

Source: Reprinted from Charlson et al.,1987, Journal of Chronic Diseases, 40.

Elixhauser Comorbidity Index

The Elixhauser comorbidity index was developed in an attempt to make more comprehensive and accurate measures of comorbidity. The Elixhauser index extended the Charlson index by including additional comorbidities that were

found to be strongly associated with the outcomes (Li et al., 2010). It was made based on administrative datasets from a statewide California inpatient database. On the basis of 30 categories of comorbidities, the Elixhauser index attempted to predict hospital charges, length of stay, and in-hospital mortality (Elixhauser et al., 1998). Even though the performance of a given comorbidity measure depends on the patient group and the outcome, Elixhauser index proved a better predictor of the risk for mortality beyond 30 days hospitalization (Sharabiani et al., 2012), mortality in myocardial infarction cases (Southern et al., 2004), and survival in colorectal cancer cases (Lieffers et al., 2011).

Figure 21.

Number of diagnosis subgroups for which the comorbidities are positively or negatively related to: In-Hospital Mortality
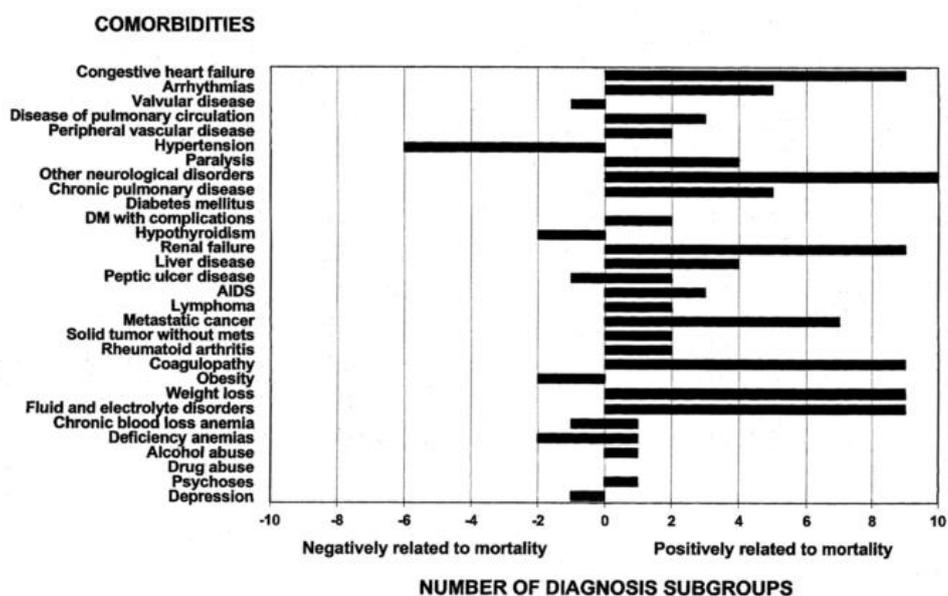
Source: Reprinted from Elixhauser et al., 1998, Medical care

Hierarchical Conditions Categories

Hierarchical Conditions Categories (HCC) was developed to risk adjust Medicare capitated payments on the basis of health expenditure risk of their enrollees by the Center for Medicare and Medicaid Services (CMS). It was intended to be used to pay insurance plans appropriately for their expected relative costs. Based on the individual's health conditions and demographic characteristics,

HCC assigns a risk factor score to the person with illness. HCC includes variable interactions, demographics such as age and gender, and indicator variables for Medicaid enrollment and disabled status. HCC can perform better than Charlson and Elixhauser index if information about the patient's diagnoses prior to the index hospitalization is available and used to code the risk adjusters (Li et al., 2010).

Causality

Analytical Methods

Difference in difference (DID)

Difference in difference (DID) is one of the most popular tools for applied research in economics to evaluate the effects of treatments of interest on some relevant outcome variable (Abadie, 2005). DID attempts to mimic an experimental research design using observational study data by studying the differential effect of a treatment on a "treatment group" versus a "control group" in a natural experiment. DID requires data measured from a treatment group and a control group at two or more different time periods (before treatment and after treatment). It calculates the effect of a treatment on an outcome by comparing the average change over time in the outcome variable for the treatment group, compared to the average change over time for the control group.

Regression Discontinuity (RD)

Regression discontinuity (RD) design was designed to be used in situations such as the foregoing, where exposure to an experimental treatment is determined by the subject's standing on a single, measured variable, and where the expected effects of the treatment are of much the same nature as would be produced by increasing magnitudes of that variable (Thistlethwaite et al., 1960). The experimental treatment should provide an additional elevation to the regression of dependent variables on the exposure determiner, providing a step-like discontinuity at the cutting score (Thistlethwaite et al., 1960). The RD design is used to evaluate causal effects of interventions, where assignment to

a treatment is determined at least partly by the value of an observed covariate lying on either side of a fixed threshold (Imbens et al., 2008). It can exploit exogenous characteristics of the intervention to elicit causal effects.

Time Series Analysis

A time series is a sequence of measurements of the same variable collected over time. It is a list of observations, each one being ordered by time. Most often, the measurements are made at regular time intervals (Romer, 2017). It is different from standard linear regression in that the data are not necessarily independent and not necessarily identically distributed. Time series analysis refers to methods for analyzing time series data with the object of extracting significant statistics and other characteristics of the data. Time series analysis is used for data compression, explanatory purposes (relationship with other variables), signal processing, and prediction (Davis, 2003). In the context of statistics, forecasting may be the primary purpose of time series analysis.

Propensity Score Matching

Propensity score matching (PSM) refers to a class of multivariate methods used in comparative studies to construct treated and matched control samples that have similar distributions on many covariates (Rubin et al., 2000). A propensity score is the conditional probability of assignment to a particular treatment given a vector of observed covariates (Rosenbaum et al., 1983). PSM is used to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predict the receiving of the treatment. It is the most developed and popular strategy for causal analysis in observational studies (Pearl, 2009).

Instrumental Variable

Instrumental variables (IV) methods are used to address the problems in ordinary least square regression, such as omitted variable bias, measurement error, and simultaneity or reverse causality (Waldinger, 2014). IV is a general way to obtain a consistent estimator of the unknown coefficients of the population regression function, when the regressor is correlated (endogenous) with an error term (Stock et al., 2003). It isolates the part of regressor that is uncorrelated (exogenous) with an error term. While the methods of adjusting

for confounding effects, such as stratification, matching, and multiple regression methods, can only adjust for observed confounders, IV, like propensity scores, can adjust both observed and unobserved confounding effects and make it possible to draw causal inferences from observational data (University of Manitoba).

Selecting topics

Acute Care Hospitalization

Acute care hospitalization is an important topic in geographic variation studies because of its dominance in health care expenditure and the availability of comprehensive hospital data. Acute hospitals are the largest component of health care expenditure, and hospital data are the most comprehensive, comparable, and commonly available (McGrail et al., 2016). In fact, the use of hospital, such as admission, readmission, and length of stay, has been a focus of geographic variation studies (Corallo et al., 2014).

Acute care services are usually connected with care provided by physicians that involves not only physician care, but also the use of pharmaceuticals and various kinds of care in community or in other facilities. Given the breadth and depth of involvement that acute care hospitalization has in health care, its variation should be approached with specified subjects.

McGrail and Lewis presented a framework for investigating variations in acute inpatient care (Figure 22) (McGrail et al., 2016). According to the framework, variation in the acute inpatient care can be investigated in four stages: Before Hospitalization, Hospital Capacity, During Hospitalization, and After Hospitalization.

Figure 22.

Sources of variation in use of acute inpatient care
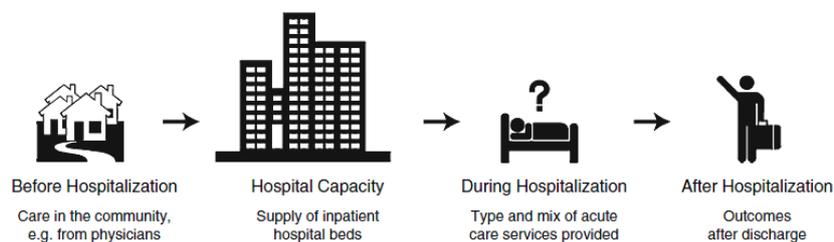
Source: Reprinted from McGrail et al. Medical Practice Variations 2016; 41-52

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Cancer

Cancer is among the leading causes of death worldwide, and its incidences have increased in most countries since 1990 (Global Burden of Disease Cancer, 2015). Cancer is the clinical condition which has been studied most extensively in geographic variation studies (Corallo et al., 2014). In terms of research topics, cancer is relevant to various subjects, such as cancer surgery, acute care, post discharge care, preference sensitive care concerning practice pattern, and end-of- life care.

Treatment of cancer often involves surgery. Surgeons play an active part in the process of cancer treatment by engaging the diagnosis and coordination of multidisciplinary treatment as well as surgery. Because surgery for cancer is provided by a wide variety of surgeons in various clinical settings, surgical decision-making is unlikely to be uniform (Richardson et al., 2016). Variation in surgical decision-making can be affected by time, geographic region, health-care system, surgeon/hospital characteristics, and patient groups, which have been the main topics of literature on geographic variation of cancer treatment. Future studies should focus on the variation in patient outcome.

Primary care

Primary care is a topic that relates to the fundamental issues in health care, such as access, quality, and outcome of care, which have been the main topics in geographic variation studies. The position and function of primary care affects the whole health care system. Primary care especially concerns effective care, which covers most basic and significant health care services including pediatric vaccination, screening for several prevalent cancers, and prescription of medications essential for disease prevention.

Primary care is important in health care for several reasons. Shackelton-Piccolo et al. (Shackelton-Piccolo et al., 2011) explained the reasons as follows:

- Primary care is the gateway to the health care system, crucially determining the course of many diseases, costs, and patient outcomes.

- It is where the vast majority of illness in society is presented and cared for.

- It may be the point of origin for the generation and amplification of many reported disease disparities.

  - It may also be the point of origin for ever-increasing costs of health care, given the suggestion that the most expensive piece of medical technology may be a physician's pen.

The literature about variation in primary care confirms that variation is evident at all levels and can be found all over the place (Westert et al., 1999). Variations in the average number of patient contacts with physicians (de Jong et al., 2003), number of follow-up contacts in a given condition (Wammes et al., 2013), physicians' adherence to guidelines (van den Berg et al., 2009), certainty of assessing a diagnosis (Shackelton-Piccolo et al., 2011), referral rates (Evans, 1990), and antibiotic prescription (Butler et al., 2009) have been investigated. In the future, factors that could affect physicians' behavior as well as the result of variation in terms of the outcome should be studied.

Elective surgery

Elective surgery could be defined as unplanned surgery as opposed to urgent or emergency surgery (Bernal-Delgado et al., 2016). Elective surgery is a topic that has been frequently dealt with in geographic variation studies due to its high incidence and its discretionary characteristics. Elective surgeries, as main subjects in geographic variation studies, can be broadly categorized into cancer-related (lung, mastectomy, prostatectomy), cardiovascular (CABG, Carotid endarterectomy), gastrointestinal (Colorectal), gynecological (Hysterectomy, Caesarea section), orthopedic, and (Spine, Fracture) ear-nose-throat surgery (Tonsillectomy) (Corallo et al., 2014).

According to Bernal-Delgado et al., when interpreting geographic variation in elective surgery rates, characteristics of the procedure should be considered (Bernal-Delgado et al., 2016).

1) When interpreting variation in effective care (e.g., colectomy in colorectal cancer), given no barriers to access, differences across areas will reflect differences in population illness.

2) When observing variation in services with an uncertain benefit-risk balance in the non-average patients (e.g., knee replacement, Percutaneous Coronary Intervention), underuse may be possible when barriers exist. Ability to pay, door-to-balloon time, economic gradient,

and ignorance about the relative benefits are the examples of barriers to access. Overuse is also likely to occur in the presence of volume incentives (e.g., fee for service).

3) When analyzing variation in low-value care (e.g., radical prostatectomy in low-risk prostate cancer), all rates are inappropriate since the category refers to both ineffective care and effective care used in inappropriate indications.

Variation in the utilization rates and outcome have been extensively investigated in the geographic variation studies of elective surgery. However, more profound investigations should be conducted concerning demand-side factors (preferences and their interaction with other demand factors, such as demographic factors or willingness to consume health care) and supply-side factors (organizational mechanisms linked to funding schemes or the territorial distribution of providers). In addition, system factors need to be studied in the future (Bernal-Delgado et al., 2016).

Spending, quality, and outcome

Unwarranted institutional variation in healthcare spending and quality may indicate discrepancies in the quantity of services provided, management efficiency, and staff capability at the hospital level (Otsubo et al., 2016). In addition, as revealed in Dartmouth Atlas, there is a weak connection between healthcare spending and its quality. Therefore, the variation of spending and quality should be carefully investigated not only because each subject is important on its own, but also because their variations can prove the fact that each subject has no serious relationship with each other and can help set the right amount of spending.

Variation in the payment system (Fee-For-Service Systems, Diagnosis-Related Group/Per-Admission Payment Systems, Diagnosis Procedure Combination/Per-Diem Payment Systems, Patient Case Mix) could affect variation in healthcare spending, utilization, and quality. In addition, hospital characteristics (Teaching Status, Ownership and for-Profit Status, Volume of Activity, Provider Prices, Quality, Geographical Location) could affect variation in healthcare spending (Otsubo et al., 2016).

The major paradigm of evaluating healthcare quality is the structure-process-outcome model developed by Avedis Donabedian (Donabedian, 1980; Donabedian, 1988; Otsubo et al., 2016). In this model, the "outcome" refers to

the effects of health care on the health status of patients and populations, and may be considered the most direct reflection of health care effectiveness and quality. Variation in quality of health care can be investigated in terms of the outcome variation. Variation in outcome measures such as mortality rates, readmissions, length of hospital stay, and patient satisfaction at discharge have been hitherto investigated. In fact, differences in practice style, resource availability, payment systems, and demographics turned out to be factors for variation in outcome.

Otsubo et al. presented a conceptual framework of variations in spending and quality (Figure 23) (Otsubo et al., 2016). The conceptual summary of the framework are as follows:

1) The extent of the observed variation is dependent on the quality of the data analyzed.

2) Patient case mix (patient demographics and disease severity), patient preferences, and environmental factors should be controlled.

3) Uneven resource availability, hospital management efficiency, medical practice variations, and iatrogenic complications could influence unwarranted variations.

The first step to reducing variations is to identify the variations accurately, including their causes. Once the variations and their factors are identified, policymakers and hospital medical staff would be able to decide if improvements are necessary and feasible and take appropriate measures to reduce variations accordingly.

Figure 19.

The conceptual framework of variations in spending and quality
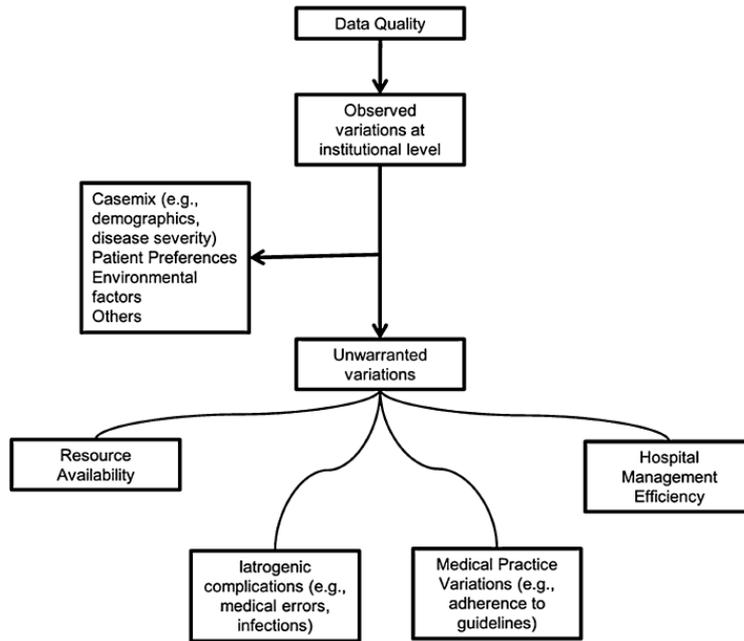
Reprinted from Otsubo et al. Medical Practice Variation 2016; 402.

Strategies to reduce geographic variation

Strategies to reduce geographic variation can be defined in three stages: Diagnosis, Guiding Policy, and Action Plans.

Diagnosis

Measuring geographic variation

The first step to correcting geographic variation is to measure accurately the difference in the amount of health care use among geographic units. An accurate measurement of geographic variation is not only important for determining the degree of variation, but also of considerable importance when it comes to raising public awareness of geographic variation. Concerning the former aspect of measurement, selecting appropriate geographic units and adjusting factors that could justly affect geographic variation is important. In terms of the latter aspect, public dissemination of information on geographic variation is important. Many countries report public information relating to the procedures and activities in the form of atlases of variation in health care.

Identifying factors

Identifying factors for geographic variation is essential for establishing appropriate measures to correct variation. The factors can be investigated in terms of supply, demand, and health care system. First, the supply factors include the amount of health care supply and suppliers as well as the behaviors of health care suppliers. Disproportionate distribution of health care resources, including health care personnel and hospitals, should be considered. Concerning the behaviors of health care suppliers, physicians' practice style or preference concerning patients' treatment is important. Second, demand factors are patient factors related to the cultural and social norms as well as patients' characteristics. Patients' preference for and trust of certain treatments, hospitals, or physicians and the degree that the preference is expressed depend

on the patients and the society where the patients live. Third, traits of a health care system, such as the payment system and resource distribution policies, can influence geographic variation.

Setting targets

Setting targets for geographic variation is related to determining the extent of acceptable variation and the factors that need to be corrected. Determining an acceptable level of variation concerns two issues: defining an optimum treatment and the desirable rate of its utilization. Variation cannot be regarded as unwarranted if there is no clear optimum treatment (McCulloch et al., 2013). For a treatment to be established as an optimum treatment, evidence of its effectiveness and cost-effectiveness is needed. In case of surgery, attempts to define criteria for general appropriateness of surgery have been made by a combination of reviews of the scientific literature and expert consensus (McCulloch et al., 2013). Concerning the factors that affect geographic variation, evidence of how much the variation is influenced by physicians, facilities, infrastructure, and patients characteristics is needed. Setting targets at the regional level can support public reporting and help meet public health objectives (OECD, 2014).

Guiding Policy

Clinical guidelines

If unwarrated variations persist in spite of the well-established evidence for optimum treatment, it may indicate a problem in knowledge translation. The development and monitoring of clinical guidelines is one of the main policy levers to disseminate clinical evidence and reduce unwarranted variations. In many countries, physician communities and health care authorities have made clinical guidelines in order to improve and harmonize clinical practices across regions (OECD, 2014). To improve compliance with guidelines, clinicians should be educated to recognize the value of guidelines. In the systematic aspect, use of guidelines should be incorporated as part of the mandatory process in treatment and incentives should be given to those who use guidelines and present the evidence of their effects.

Decision aids

Shared decision-making is a process in which clinicians and patients work together to select tests, treatments, management or support packages based on clinical evidence and the patient's informed preference. It involves the provision of evidence-based information about options, outcomes, and uncertainties, together with decision support counselling and a system for recording and implementing patients' informed preferences (Coulter et al., 2011). Decision aids are a tool that facilitates shared decision-making. Based on research evidence, they offer information to patients and help them to think about the significance of the different options. Compared to usual care across a wide variety of decision contexts, people exposed to decision aids feel more knowledgeable, better informed, and clearer about their values and risks, and they can have a more active role in decision-making (O'Connor et al., 2009). Decision aids have various forms including simple sheets outlining the choices, more detailed leaflets, computer program or interactive websites (Coulter et al., 2011).

Action Plans

Financial approaches

The financial approaches can be characterized in two ways: payment system and financial incentives. In the case of payment system, the mechanism of control depends on how health systems are operated. In fee-for-service systems, modification in fees can control variation. In systems where contracts and tariffs are negotiated with hospitals, the number of procedures per year paid for at the standard tariffs are negotiated with hospitals (McCulloch et al., 2013). Financial incentives and disincentives to discourage overuse of procedures can be used to reduce variations. The effect of financial incentives was shown in the case of caesarean section in some countries including England, France, and Korea (OECD, 2014).

Resource manipulation

Reallocation of resources (physician, spending, and equipment) could be a potential means to reduce variation. Increasing access to health care in rural or less developed areas can be done by direct and indirect ways. Increasing the number of health care facilities or physicians by offering with supportive policies would be direct ways to improve health care use in rural areas. And restriction on number of physicians, licensing and training programs would be an indirect way to improve access in rural areas by redistributing health care resources concentrated in certain areas.

Monitoring and feedback

Monitoring and feedback continues to be widely used as a means to improve physicians' practice and they were found to modify health care providers' behavior (Jamtvedt et al., 2006). Many countries have used a number of jurisdictions to monitor the procedure rate and investigate the performances, and the measures were proven effective (OECD, 2014). The monitoring and feedback do not necessarily have to be performed by governmental organization. Not only national organizations but also networks of researchers, patients, citizens, or patients can affect health care providers by monitoring and providing feedback on their performances.

Geographic Variation- Present and Future

Development of geographic variation studies can be divided into four stages (Figure 24). Geographic variation studies have evolved from describing variation to elucidating the causes of variation. Future direction of the study will be developing scientifically well-established theories and presenting remedies to variation.

Figure 24.

Stages of Development – Studies of Geographic Variation of Health Care

Exploratory studies
- Opportunistic
- Descriptive
- Atheoretical
- Cross-sectional
- Focus on utilization

Causal studies
- Development of inferential models
- Shift to cohort and longitudinal analyses
- Analyses include health outcomes, cost, and/or resource inputs

Established causal theories
- These may vary by clinical area and by health system.
- Causes are controversial because they are linked to accountability.

Developed remedies
- Linked to causal theories
- Establishes the value of studies (finally)
- Progress requires continued surveillance of outcomes

As long as there is a quest for optimum health care for a population, geographic variation will remain an important issue in health care policy and research. What matters the most in geographic variation study is making it work. Geographic variation studies should be a coordination of two values: integrity of the study and integration into the world.

Recommendations

In a short period of time, Colombia has achieved a well-developed health care system. Since the implementation of Law 100 in 1993, which mandated the compulsory health insurance, the insurance coverage in Colombia has increased from 23.5% of the population in 1993 to 96.6 % in 2014 (OECD, 2016), and the catastrophic health spending has been reduced with a decreased burden of out-of-pocket spending (Giedion et al., 2009). In addition, health indicators, such as life expectancy and infant mortality, showed rapid improvement.

However, compared with most developed countries, the health conditions of the population in Colombia have not attained the status that is satisfactory enough. Health parameters, such as mortality rate, infant mortality rate, and maternal mortality rate, despite recent decreases, are still much higher than in the developed countries (OECD, 2016). Furthermore, the recent improvements in health care in Colombia are not equally enjoyed among different socio-economic groups. This disparity is more pronounced compared with developed countries.

If the access and quality of health care does not improve equally among populations and regions, those who benefit less are likely to lag behind in maintaining and improving their health, and this could hinder the improvement of national health care outcome. Measuring geographic variation in health care can be an important tool, which diagnoses the disparity in health and the quality of health care among populations in Colombia.

How to measure geographic variation in Colombia

Geographic units

There are two kinds of geographic units that can be used for the analysis of geographic variation of health care. Administrative areas are convenient in terms of data manipulation, policymaking, and health care provision, while the areas that are organized for the pupose of analysis can be advantageous in measuring variation more accurately.

The selection of the geographic units is a compromise between practical application and methodological accuracy. Given the challenges in health care that Colombia faces, the possibility of practical application has more importance for Colombia at the moment. Being readily understandable to those who deal with health care policies and easily applicable to policy to make changes becomes a priority in the case of Colombia. In that respect, analysis of geographic variation in health care in Colombia should first be conducted based on administrative areas.

Figure 25.

Capital district and departments of Colombia
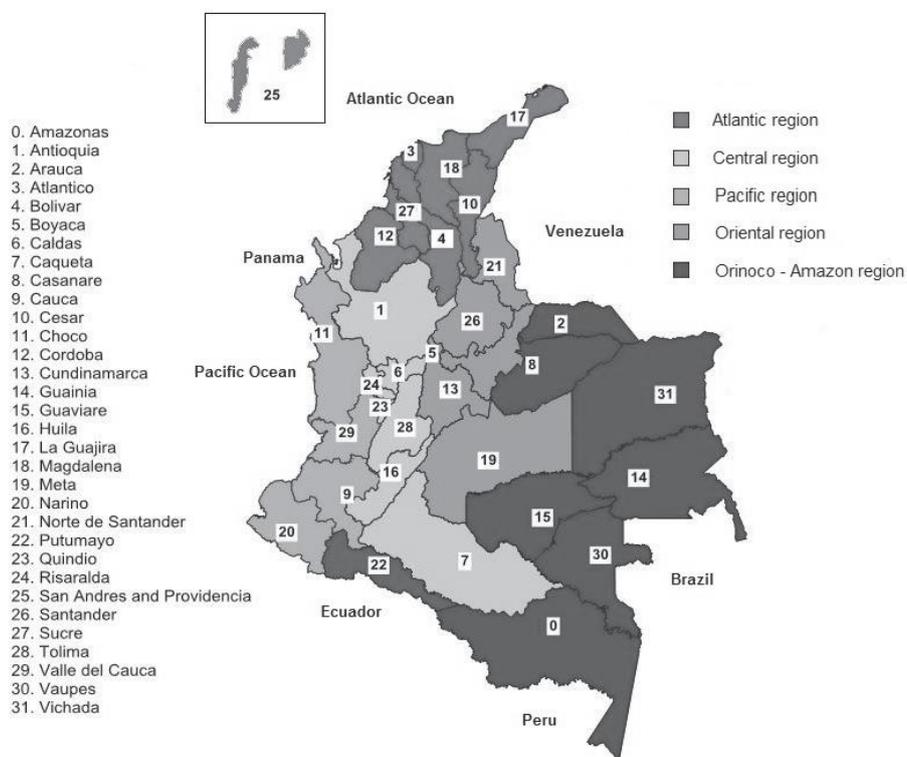
Source: OECD (2015) OECD Review of Agriculture Policies Colombia (OECD, 2015a)

Based on the units of department and municipalities (Figure 25), geographic units can be grouped or merged according to the characteristics of the area for the purpose of analysis. The grouping or merging of geographic units can be performed for various reasons, including reflection of actual health care use, reduction of disparity in the size of population, which can produce additional variations, and the scope of local governments. Compared with the OECD

member countries, the variation in the size of population, as represented in coefficient of variation, is not so prominent (Figure 26). This lessens the possibility that the analysis of geographic variation in Colombia is affected by the extra-variation caused by the variation in the size of population. Regarding smaller levels of administrative areas like municipalities, it is likely that a significant number of outcome variables are not obtained due to the small size of population. In that case, merging and grouping should be considered for the analysis of geographic variation.

Figure 26.

Average and coefficient of vartiation of number of population

Colombia and other countries
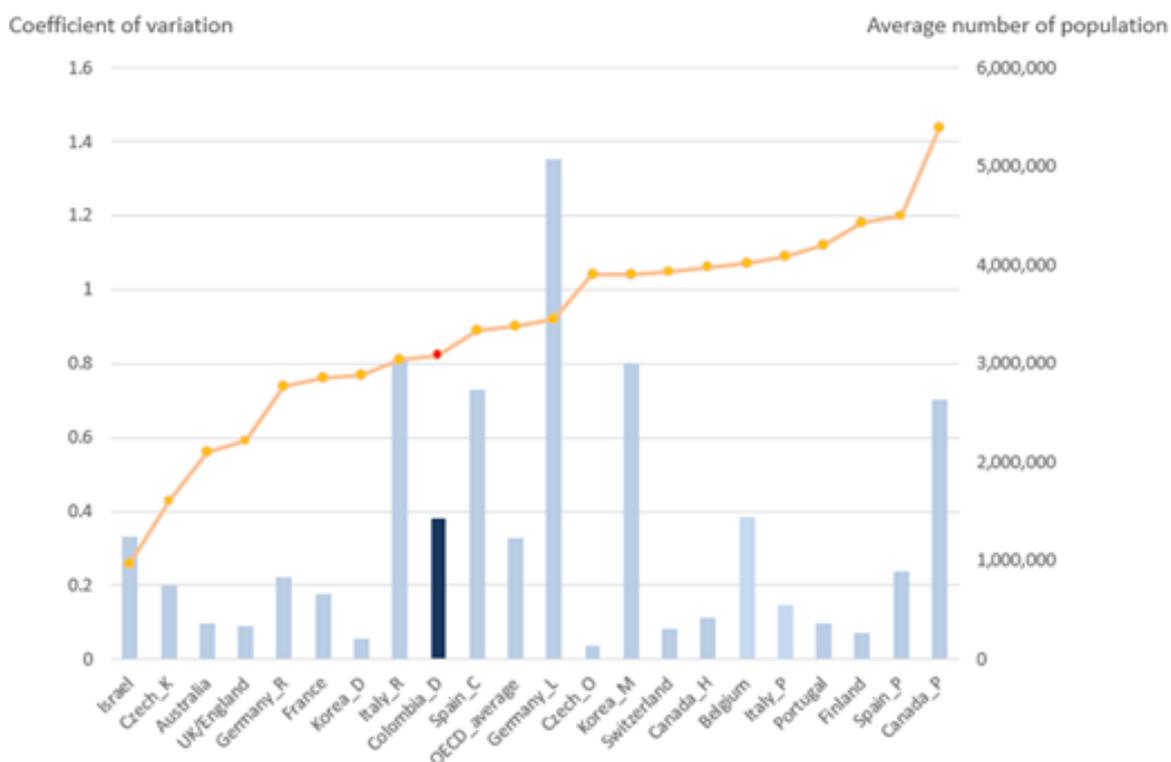
Source: Population of Colombia from Wikipedia (Wikipedia, 2017) and the population of other countries from Kim et al. J Prev Med Public Health 2016; 49(4): 233. The administrative areas of each country are marked with the first letter of name of the administrative area. E.G. – Colombia_D: Colombia_district

Displaced population

Colombia's internal armed conflict has continued for over 50 years, and this resulted in forced displacement. About 6.4 million people are in the displacement registry, and the number of internally displaced people in Colombia is among the highest in the world (OECD, 2015b). Internally displaced people are likely to be exposed to unhealthy living conditions and violence, and to suffer from the limited access to basic necessities, which puts their lives at risk (Carrillo, 2010). An estimated 30% of Colombia's internal refugees lack access to government-run health services (Webster, 2012c), which also suggests the lack of information about the health status and health care use of those populations.

In terms of geographic variation studies in Colombia, the displaced population require a special attention for the following reasons. First, their number is sizable enough to influence the regional and country-level health data. Second, their health status and access to health care are in poor condition, which could definitely prevent national improvement in health care. Third, due to lack of established location of residence and access to social services, their information is less likely to be acquired, which result in less reliable results and prevent setting up strategies for improving their conditions. Not only from the view of society but also from that of public health, displaced populations deserve special attention. Their existence should be included for consideration in the study of geographic variation in Colombia.

Selecting topics

Hospitalization

Despite its importance as a health care indicator, the statistics for hospitalization in Colombia are not well established. However, for the sake of well-being of the population and economic efficiency, the information on hospitalization concerning its frequency, length, and cost should be well prepared and analyzed in view of geographic variation. Indicators like use of hospital, such as admission, readmission, and length of stay, can be investigated (Corallo et al., 2014).

In terms of hospitalization, avoidable hospitalization is especially important in that it can be prevented and, thus, is related to cost-saving as well as prevention of deterioration of disease. The proportion of avoidable hospitalization in Colombia is higher at 21.7 % compared with other Latin American countries of which the average is 19.0% (Guanais et al., 2012). This indicator deserves special attention.

Cancer

Cancer is the second leading cause of death in Colombia (OECD, 2015b), and its rate is expected to increase. Cancer is an extensively studied issue in geographic variation study as it is related to topics like cancer surgery, acute care, post discharge care, preference sensitive care concerning practice patterns, and end-of-life care.

Given its significance concerning population health and potential cost, the prevalence, treatment including temporal and spacial appropriateness, and long-term management should be thoroughly studied. As its treatment is deeply affected by access to health care, the issue should also be studied in terms of geographic variation.

Primary care

Colombia has sought to establish a good primary care system and to integrate it into public health activities and intersectoral activities. However, the primary care system in Colombia is not performing well due to problems such as poor employment contacts, inefficient payment system and a lack of quality-related infrastructure (OECD, 2015b).

Despite efforts to measure the performance of primary care such as *Observatorio de Calidad,* improvements are required for those results to be used as a stable country-level indicator. In terms of primary care, geographic variation studies can be useful to estimate how the primary care system is established and is functioning. Measures concerning primary care workforce, outpatient visits, disease prevention activities, and chronic disease management should be studied.

Surgery

Surgery is a treatment modality encompassing most organs and diseases. In addition to its importance as a treatment, its characteristics, which require a team approach, technology and instruments, make the access to surgery distinctively different among different social strata. Therefore, access and affordability become important issues when it comes to surgery. As geographic variation in surgery is a less investigated area in Colombia, it should be thoroughly examined in terms of affordability and access as well as frequency and performance.

Spending, quality, and outcome

Spending on health care in Colombia has increased in recent years, and health insurance coverage reached 96% of the population. However, given the economic instability and high rate of unemployment and informal labor, cost containment is of paramount importance. In addition, pharmaceutical costs are skyrocketing and insurance fraud is rampant in Colombia (Webster, 2012a). This is another compelling reason for establishing a good database for geographic variation in health care spending in Colombia.

Quality and outcome are significant topics on their own as they are essential elements in health care. However, these parameters are also important in terms of spending and cost because all those measures are necessary components for measuring the efficiency of the health care system.

As establishing a sound health care system with financial stability is an important task in Colombia, financial supervision should be thoroughly performed. Geographic variation studies on spending in relation to quality and outcome would be a primary step toward supervising the health care system in Colombia.

Health issues related to violence

Violence is a major concrn in Colombia, and it is seriously affecting the health and health care of the Colombian people. Homicide rate in Colombia is at 28

per 100,000 inhabitants which is about seven times the OECD average (OECD, 2015b). Despite a recent decrease in the number of homicides in Colombia, it is still high and calls for close attention. Internal armed conflict in Colombia, which has lasted for half a century, involves widespread violence such as homicide, kidnapping, injuries and sexual violence across the country. Therefore, violence should be investigated in terms of geographic distribution.

Indicators in health care process

Geographic variation in health care should be measured in various aspects as a pathway to health care use with issues like access, utilization, quality, and outcome (Birkmeyer et al., 2013)(Figure 27). These approaches can help to reveal an inappropriate health care use: overuse and underuse.

Figure 27.

Identifying variation in the flow of health care
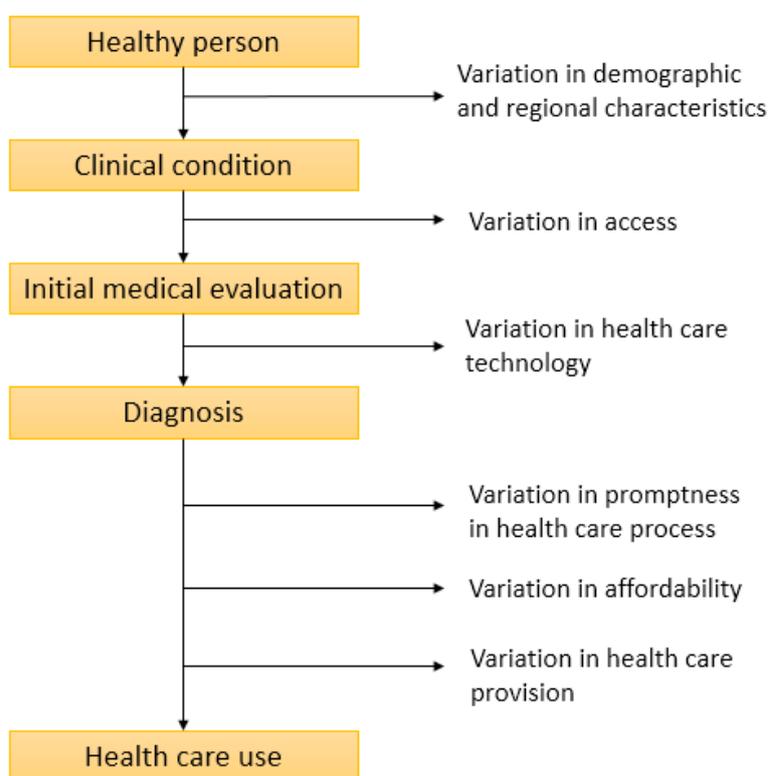
Source: Adapted and modified from Birkmeyer et al. Lancet 2013; 382 (9898):1125.
.

Parameters that should be examined are described below and Table 4 is an example of how to define and measure a variable in describing geographic variation in health care.

Demographic characteristics and disease prevalence: Without well-organized data about demographic characteristics and disease profile of the population, it is impossible to obtain reliable information about geographic variation in Colombia.

Access: Percentage of insured population, insurance coverage, time of visit to clinic

Resources: Number of hospitals, number of clinics, number of physicians, number of health care workers

Health care spending: Total health care spending, public spending for health care, out-of-pocket spending

Health care utilization: Admission rate , number of outpatient visits, surgery rates (general surgery, cardiac procedure, joint procedures and gynecologic procedures), rate of childhood vaccination, length of stay

Health care productivity: Outpatient cancellation rates, outpatient new to follow up ratios

Health care outcome: Mortality rate, infant mortality rate, maternal mortality rate, standardized mortality ratio

Table 4.

Example of definition of variable – Hospital admission

Description	Hospital admission for a minimum one night inpatient stay. Hospitals are defined to be general or specialised hospitals (HP.1.1. and HP.1.3 in the System of Health ccounts)admission
Rules	All medical discharges
Exclusion	Day care is not included. Exclude surgical discharges.
Units to be used for rates	Per 100 000 population
Age group	15-34, 35-44, 45-54,55-64,65-74,75+ OR five-year age groups
Resource use	Density of hospital beds by territorial unit

Source: OECD (2014) OECD Health Policy Studies Geographic Variations in Health Care

Reducing variation - Way to achieve health for all

Health care in Colombia is still facds many challenges. Further improvement in health conditions, securing access to care for the whole population, and solving problems related to health care cost and finance remains to be achieved. Inequity is an issue that permeates all facets of the health care system in Colombia (Figure.27). It is a serious concern, which could put the health care system of Colombia in jeopardy (Webster, 2012b).

Measuring geographic variation in the health care system is an essential step to correcting the inequalities in health care in Colombia. Regional boundaries mean more than geographic division; they can signify the boundaries of wealth, resources, and finally, life. Measursing geographic variation in health care would not only describe the disparities among the regions, but also would reveal factors that have hitherto been undisclosed. Further efforts to correct geographc variation can be made based on scientific measurements. The efforts would contribute to reduction in inequalities concerning the right to maintain one's own health.

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Part II. Utilization of Health Atlases as a Policy Tool

Introduction

One of the important societal objectives of health policy is to promote "equal access to safe and effective health care for equal need" (Schang et al., 2014), so it should be consistently and thoroughly monitored and evaluated to achieve the policy objectives. Since 1954, when John Snow used health maps to describe the cholera outbreak in London and indicate ethe source of the epidemics, health atlases have been used as a useful policy tool that visualizes and accumulates evidence of a healthcare system's performance.

Among several definitions of a health atlas, Ramos Herrera adefines it as "a collection of maps related to health conditions, with a unique method to analyze data and describe the magnitude of health problems, identify their relationships with social situations, determine conditioning factors, and support decision making from health authorities, government, non-government organizations, and the community" (Ramos Herrera, 2016, p.2).

Such definition underlines critical characteristics of a health atlas in the following 5 aspects (Ramos Herrera, 2016).

1) A series of maps about health conditions
2) Describe the health-related practices geographically
3) Analyze data and describe the magnitude of health problems
4) Identify the correlation between social, environmental and cultural conditioning factor and determine conditioning factors
5) Support decision-making of policy stakeholders.

First, a health atlas is a collection of maps that visually exhibit health conditions in geographic areas. Maps are a useful policy tool as they provide visual information demonstrating the levels of variation that exist between the geographic areas (see Figure 28). Especially, maps are a tool for "visualization" of evidence that enforces the "aspect of human ability to develop mental image" (Denil, 2006, p.12). Maps are such tools to facilitate and augment the human ability, so humans can go through the visual and cognitive processes to almost automatically focus on the patterns depicted (Denil, 2006).

Via a health atlas, information on variations in health conditions as well as health care resources and practices can be presented and compared across regions. By providing such information visually, a health atlas allows researchers and policy makers to explore, confirm, synthesize, and preasent data more effectively. In doing so, various methods are used to analyze the

data and describe the magnitude of problems that are related to health and healthcare services.

Figure 28.
The role of maps as a tool in a geographic research sequence
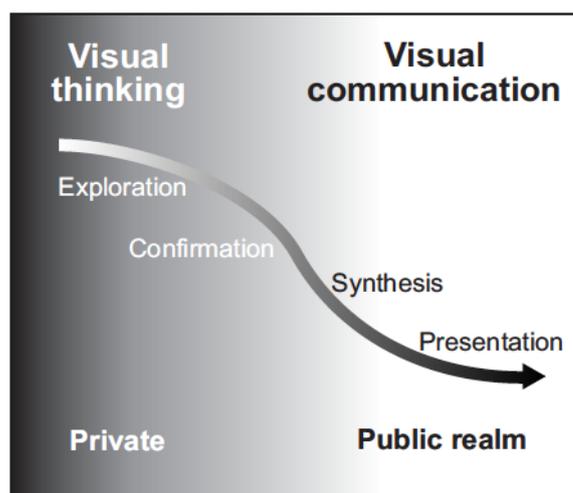
Source: Reprinted from Van Elzakker, C. P. (2004).

Next, a health atlas describes geographical variations in health problems and medical practices so that researchers and policy makers can describe and analyze the magnitude of the variations. Not only for equity reasons but also for safety and quality issues, healthcare practices are expected to be similar across regions, if not identical, if there are no warranted reasons for them to vary. It should not be allowed that patients receive a different amount, type, or quality of medical service or they receive a different quality and quantity of preventative care depending on their location, hospital, or health professionals they consult with.

In addition, by providing geographically comparative information not only on health problems and practices, but also on various environmental factors, a health atlas helps researchers and policy makers to identify potential correlations between social, environmental and cultural conditioning factors. By presenting geographic variations not only on health problems, disease prevalence, and medical practices but also on environmental factors and patient preferences, a health atlas can provide information on whether such variations in medical practices are "warranted", meaning that such variations in practices correspond with variation in health conditions, concerns or problems in the

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geographical area. Such concerns arise as accessibility, safety, and quality of health care should not vary unless there are warranted reasons.

Lastly, linking potential causal factors for health problems with environmental factors as well as medical practices can help researchers and policy makers with evidence-based policy decision making. In making decisions on allocation of resources for healthcare services, decision makers can utilize information and knowledge that are obtained from analysis and interpretation of the health atlas data, which will then ensure decision-making that is more accountable to the stakeholders including the public and patients both at the national and local level.

Background

Evidence-based decision-making

In the era of responsible governance, evidence-based decision making, which is "an approach to policy decisions that aims to ensure that decision making is well-informed by the best available evidence" (Oxaman et al., 2016, p.S1), is becoming a mandate for policy makers. Evidence-based approach has become easier with several recent changes in the policy environment, such as improvement in technologies, which allows more rigorous data collection, easier access to data files, a more advanced ability to analyze the data, and enhanced methods to measure performance.

While evidence-based decision making is not a new concept, it is known to have gained its prominence again with the Blair government's emphasis on moving the policy making approach from a *political and ideological* one to a *logical and rational* one (Sutcliffe and Court, 2005). Evidence-based decision making practices are acclaimed as a significant contributor to better decision-making, as the practices have moved the focus of decision making from "a discourse of power to a discourse of reason" (South African policy-maker, quoted in Paine-Cronin and Sadan, 2015, p.14). The practices emphasize "what works," more specifically, "what policy interventions have worked in the past, where, for whom, how and why, and what is the likelihood that they will work in future." (Ramos Herrera et al., 2016, p.12). The approach promotes a more rational, rigorous and systematic approach to decision-making, based on rigorous

research methodologies such as randomized control trials (RCTs) or statistically solid analytic models to produce reliable and valid data. With the mandate of evidence-based decision-making, governments are now demanded to "produce policies that really deal with problems; that are forward looking and shaped by the evidence rather than a response to short-term pressures; that tackle causes not symptoms" (White Paper: Modernising the Government, 1999).

Evidence-based policy decision making are expected to have the following benefits (Pew-MacArthur Results First Initiative, 2014).

1) *Efficiency*: With evidence on the program performance, policymakers can identify and eliminate programs that are not efficient and reallocate resources to an area where the outcome can be produced more effectively and efficiently.
2) *Innovation*: New and innovative programs and practices can be scaled up and funded based on the evidence of successful outcomes in small-scale trials. Scienfitically designed RCTs and rigorous statistical analysis of the findings from the trials can ellicit new ideas.
3) *Accountability*: Presentation of data on performance indicators throughout the process of policy implementation can require the government agencies to be more accountable for results.

Box 1.

Why do we need evidence-based decision-making practices?

• Understand the policy environment and how it's changing.

• Appraise the likely effects of policy changes so we can choose between different policy options and subsequently assess their impacts.

• Demonstrate the links between the strategic direction, intended outcomes and policy objectives to show that there are clear lines of argument and evidence between what we are aiming for and what we are doing now.

• Determine what we need to do to meet our strategic goals or intermediate objectives.

• Influence others so that they help us achieve our policy goals and take them through to delivery.

• Communicate the quality (breadth and depth) of our evidence base

to meet the open government agenda.

As shown in Box 1, evidence-based decision-making practices, such as making health policy decisions based on findings from a health atlas can 1) promote a better understanding of the health policy environment, distribution of health problems and medical practices in particular areas, the trends of the changes over time, and practices and resources to address those problems, and 2) allow policy makers to see the potential correlation between future policy plans and intended outcomes so that they can choose more effective and relevant policy options, and transparently communicate the expected outcomes before implementation and resulting performance after monitoring and evaluation of policy implementation.

Figure 29.

The policy cycle
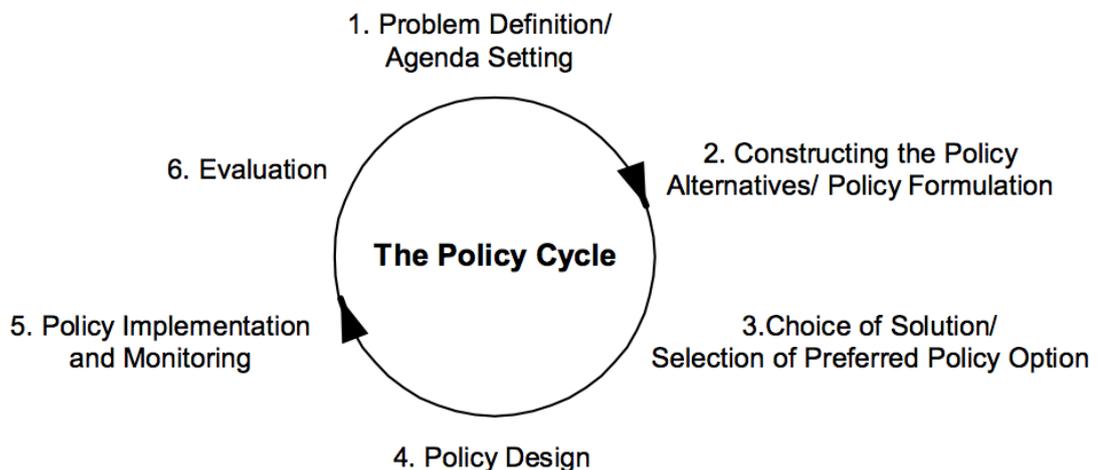
Source: ODI, 2005, Young and Quinn (2002)

There are a few issues related to evidence-based decision-making (ODI, 2005). First, selection of evidence is a critical matter, as the quality, credibility, relevance to the evidence are crucial factors for heightened accountability of

policy decisions. Second, how and when to utilize the evidence is also important. Most policy-making processes are not a linear and logical process, but rather a cyclic and chaotic process (Figure 29). Therefore, when and how to introduce evidence along the complex policy decision-making cycle is not a trivial nor an easy matter. Information on a health atlas can be utilized before, during, and after policy decisions being made and implemented. As suggested in Table 5, issues regarding utilization of evidence differ depending on the steps of a policy cycle.

Table 5.

Components of policy process and different evidence issues

Policy Process Steps	Descriptions	Different evidence issues
Set the Agenda	Issue awareness and riority	- Identifying new problems - Building up evidence on the problem magnitude for policy actors - Way of communicating evidence as well as the credibility of evidence is critical
Formulate	Two policy formulation process - Policy options determination - Preferred option selection (see Young and Quinn, 2002:13-14)	- Policymakers are sure to understand the specific situation and different options in as detailed and comprehensive a manner as possible. - Coupled with the link between the expected cost and intervention impact, correlation between an activity and the outcome is to be included. - Both quantity and credibility of evidence are significant.
Implement	Actual practical activities	- Focus on operational evidence to improve the effectiveness of initiatives Both systematic learning and analytic work can be inclusive. - Action research and pilot project can be considered - The evidence should carry practical relevance across different contexts.
Evaluate	The process and impact (or intervention) monitoring and assessment	- Monitoring mechanisms should be developed first. - In order to determine the effectiveness of an implemented policy and provide the basis for future decision-making, a comprehensive evaluation procedure is crucial (Young and Quinn, 2002). - For monitoring and evaluation process, the evidence should be objective, thorough and relevant. Also, it is important that the evidence should be communicated into the existing

		policy process.

Source: ODI, 2005, Adapted from Pollard and Court (2005)

Thirdly, policy decisions are never made in a strictly controlled environment as would most scientific experiments. They are bounded by a highly complicated political, social and economic environment factors. In addition, policymakers' individual characteristics, such as their experience, expertise and personality, and the institutional capacity of the organization in charge of policy decisions can become critical constraints. These environmental factors can affect the choice, use, and evaluation of the evidence used for decision-making.

Box 2 presents quotations on the objectives and potential use of a health atlas for evidence-based decision-making.

Box 2.

Quotations on the objectives and potential use of a health atlas for evidence-based decision-making.

**Quotations on the objectives of a health altas
(National Health Services (NHS) Right Care)**

"We hope this collaboration of work between Public Health England (PHE), National Health Services (NHS) Right Care and NHS England will encourage commissioners, service providers and clinicians to engage with this tool and ensure resources are being used effectively, and that outcomes improve." (John Newton, Chief Knowledge Office at PHE)

"This Atlas exposes some inconvenient truths about the extent of clinical practice variation in care for some common conditions. The good news is that at a time of financial pressure across the health service, hospitals, GPs and mental health providers have substantial opportunities to unleash greater value from their existing NHS budgets."
(Professor Sir Bruce Keogh, National Medical Director of NHS England)

"The first step in tackling unfair variation in health services is to identify where the problems are. This Atlas is a key tool in enabling us all to do this. Our challenge now is to consider how we can better understand and tackle the

underlying causes. This is not a straightforward task, but exploring the data that lies behind these variations will be an important starting point." (Chief Medical Officer, Professor Dame Sally Davies)

Using a health atlas for evidence-based decision-making

A health atlas can be also used as a monitoring and evaluation tool from a population perspective*,* especially when routinely available data are published. Information gained from routine monitoring and evaluation activities from the population perspective is useful for making decisions for future investment and activity plans, not just to those who happened to contact a particular service at a certain point of time, but to the whole population within a geographical area.

It is also useful for developing and adopting logical models of health services such as which activities, outputs, and outcomes are useful to monitor and provide feedback to improve performance. Such information can be critical for fulfilling the two objectives of monitoring and evaluation, namely to promote *accountability* (to check and be responsible for attainment of policy goals) and *learning* (to gain knowledge on which programs and activities are effective in producing desired outcomes).

As a recent example of a health atlas that provides routinely available data, the NHS of UK produced a routine collection of Health Atlases between 2010 and 2015, launched by the Quality, Innovation, Productivity and Prevention (QIPP) program. Since the NHS Atlas published 34 maps of variation in November 2010, NHS Atlas has continuously provided information on trends of geographical variation and become a guideline for policies to reduce unwarranted variation in the provision, uptake, outcome, and cost of health care. They can be a key resource to identify any excess in the system and catalyse the decision to release those resources for higher-value interventions.

As health data have become an important asset of many governments and institutions in recent years (Ramos Herrera et al., 2014), health atlases are now used to provide information on geographical trends of health problems, health resources, and medical practices, which allows decision-makers to make future plans for the health system.

Why is it important to learn about geographical variation of health problems and practices? First of all, medical practice variations cannot solely be explained by differences in demographic and illness profiles of regional populations. Information on the geographical variation facilitates identifying so-called 'unwarranted' variations. Unwarranted variations are a portion of variation that cannot be explained on the basis of variation of disease, patient preference, or medical science across geographical areas (Wennberg, 2014), but can be explained by differences in health system performance (Goodman, 2012). Evidence of such unwarranted variation can challenge the core societal

objective of the health system to provide equal access to safe and effective heaalthcare for equal needs. Then, it is important to identify a number of geographic and clinical areas where marked variation in practice is occurring so as to improve decisions on healthcare resource allocation.

Utilization of atlas data can help policymakers to reduce unwarranted variation by promoting appropriate management to produce better, more scientific and evidence-based healthcare policies for stakeholders. Figure 30 shows how a health atlas can influence policymakers' decisions, thus leading to appropriate policy changes to reduce unwarranted variation in health problems and practices.

For example, publishing a health atlas and disseminating information about "unwarranted variation" across geographical areas can help health providers, hospitals, and professional organizations to reconsider their pre-existing assumptions, be informed and motivated to make clinical improvement, and challenge current practices. At the same time, the media can deliver messages to the public and engage audiences, placing the unwarranted variation high on the policy agenda and facilitating discussions for change. Based on the information provided in the health atlas, policy community, the state and federal government can provide models for monitoring and evaluation and provide appropriate feedback to stakeholders in the health system. Academics can utilize the information from health atlas to encourage and support clinical and policy research.

Figure 30.

Dartmouth Atlas Theory of Change
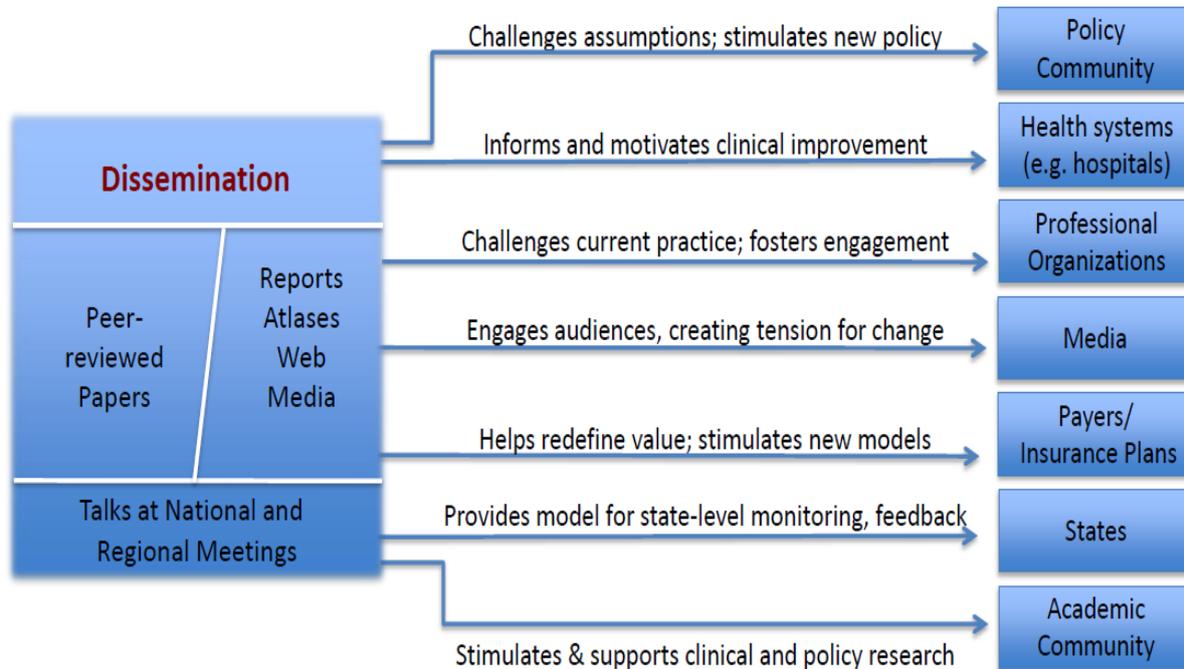
Source: Goodman. (2012). From Theory to Health Care improvement: The Dartmouth Atlas of Health Care.

Using health atlases as a "tin-opener" or "dial"

Depending on the purpose of a health atlas, it can play different roles. Regarding the role of a health atlas, Carter et al (1995)'s clssification of data (performance indicators) can be an interesting reference, especially in directing the strategical direction of a health atlas. Carter et al. (1995) classifies the role of indicators into two categories: a "dial" and a "tin-opener".

A "dial" operates prescriptively with a clear understanding of what good and bad performance entails and precisely measures the input, output, and outcome. In contrast, a "tin-opener" descriptively measures and shows performance, and in doing so, it can ignite policy discussions and raise the issue to the policy agenda. As it simply describes the phenomenon and raises questions, it can only provide an incomplete and inaccurate picture of performance by itself.

Implicit in the use of a health atlas as a "dial" is the assumption that standards of performance are unambiguous; implicit in the use of performance indicators as a "tin-opener" is the assumption that performance is a contestable notion

(Carter et al., 1995). In health atlas data, it is not always easy to precisely define an optimal performance level or to compare with other best cases even if it observes substantial geographical variations (Schang et al., 2014). Therefore, performance indicators in the public sector tend to be used as a "tin-opener" rather than a "dial".

For example, a recent study of Schang et al. (2014) on health atlases showed the utilization of a health atlas as a tin-opner. About fifty percent (twenty five out of fifty three) of staff members of local payers in England, who are responsible for strategic planning, procuring services, monitoring and evaluation to support patient choice, manage performance, and seek public and patient views, reported that they did not use a health atlas in policy decision-making because they were not aware of it, perceived themselves to be lacking the right capacity to analyze it, or did not see the information applicable for decision-making (Figure 31). This result suggests that a health atlas often serves as a tin-opener rather than a dial.

At least about half of the respondents paid attention to the NHS Atlas, were aware of, accepted, perceived it to be applicable, planned to use, and ultimately used it in some forms. Nevertheless, while many used the NHS Atlas as a prompt to understand the variations and used it as a visual tool for communication with clinicians, it seems that significantly more efforts are required to move beyond the tin-opener stage and use the information to facilitate decision-making, implement policies to reallocate resources and induce behavioral changes, monitor and evaluate the performance.

Figure 31.

Survey responses to the NHS Atlas (n = 53 PCTs)
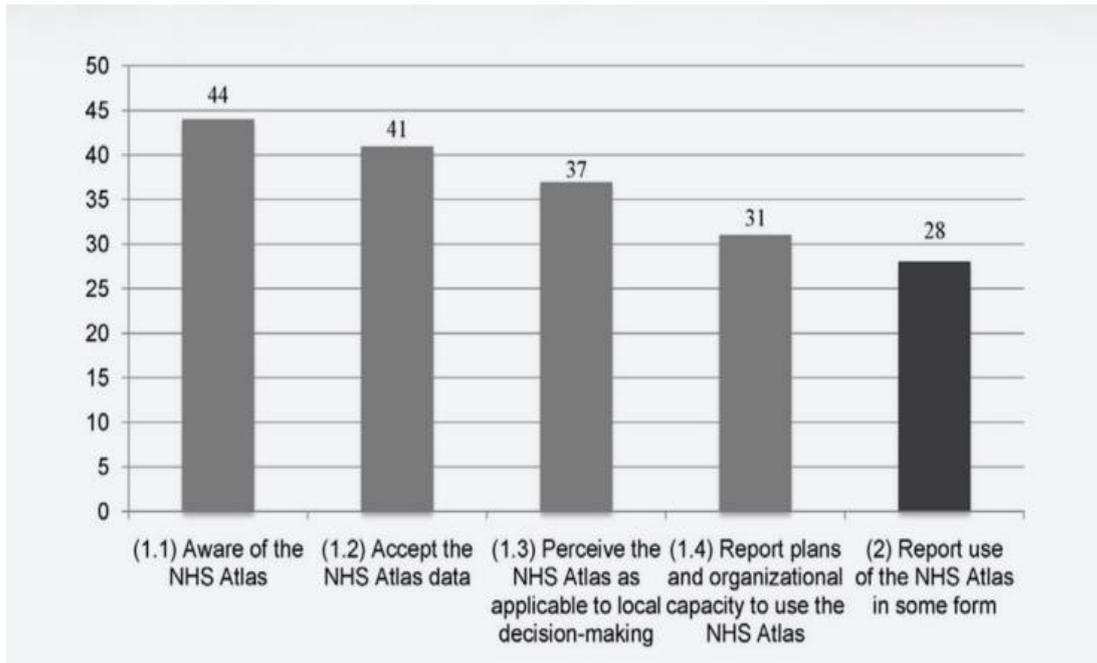
Source: Schang, et al., 2014.

Systematic Review of Health Atlas Studies

Review of Journal Articles

Objective of the study

Starting from the Dartmouth Atlas of Health Care, many health authorities have developed atlases since 1996 and a large volume of research on health atlas has been published since then. However, there have been no studies that offer critical reviews of and synthesize the previous academic research, especially from a performance management perspective to consider health atlases as a policy tool.

In this report, we attempt to systematically review and qualitatively synthesize the literature on health atlases. For the purpose of this paper, we reviewed research articles that used health atlas data. We sought to understand research trends regarding health atlases and isdentify their role as a performance

indicator. In addition, we synthesized the results of our review to suggest the future direction of the study on health atlases.

Methods

For our review, a review protocol was developed and updates were documented when necessary.

Search strategy

We searched for all types of articles in three scientific databases using groups of keywords combining three collective terms: (a) health, (b) variation, and (c) atlas. Appendix A provides the search terms for the review. The databases used are PubMed, Web of Science, and EBSCO. The search was conducted in September 2016 and updated in October 2016. Our aim was to give an overview of the research from the last 20 years. This timeframe enables a comprehensive evaluation of the current state of health atlas research. Additionally, we excluded articles published before 1996 as the Dartmouth Atlas of Health Care was first published in 1996.

In addition to searching the literature databases, we also checked the references of the relevant studies and searched the Darhmoth Atlas of Health Care, NHS Right Care Atlas, and Google scholar for grey literature and unpublished reports. Through this process, we identified 10 additional records, including reports and reviewed articles. Appendix B provides the bibliographic information of all search results derived from the databases and of all the studies identified via references and citations.

Selection of studies

The initial search on PubMed, Web of Science, and EBSCO yielded 13,466 articles (2,740 articles from Pubmed, 8,653 from Web of Science, and 2,073 from EBSCO respectively), from which 2,705 duplicates were excluded. Among the 10,761 articles that were left, we then utilized Endnote, which is a commercial reference management software, to select relevant articles. After abstract and keyword search in Endnote, three reviewers (MK, JC, and HK) independently screened titles and abstracts for inclusion, then reviewed the full-text articles using standardized inclusive criteria.

Studies that fulfill the following criteria were included in the final review: (a) the study appears in the English language in a health sector peer-reviewed journal published after 1 January, 1996; (b) full-text is available; (c) the study includes the words, "map or atlas" and "geographic variation or geographic variance", in its title, abstract, or keyword; (d) the study includes 'atlas of variation in health care' issues in its title; and (e) the study includes 'geographical variation' issues in its abstract.

After combing all search results from the databases, and eliminating duplicates, abstract/keyword search among 10,761 articles was done automatically via Endnote by adjusting search settings. 10,514 articles were excluded during this first abstract/keyword screening via Endnote. 247 articles were yielded through the first step. For the second step, two reviewers manually screened the title and abstract of each study, and excluded all thematically irrelevant studies according to the inclusion criteria. 194 articles were excluded through this process and 48 articles were subjected to full-text qualitative synthesis. The details of the search and exclusion process are presented in Figure 32.

The first reviewer assessed the full-text of the articles according to the inclusion criteria. The second reviewer double-checked the inclusion choices by reviewing the abstracts. Disagreements were settled in discussions among all three reviewers.

Figure 32

Flow diagram of the process including reviewed studies

[Identification]

Pubmed	Web of Science	EBSCO
(n=2,740)	(n=8,653)	(n=2,073)

13,466 entries in original database

Excluded 2,705 duplicates

[Screening]

10,761 records

Excluded 10,514 non-relevant studies via EndNote keyword screening

247 potential studies

Excluded 194 non-relevant studies by screening titles/abstracts

[Eligibility]

53 studies eligible for full-text analysis

```
                                    ┌─────────────────────────┐
                                    │ 5 studies did not       │
                                    │ meet          the       │
                                    │ inclusion criteria      │
                                    └─────────────────────────┘
                                    ┌─────────────────────────┐
**[Included]**                      │ Studies     included    │
                                    │ in    the    review     │
                                    │ (n=48)                  │
                                    └─────────────────────────┘
```
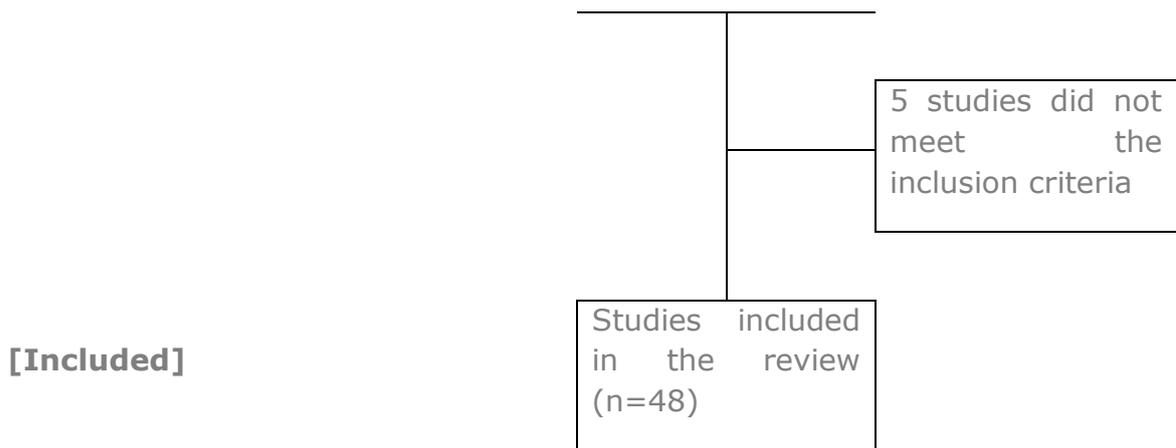
Analytic strategy

Two reviewers (JC and HK) created a standardized form to synthesize included studies and used thematic analysis methods[1] to conduct coding on each article. The initial round of coding was done under the criteria as presented in Table 6. The coding criteria were intentionally set broad in order to capture general aspects and trends of health variation presented in the articles. The criteria were developed to identify the range of study, dimension of variation, and value perspective on health care. "Criteria 4: Function as Policy Tool" was developed to classify the function of the articles as a policy tool based on reviewers' evaluation. Criteria were revised through discussion when necessary.

Table 6.

Analytic Framework

Criteria 1	Criteria 2	Criteria 3	Criteria 4
Range of Studies	**Dimension of Variation**	**Value Perspectives**	**Function as Policy Tool**
Variation	Access	Equity	Tin-opener
Cause	Resource	Quality	Dial

---

[1]   https://www.psych.auckland.ac.nz/en/about/our-research/research-groups/thematic-analysis/about-thematic-analysis.html

Research setting	Treatment	Satisfaction	-
-	Disease/ health outcome	Efficiency	-

The reviewers used an open coding mechanism in order to systematically review and synthesize findings of the included studies. Two reviewers analyzed full-text articles and applied the coding criteria manually. Table 7 presents the definition of criteria used in the analyses.

Table 7.

Definitions of Criteria

Criteria 1	Range of studies
Variation	The article includes health variation issues. 0 is no. 1 is yes. Articles classified as 1 was sub-categorized as below: 11: variaion within region 12: variaion within country 13: variaion among countries 14: others
Cause	The article explores cause of variation. 0 is no. 1 is yes. Articles classified as 1 was sub-categorized as below: 11: correlation 12: causation
Research setting	Identify the research setting of the article 0 is a developing country[2]. 1 is an advanced country.
Criteria 2	**Dimensions of variation**
Access	Variations in physical access to health services or facilities was identified in the article. 0 is no. 1 is yes.
Resource	Variations in resource were identified in the article. 0 is no. 1 is yes. Articles classified as 1 was sub-categorized as below: 11: human resources 12: physical resources 13: financial resources 14: social/cultural resources 15: environmental resources 16: others
Treatment	Variations in treatment was identified in the article. 0 is no. 1 is yes.

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[2] Afghanistan, Madagascar, Angola, Malawi, Bangladesh, Mali, Benin, Mauritania, Bhutan, Mozambique, Burkina Faso, Myanmar, Burundi, Nepal, Cambodia, Niger, Central African Republic, Rwanda, Chad, Sao Tome and Principe, Comoros, Senegal, Congo, Dem. Rep., Sierra Leone, Djibouti, Solomon Islands, Equatorial Guinea, Somalia, Eritrea, South Sudan, Ethiopia, Sudan, Gambia, The, Tanzania, Guinea, Timor-Leste, Guinea-Bissau, Togo, Haiti, Tuvalu, Kiribati, Uganda, Lao PDR, Vanuatu, Lesotho, Yemen, Rep., Liberia, Zambia (source: http://www.un.org/en/development/desa/policy/cdp/ldc/ldc_list.pdf)

		Articles classified as 1 was sub-categorized as below: 11: medicine 12: type of surgery/treatment 13: prescription 14: others
Disease/ health outcome		Variation in disease/health outcome was identified in the article. 0 is no. 1 is yes.
Criteria 3		Value perspective on health care
Equity		Equity issue was identified in the article. 0 is no. 1 is yes.
Quality		Quality issue was identified in the article. 0 is no. 1 is yes.
Satisfaction		Satisfaction issue was identified in the article. 0 is no. 1 is yes.
Efficiency		Efficiency issue was identified in the article. 0 is no. 1 is yes.
Criteria 4		Function as policy tool
Tin-opener		The health atlas in the article can be classified as a "tin-opener". 0 is no. 1 is yes.
Dial		The health atlas can be classified as a "dial". 0 is no. 1 is yes.

Results

Range of studies

A total of 48 studies were eligible for the final review. There has been a slow increase of the number of studies on health atlases (Figure 33).

Figure 33.

Number of Health Atlas Studies by Year

Number of Studies by Year
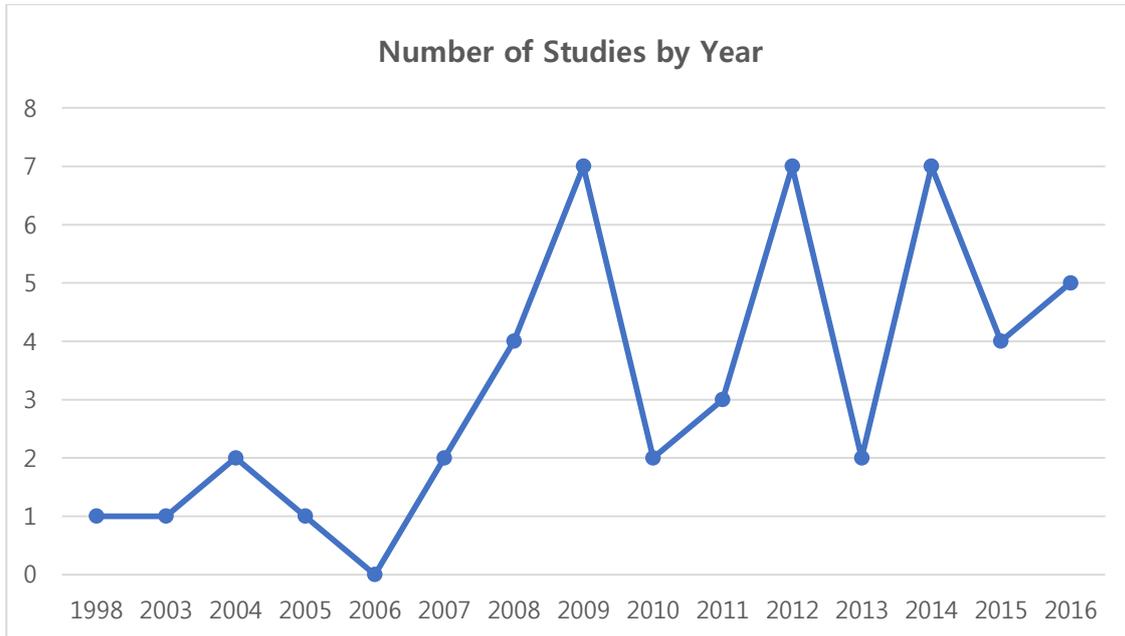
All of the studies included health variation issues although the unit of analysis varied among studies. Within country analysis (35 studies) was most frequent and it was followed by within-region analysis (10 studies). Only one study dealt with health variation issues among different countries. Another study compared three countries (Kenya, Mexico, Vietnam), but its unit of analysis was within a country. Majority of the studies also tried to find possible cause of the variation by empirical data analysis and preceding literature. 75% of the studies included (36 studies) explored the cause of health variation. Among 36 studies, 34 studies explored correlation and only 2 studies tried to prove causation between potential factors and health variation in the targeted region/country. In regards to study settings, majority of studies (36 studies) used cases in developed countries, especially in the US, UK, Canada, New Zealand, and Spain rather than cases in developing countries. Several studies (12 studies) documented geographical variation in low and middle income countries. Study summaries are presented in Figure 34, 35, and 36.

\

Figure 34.

Purpose of Atlas Research.

Purpose of Atlas Research

- variation: 48
- cause: 35
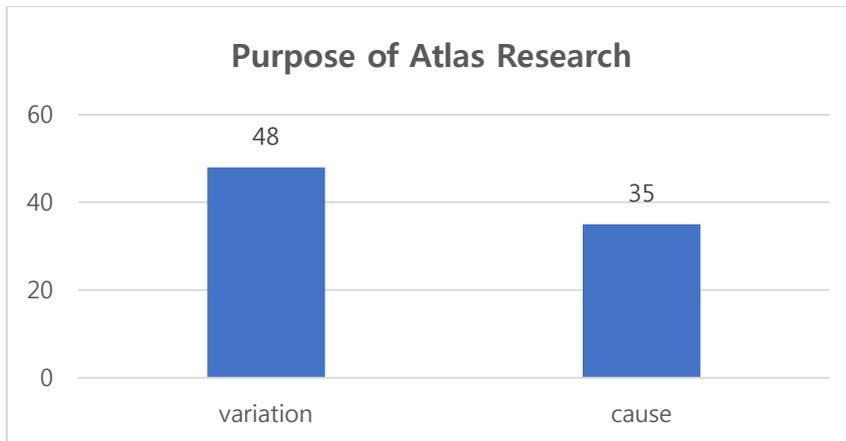
Figure 35.

Purpose of Atlas Studies: Correlation or Causation

Correlation or Causation

- correlation: 34
- causation: 2
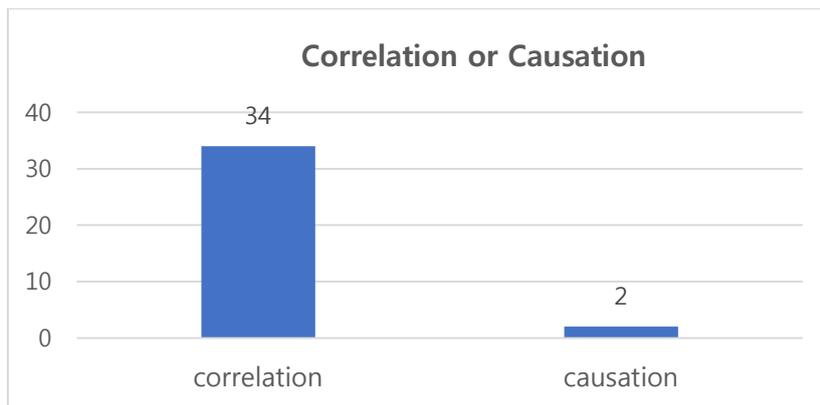
Figure 36.

Research Setting: Developing or Developed Country

Research Setting

	developing country	developed country
40		
35	36	
30		
25		
20		
15		12
10		
5		
0		
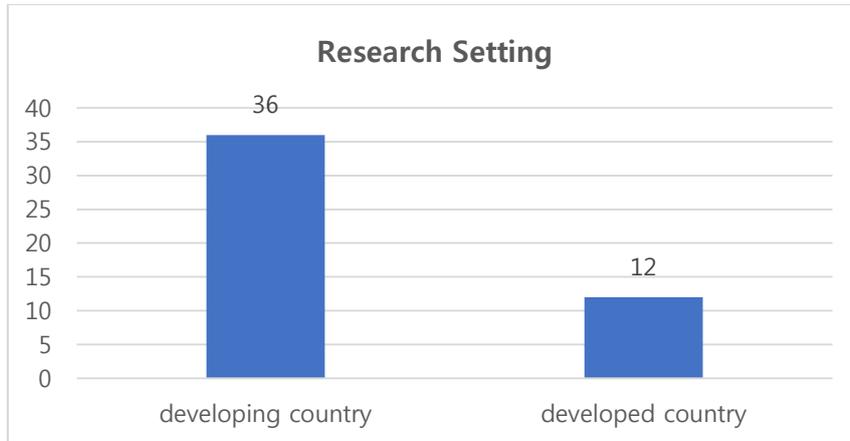
Dimensions of studies

34 studies were focused on the geographic variation of specific diseases—cancer, diabetes, and obesity in particular—or the variance in health indicators such as mortality rates. About 70% of the studies (30 studies) dealt with geographic variation of health care resources. A few articles investigated the variation in medical treatment (12 studies) such as medicine, type of surgery/treatment, and prescription, and accessability (9 studies) such as distance to health care facilities. For resources, we found financial (16 studies) and social/cultural (18 studies) resources are the most dominant indicators in relation to health variation. Physical resources (12 studies) such as health facilities, infrastructure, and surroundings of area of residence, and environmental resources (13 studies) such as ecological environment and level of pollution were also found frequently. Human resources (9 studies) such as the size or quality of medical personnel was mentioned less frequently than others.

Figure 37.

Dimensions of Variation on the Health Atlas

Dimension of Variation
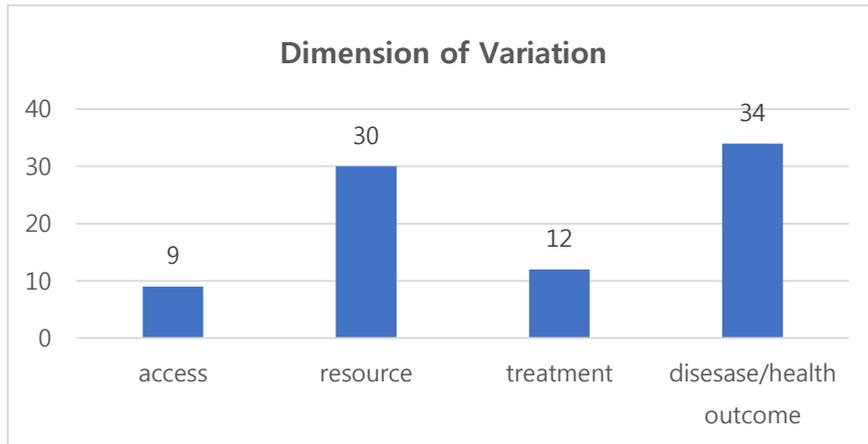
Figure 38.

Indicators: Types of Resources

Type of Resources
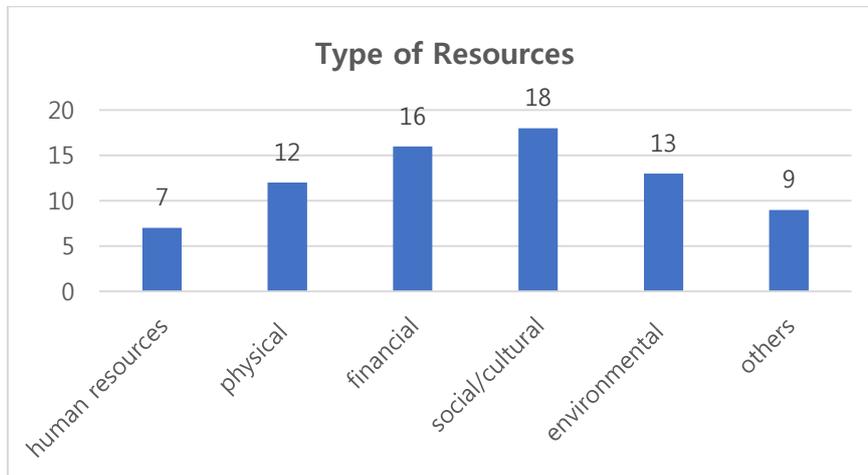
Figure 39.

Indicators: Type of Treatment

Type of Treatment
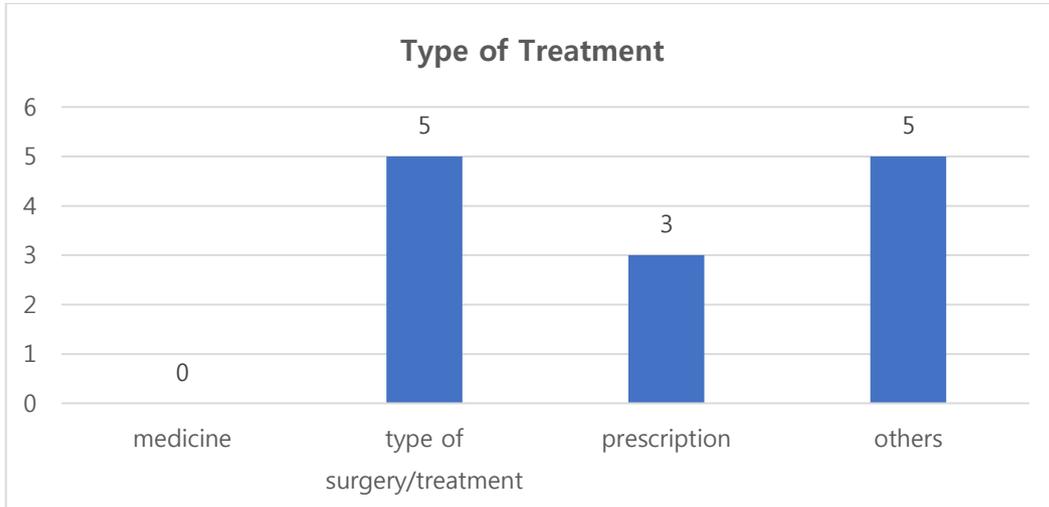
Value perspective on health care

32 articles examined geographical variation from equity perspective, which was followed by efficiency (9 studies) of health care in number. Quality of health care was rarely investigated (5 studies) and there were no studies that analyzed geographic variation from the perspective of satisfaction in health care.

Figure 40.

Value Perspectives of Health Atlas

Value Perpectives

	equity	quality	satisfaction	efficiency
	32	5	0	9

Table 8.
Study summaries

First author (Year)	Range of studies				Dimension of variation									Value perspective on health care				Function as policy tool	research setting	Method (model)
	Varia-tion	Varia-tion_1	cause	cause_1	access	Resour-ce	resource_1			Treat-ment	Treat-ment_1		disease/ health outcome	equity	quality	Satis-faction	Efficien-cy			
Hahn (1998)	1	12	1	11	0	1	14			0			1	1	0	0	0	0	1	mapping, cluster analysis, correlation analysis and regression
Gupta (2003)	1	14	1	11	0	1	11			0			0	1	0	0	0	0	0	mapping, measure inequality using gini coefficient
McLafferty (2004)	1	11	0	11	1	1	12			0			0	1	0	0	0	1	1	GIS analysis
Havranek (2004)	1	12	1	11	0	0				1	12	13	0	0	1	0	0	1	1	Baysian Model
Raso (2005)	1	11	1	11	0	0				0			1	1	0	0	0	0	0	GIS analysis Bayesian geostatistics
Pollan (2007)	1	12	1	11	0	1	13	14	15	0			1	1	0	0	0	0	1	Bayesian Markov Chain Monte Carlo(MCMC) simulation methods, Poisson regression, GIS
Aragones (2007)	1	12	1	11	0	0				0			1	1	0	0	0	0	1	
Friedly (2008)	1	12	1	11	0	1	16			1	12		0	0	0	0	1	0	1	mapping, correlation analysis
Magan (2008)	1	11	0		1	0				0			0	1	0	0	0	0	1	
Neff (2008)	1	12	0		0	0				0			1	1	0	0	0	0	1	mapping, spatial analysis
Goldsmith (2008)	1	12	0		1	1	11	12		0			0	1	1	0	1	0	1	mapping, logistica

																				regression
Pouliou (2009)	1	12	1	11	0	0					0		1	1	0	0	0	0	1	spatial analysis
Kandala (2009)	1	12	1	11	0	0					0		1	1	0	0	0	0	0	logit, probit
Moriarty (2009)	1	12	0		0	0					0		1	1	0	0	0	1	1	mapping, descriptive statistics
Armero (2009)	1	11	0		0	0					1	13	0	0	0	0	1	0	1	Bayesian Hierarchical models
Faure (2009)	1	12	0		0	0					0		1	1	0	0	0	0	1	
Tottrup (2009)	1	12	1	12		1	14	15			0		1	1	1	0	1	0	0	GIS
Movahedi (2009)	1	12	0		1	0					0		1	1	0	0	0	0	1	mapping, linear regression, fractional polynomial regression
Hegarty (2010)	1		1	11	0	0					0		1	0	0	0	1	0	1	Bayesian spatial models
Odton (2010)	1	12	0		0	0					0		1	1	0	0	0	0	1	mapping, poisson generalized linear model
Cramb (2011)	1	11	0		0	0					0		1	1	0	0	0		1	Bayesian Hierarchical models
Ibanez-Beroiz (2011)	1	12	0		1	0					0		0	1	0	0	0	0	1	small-area analysis, Besag-York-Mollie modelling, Shared Component modelling
Tu (2011)	1	11	0		0	0					0		1	1	0	0	1	0	1	
Chan (2012)	1	11	1	11	0	0					0		1	1	0	0	0	0	1	Bayesian spatial metod
Kazembe (2012)	1	12	1	11	0	0					0		1	1	0	0	0	0	0	mapping, multivariate regression model
Martin (2012)	1	11	1	11	0	1	12	14			0	0	1	1	0	0	0	0	1	Dephi technique/ spatial multi-

																				critera analysis
Magalhaes (2012)	1	11	1	11	1	1	12	14	15		0	0	1	1	0	0	0	0	0	bayesian geostatistical model
Zhang (2012)	1	12	1	11	0	1	16				1	13	0	0	1	0	0	1	1	regression analysis(individual level)
Whedon (2012)	1	12	1	11	0	1	11	13			1	12	0	1	0	0	0	0	1	spearman's test
Earnest (2012)	1	12	1	11	0	1	13	14			1	14	0	0	0	0	0	0	1	sptial regression model/ conditional autoregressive(CAR) model
Cooper (2013)	1	11	1	12	0	1	13				1	14	1	1	0	0	1	0	1	
Wheeler (2013)	1	12	1	11	0	1	15				0	0	1	0	0	0	0	0	1	linear regression model/ cross-sectional ecological study
Deribe (2014)	1	12	1	11	0	1	15					0	1	0	0	0	0	0	0	multivariate regression model
Penney (2014)	1	12	1	11	0	1	15				0	0	1	0	0	0	0	0	1	cross-sectional secondary sptial data analysis
Kandala (2014)	1	12	1	11	0	1	13	14	15	16	0	0	1	1	0	0	0	0	0	bayesian geo-additive discrete-time survial mixed model
Smieliauskas (2014)	1	12	1	11	1	1	11	13	14		1	14	0	1	1	0	1	1	1	logistic regression
Hystad (2014)	1	12	1	11	0	1	13	14	15		0	0	1	0	0	0	0	0	1	hierarchical logistic regression model
Pullan (2014)	1	13	0	0	0	1	15				0	0	1	0	0	0	0	0	0	bayesian framework using simple nested linear mixed model
Mwase (2014)	1	12	1	11	0	1	15				0	0	1	0	0	0	0	0	0	spatial model/MaxEnt
Clouston (2015)	1	12	1	11	0	1	12	13	14		1	12	1	1	0	0	1	0	0	multi-level logistic

																					modeling
Lee (2015)	1	12	1	11	0	1	11	12	13	14		0	0	0	0	0	0	0	0	1	spatial analysis(gis)/regression
Tatalovich (2015)	1	12	1	11	1	1	11	12	13	14		1	14	1	1	0	0	0	0	1	regression analysis/gis
Gebreab (2015)	1	12	1	11	0	1	12	13	14	16				1	1	0	0	0	0	1	micromap plots/multilevel logistic models
Maigeng (2016)	1	12	1	11	1	1	12	13	14	15	16			1	1	0	0	0	0	1	multilevel spatial logistic analysis
Ehrlich (2016)	1	12	1	11	1	1	11	12	13	14	16	1		14	1	1	0	0	0	0	1	retrospective cohort analysis/bayesian hierarchical intrinsic conditional autoregressive spatial probit models
Setegn (2016)	1	12	1	11	0	1	12	13	14	15	16	0	0	1	0	0	0	0	0	0	bivariate and mulitivariable logistic regression analysis
Schroeder (2016)	1	12	1	11	0	1	12	13	14	16		1	12	0	0	0	0	0	0	1	retrospective cohort analysis/multivariate logistic regression
Bassil (2016)	1	12	1	11	0	1	13	14	15	16		0	0	1	0	0	0	0	0	1	logistic regression

Functions as a policy tool

It was found that most studies were classified as "tin-openers" rather than "dials". The majority of studies (37 studies) describe geographic variation of health care in a targeted region or country to better understand the current situation. The "tin-openers" do not give definitive answers to policy problems at hand, but provide reference that can be instrumental for future policy planning and often prompt interrogation and inquiries for further actions. A limited number of studies (12 studies) provided specific recommendations for policy actions and performance measurement.

Figure 41.

Functional Type of Health Atlas as a Policy Tool
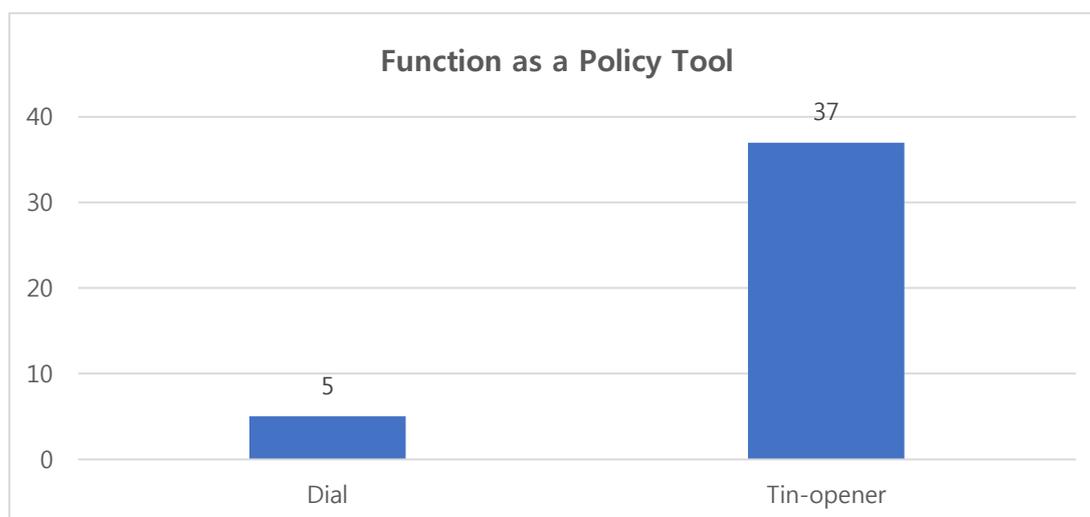
Discussion

After reviewing the literature, health atlas studies could be classified into three categories: (1) studies that describe the geographical variation of medical practices and attempt to find its causes; (2) studies that explore the appropriate statistical methods to better understand geographical variations; and (3) studies

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using atlas as a performance indicator of healthcare systems and providing future direction and strategies for policy intervention.

From the evidence-based decision-making perspective, we found that the majority of the health atlas studies have utilized health atlases as a tin-opener rather than a dial. Studies using health atlases as a dial seek to find regional variation to monitor and evaluate the health-related systems. For example, McLafferty & Grady (2004) described the geographical pattern of prenatal care need and its supply for policymakers to identify high priority locations for new clinics. In contrast, studies using health atlas data as a tin-opener show the geographical variation and the its causal factors.

In fact, many performance indicators of the public sector serve as a tin-opener, because precise measures of inputs, outputs, and outcomes based on a clear understanding of what good and bad performance entails are not available (Carter et al., 1995). In public health systems, it is generally unknown whether low rates represent underuse, and thus poor quality of care, or if high rates represent overuse and poor quality of care (Havranek et al., 2004). The result shows that studies using atlases as a "dial" measure is still limited as many studies face challenges in developing appropriate tools to explain the causes of unwarranted variation. Therefore, further study from the standpoint of causation is required in order to better utilize health atlases for evidence-based decision-making.

Limitations of the study

There are some limitations to our review study. When searching for the literature to review, there were some studies that did not include exact keywords such as "atlas" or "map" in the title or the abstracts may have been excluded from the review pool. With regards to the reviewing process, despite the application of the strategy to systematically organize article search and analysis in the peer review process, subjectivity of multiple reviewers may have affected the analysis results. Therefore, future studies should be conducted in consideration of these limitations.

Review of Health Atlas Reports

Objective of the study

In order to supplement findings from peer-reviewed journals, we have also searched and analyzed findings from gray literature and unpublished reports.

Methods

Using the Google web browser, we searched for websites or reports using groups of keywords combing three collective terms: (a) national, (b) health, and (c) atlas. Results showed that particular countries, namely the USA, the UK and other member countries of the Commonwealth such as Canada, Australia, and New Zealand, were dominant in publication of health atlas reports or information. Some other countries such as the Philippines and Ireland also appeared in search results, but their websites were either closed or not functioning properly. Excluding those that do not carry relevant information, 100 websites and reports were identified. Among them, we excluded seven websites that offer only the web-based mapping service. These include health atlas websites of Wisconsin, Chicago, New Zealand, and some of Canada as well as Australia. Therefore, ninety-three (93) health atlas reports were included for our review (See Appendix C for the list of 93 reports).

We then classified the reports by country. Since the USA and UK are on the forefront of reporting health atlas issues, we categorized countries into three groups: USA, UK, and Commonwealth countries (Canada, Australia). In addition, through comprehensive search of various resources, we found that only limited number of countries and organizations publish health atlas reports on a regular basis. Therefore, for efficient review, we selected the most recent reports from each organization for the final review.

In sum, we analyzed five reports in detail and presented results of analysis by country (See the Table 9). In order to systemically analyze unpublished health atlas reports, we adopted the analytic framework that is used in reviewing peer-reviewed journals. The screening standards are as described below.

Table 9.

Analytic framework of health atlas reports

Criteria 1	Source of Publication
	Indicate source of publication. 0 is private. 1 is public. If the report was published by a public entity, it is specified as below: 10: central government 11: regional government 12: others
Criteria 2	Level of analysis
	Level of analysis is specified as below: 10: health policy 100: general trend 11: program(theme) specific 12: region-specific 21: disease-specific 22: target population-specific 23: others
Criteria 3	Value perspective
	Values that the respective report carries is specified as below: 0: none 1: equity 2: quality 3: satisfaction 4: efficiency
Criteria 4	Policy cycle
	Policy cycle that is represented in the respective report is specified as below: 1: problem definition 2: identify causes of problem 3: policy development 4: political decision 5: implementation 6: evaluation
Criteria 5	Policy tool
	Policy tool that is represented in the respective report is specified as below: 0: tin-opener 1: dial 2: hard to tell

Most of reports (82%) were published by private organizations and only 18% were published by public organizations. A majority of reports from the USA and Canada were published by private organizations whereas reports from the UK and other member countries of the Commonwealth were published by public organizations.

Results

We performed in-depth analysis of some representative health atlas reports from four countries. A total of 6 reports were included in our case study of health atlas reports. The results of our comprehensive analysis are as follows.

First, in terms of the level of analysis, there was no atlas reports that focused on the variations in health policies. In contrast, most studies were program-, disease-, or target population-specific. Secondly, almost all of the reports included in the analysis focused on the equity issue. Quality of care and efficiency in healthcare services were the next frequently used focus. However, there were no reports that were focused on satisfaction with health care.

Next, from the policy cycle perspective, most reports focused on the problem definition. It means that most of the health atlases we examined seem to be most helpful in the first stage of a policy cycle. Another four studies corresponded to the stage of "identifying causes of problem" and "policy development" in the cycle. Lastly, in terms of policy tools, there were more atlas reports based on the tin-opener model than those on their counterpart, the dial model.

Figure 42.

Level of Analysis
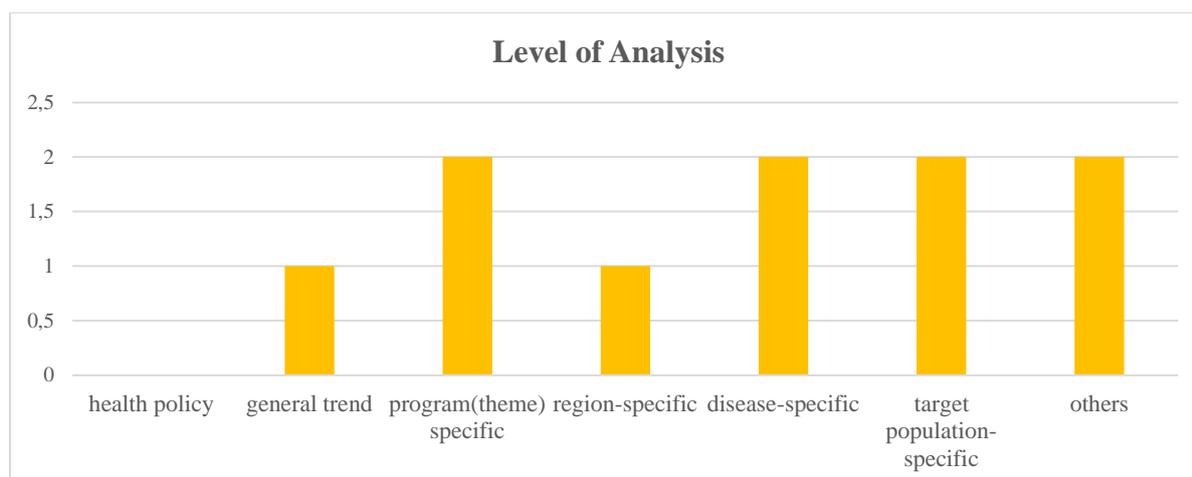
Figure 43.

Value Perspective

Value Perspective

Figure 44.

Policy Cycle

Policy Cycle

Policy Tool: Tin-opener or Dial

3,5	

(bar chart: tin-opener = 3, dial = 2, hard to tell = 0)
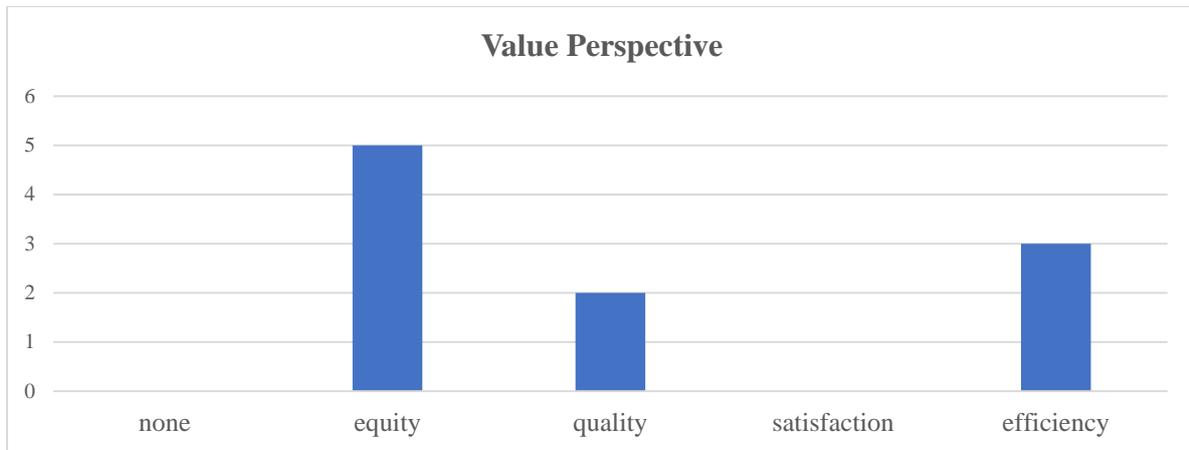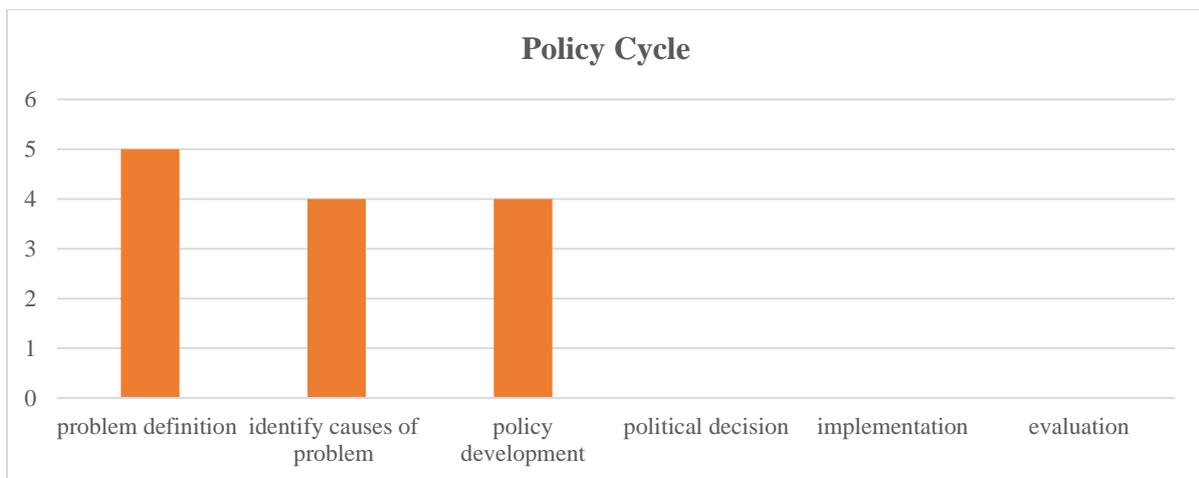
tin-opener   dial   hard to tell
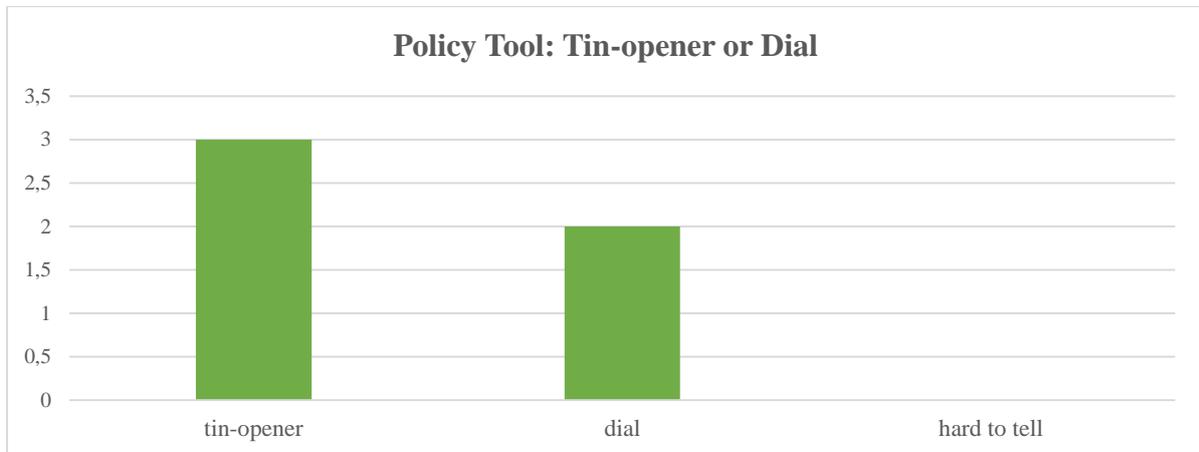
Case Study of Selected Reports

USA

Overview

USA is definitely a country at the forefront of health atlas initiatives. Over 63% of the reports that we found were published in USA. Indeed, the Dartmouth Atlas of Health Care is a leading organization. While significant amount of efforts are made by private foundations and institutions in mapping geographical health variation in the US, the federal government's contribution seems to be quite limited.

However, some states, namely California, Wisconsin, and Chicago, are making efforts in providing health atlas information through their websites. A notable distinction between the Dartmouth Atlas of Health Care and the state health atlases is that a state health atlas is designed to provide more information on a broader spectrum of factors that may affect the health of the people in the respective state. While reports by the Dartmouth Atlas of Health Care are

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specifically focused on health or disease-specific issues, state health atlases tend to cover broader aspects of "social determinants of health", such as demographic and social characteristics, and environmental conditions, and etc. California is the only state government that manages to provide health atlas information online. Although information available from the website is somewhat outdated, the reports offer summary information and maps on various information, such as healthcare facility distribution, hospital information, proportions of people with insurance, volumes of common procedures, and workforce shortag at the county level. Los Angeles, quite uniquely, was the only place that operates an independent health atlas website at the city level. The LA Health Atlas seems to carry the most structured information compared to the other state health atlas websites. LA, Chicago, and Wisconsin health atlas websites are supported by private foundations and operated in association with the respective public health authorities. Unlike the health atlases of California and LA, which provide report-format information, Chicago and Wisconsin only provide online interactive visualization maps.

In the next section, we analyze two representative health atlas reports published in USA: a report from the Dartmouth Atlas of Health Care and the LA health atlas report. Among many reports published by the Dartmouth Atlas of Health Care, we chose the most recent publication as we aim to grasp the current concerns around health variation in the US. The health atlas by Los Angeles, published in 2013, is the only health atlas report available on the website other than the Dartmouth Atlas of Health Care reports. Although the California Health atlas, operated by the Office of Statewide Health Planning and Development, seems to publish reports by county, the website only provides figures and graphs on their population health, and therefore, complete reports were not available for more detailed examination. Thus, we excluded the California health atlas report from our in-depth case study.

The Dartmouth Atlas of Health Care: "Our Parents, Ourselves: Health Care for an Aging Population (2016)"

Overview

For more than 20 years, the Dartmouth Atlas Project has documented glaring variations in how medical resources are distributed and used in the United

States. The project uses Medicare data to provide comprehensive information and analysis about national, regional, and local markets, as well as individual hospitals and their affiliated physicians. It has helped policymakers, the media, healthcare analysts and others improve their understanding of the efficiency and effectiveness of the healthcare system. In addition, its valuable data forms the foundation for many of the ongoing efforts to improve health and health systems across America.

The Dartmouth Atlas Project has been publishing reports on an annual basis since 1996, though there was some gaps between the year 2000 and 2005. Beginning from 1996, it published 68 reports till 2016. The project categorizes reports according to its research topics: issue briefs, topic briefs, surgical variation studies, national atlas editions, specialty-specific editions, state editions, regional editions, and etc. In the early days, each Dartmouth report tried to cover specific regions by its topographical condition. For example, the reports classified states into 3 areas, namely, the Mountain States, the Pacific States, and the Great Lakes States.

It seems that Medicare became a big issue between 2006 and 2011. Quality of care, expenditure, and variation in use of services of Medicare beneficiaries were frequently discussed issues in the reports. In the course of evolution, the Dartmouth project seems to have experienced a shift in its research perspective. It appears that in the past, the project used to view and analyze health issues mostly from health service providers' perspectives. However, starting from 2011, the reports began to incorporate patient's perspectives more in examining issues in the reports. The Dartmouth reports in early days seemed to focus on providing information concerning effective care, tracking patients with specific needs, or specific diseases. In recent years, however, they show more interest in issues that are closely related to patients such as patient's decision-making, quality of care, and end-of-life care.

It is notable that the only Dartmouth report released in 2016 was on health care for aging population. "Our Parents, Ourselves: Health Care for an Aging Population" (Bynum, et al., 2016) seems to pay more attention to the fact that the United States population is aging and older Americans face special challenges when they use healthcare services. It examines various dimensions of healthcare services, experienced by the entire Medicare population between the ages of 65 and 99. Using Medicare claims data, this report examines the

demographics of older adults, including their age, race, enrollment status, and other characteristics, to understand the current characteristics of older adults in the US. Following is the list of indicators that were dealt with in the report (see the Table 10 below).

Table 10.

List of Indicators for Health Care Atlas for Aging Population

1	Geographic Distribution of Medicare Beneficiaries by Race
2	Fee-for-Service Care for Medicare Beneficiaries
3	Medicare Beneficiaries Living in Nursing Homes
4	Medicare Beneficiaries who are Eligible for Medicaid
5	Medicare Beneficiaries who are Dual-Eligible and Living in Nursing Homes
6	Home and Community-Based Services Investments & Nursing Home Use among Dual-Eligibles
7	Number of Contact Days
8	Predominant Provider of Care
9	Number of Unique Clinicians
10	Annual Wellness Visits
11	Number of Days Spent in an Inpatient Setting
12	Screening for Prostate Cancer in Men Age 75 and Older
13	Screening for Breast Cancer in Women Age 75 and Older
14	Late Hospice Referral at the End of Life
15	Feeding Tube Placement in People with Dementia
16	Days Spent in the Intensive Care Unit in the Last Six Months of Life
17	Use of High-Risk Medications
18	Comprehensive Diabetes Testing
19	Preventable Hospital Admissions
20	Thirty-Day Readmission Rates
21	Contact with the Healthcare System
22	Use of Inpatient Services

Characteristics

In this report, authors claimed that they examined health care for older Americans with an emphasis on the *patient's perspective*. For the first time, they measured the *intensity of care,* meaning how many days per year the average Medicare beneficiary is in contact with the healthcare system. By doing so, it confirms that there is a great diversity of care approaches across the country. It also identifies areas in which *patient-centered improvements* are most needed for older patients, as well as recognizes areas in which those improvements are already under way. Finally, it notes the distinctive challenges and opportunities presented by *special populations*, including people with multiple chronic conditions and dementia. The reports effectively utilized maps and graphs in presenting the results, which helps readers understand geographic variation at a glance. Illustrated below are some examples of the visual aids.

Figure 46.

The Dartmouth Atlas of Health Care: Our Parents, Ourselves: Health Care for an Aging Population (2016)

Anchorage, AK	99.0%
Salinas, CA	98.6%
Chico, CA	97.3%
Mason City, IA	96.5%
Salisbury, MD	95.4%
U.S. average	**70.7%**
San Bernardino, CA	40.6%
Salem, OR	40.1%
Pittsburgh, PA	39.4%
Rochester, NY	37.7%
Johnstown, PA	34.7%
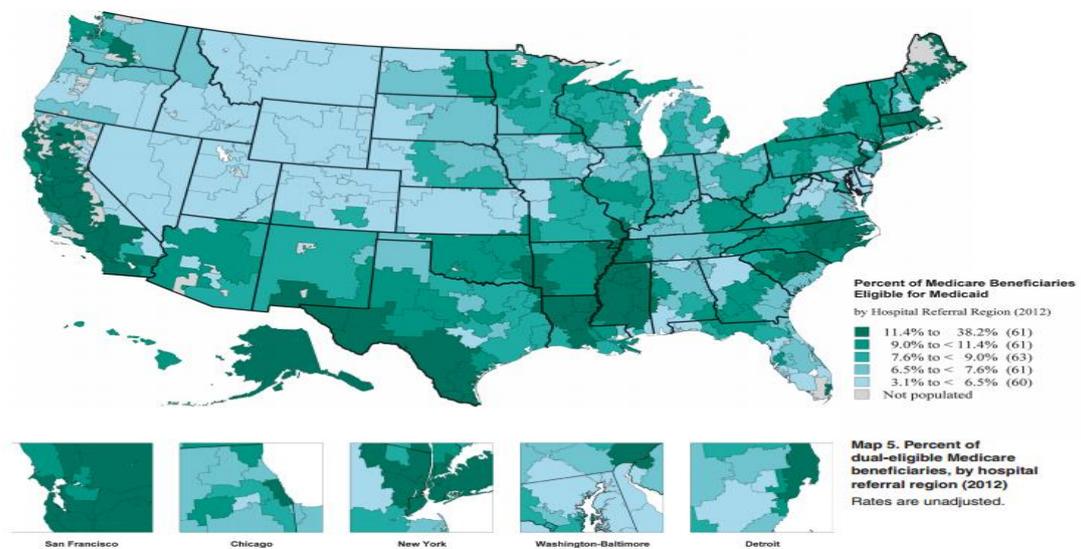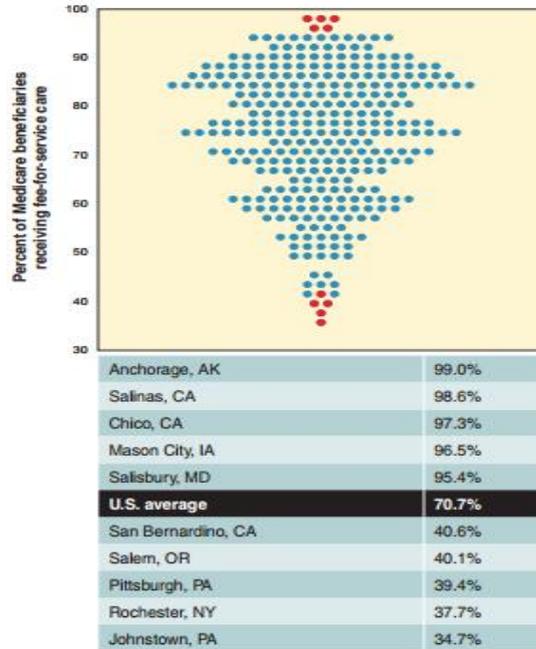
Figure 2. Percent of Medicare beneficiaries receiving fee-for-service care, by hospital referral region (2012)

Each blue dot represents one of 306 hospital referral regions in the United States. Red dots indicate the five regions with the highest and the five regions with the lowest percentages of Medicare beneficiaries who received fee-for-service care in 2012. Rates are unadjusted.

A "Tin-opner" or a "Dial"

Unlike the early publications of the Dartmouth Atlas Project, which had its emphasis on efficiencies in service delivery and resource distribution, this report highlights the problem of uneven distribution and use of care service, particularly in older adults in the US. Pointing out that our current ability to improve care for older adults has been hampered by large gaps in our knowledge about how care is delivered for the elderly in communities across the United States, this report itself serves to close the gaps by providing data and information that is more meaningful for older adults and their families. It also recognized that change in health care requires a compelling story driven by data to rally the support of clinicians, patients, and policy makers around the need for change. Also, it identified the demand of aging population that we improve the delivery of care and improve policies to benefit the older adults of today.

Therefore, this report, even though it may not directly call or "dial" for a specific policy action, certainly acts more as a "tin-opner" in tackling the equity issues in health care of older population. This report not only provides comprehensive picture of challenges faced by older adults, but also leaves us with solid information and recommendations to move forward.

Table 11.

A Summary of characteristics of the Dartmouth Health Atlas

Criteria	Shown in the Atlas
Level of analysis	Target population-specific

Value perspective	Equity
	Efficiency

Policy cycle	Policy development

Policy tool	Dial

LA Health Atlas: Health Atlas for the City of Los Angeles (2013)

Overview

Health Atlas for the City of Los Angeles is published by Raimi + Associates and Rosten Woo in collaboration with the Los Angeles Department of City Planning. It was funded by the Centers for Disease Control and Prevention through the Los Angeles County Department of Public Health and the state government of California. Unlike the annual publication of the Dartmouth Atlas Project, this report is the first and only publication from the LA Health Atlas.

This report had a specific policy objective, which was to serve as the first step in the process to develop a Health and Wellness Chapter for the city's General Plan Framework. Therefore, this report is specifically desiged to help city officials understand the areas of the city that are burdened with the most adverse health-related conditions and identify priorities to improve health outcomes for all Angelenos. In order to provide a data-informed snapshot of health issues and outcomes in Los Angeles, this report illustrates a broad range of factors that could be related to health outcomes (see the table 8 below). Each chapter includes a series of maps and associated indicators examining the differences in communities across the city, and a discussion section on how a particular indicator relates to health. Where appropriate, indicators for Los Angeles and neighborhoods within the city are compared to national, state, and county figures. The indicators were selected based on availability of data and known relationships to health behaviors and outcomes. Also, they utilized various data sources[3] in order to deliver complete and reliable information.

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[3] Population Data, 2010 U.S. Census; Community Plan Areas, 2012 City of Los Angeles Department of City Planning; Metro Rail and Liner Routes and Stations, 2012 Metro; Metrolink Lines, 2006 Los Angeles County Urban Research; Metrolink Stations, 2012 Raimi + Associates; Proposed Metro Rail Routes and Stations, 2012 Raimi + Associates; Interstates and Highways, 2008 Tele Atlas North America, Inc.; World Terrain Base, 2009 ESRI

Table 12.

Categories of Indicators for Health Atlas

1	Regional Context : Maps showing all the different geographic scales used in the Health Atlas, including City Council Districts, Community Plan Areas (CPAs), Health Districts (HDs), Service Planning Areas (SPAs), zip codes, and U.S. Census Bureau geographic designations.
2	Demographic and Social Characteristics : Information on age characteristics, racial and ethnic groups, and linguistic isolation. Data is shown at the census block, census tract, and CPA scales.
3	Economic Conditions : Information about the location of economic hardship, income, poverty, and unemployment. Data is shown at the census block, census tract, and CPA scales.
4	Health Conditions : Information on life expectancy, causes of death, obese and overweight populations, asthma and other respiratory diseases, birth weight, tobacco use, and access to health care. Data is shown at the Public Use Microdata Area, zip code, HD, SPA, City Council, and census tract scales.
5	Land Use : Information on land use, block size and structure, parks and open space, and employment areas. Land use data is shown at the census tract and census block scales.
6	Transportation : Information on transportation demand, infrastructure, and safety. Data is shown at the census tract and CPA scales.
7	Food Systems : Information about the location of healthy and unhealthy food sources, alcohol outlets, and food security program participants and vendors. Data is shown at the census tract and CPA scales.
8	Crime : Physical location of criminal activity within the City and the spatial concentration of specific types of violent crime. Data is shown at the census tract and zip code scales.
9	Housing : Information on housing density, diversity, overcrowding, and cost. Data is shown at

	the census tract and City Council District scales.
10	Environmental Health : Information on a number of exposures to pollution and the burdens that many communities face from different environmental pollutants. Data is shown at the census block and zip code scales.
11	Community Health and Equity Index : Demographic, socio-economic, health conditions, land use, transportation, food environment, crime, and pollution burden variables into a single index to compare health conditions

Characteristics

In the report, they identified that LA is a city with great health disparities and the patterns of inequality. It is shown that the geographic variation in socio-economic conditions, demographic characteristics, and health factors tend to result in variations in health outcomes. The hardship and lack of educational attainment that is prevalent in some of the poorest neighborhoods is often associated with worse health outcomes. Geographic location is such an important indicator of health that a resident born and raised in Brentwood can expect to live 12 years longer than a resident who is born and raised in Watts. The disparity between the more affluent neighborhoods on the city's westside and the poorer communities in the central and southern part of Los Angeles are consistently reflected in the data. This report also efficiently utilized graphs and maps in presenting results. The following are some examples of the visual aids[4];

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[4] Health atlas for the city of Los Angeles (2013) page 170, 182, and 183

http://healthyplan.la/wordpress/wp-content/uploads/2013/10/Health-Atlas-for-the-City-of-Los-Angeles-July-2013-FINAL-SMALL.pdf

Figure 48.

LA Health Atlas: Health atlas for the city of Los Angeles (2013)

Figure 41: Percent of Adults (18+ years old) Who Reported Having Eaten Five or More Servings of Fruits or Vegetables in the Past Day by Health District in 2011

Percent of Adults (18+ years old) Who Reported Eating 5 or More Servings of Fruit/Vegetables in the Past Day
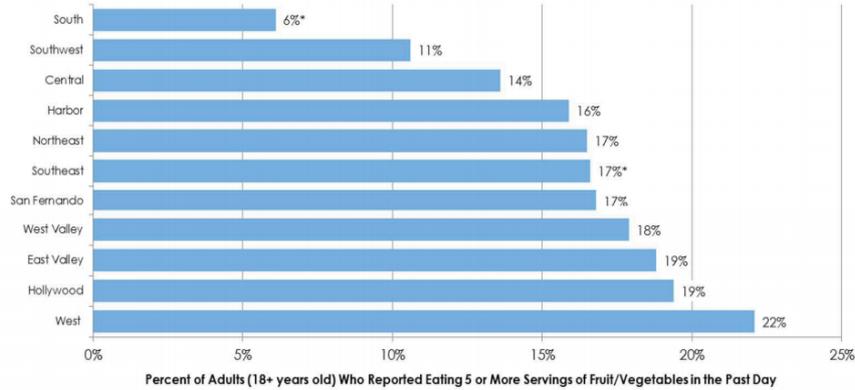
*The estimate is statistically unstable (relative standard error >23%) and therefore may not be appropriate to use for planning or policy purposes..

Source: Office of Health Assessment and Epidemiology, Los Angeles County Department of Public Health. (2013). 2011 Los Angeles County Health Survey: Fruits and Vegetables Consumption [Data File].

Figure 49.

LA Health Atlas: Health Atlas for the City of Los Angeles (2013): Community Health Equity Index Components

Table 2: Community Health and Equity Index Components

INDEX OR VARIABLE	Topic	Weight
Hardship Index (Standardized Index Score for Overcrowding, Poverty, Employment Status, Educational Attainment, Age Dependency, and Income)	Demographic, Economic, Housing, and Education	35
Life Expectancy at Birth	Health	15
Health Variables (Childhood Obesity, Respiratory Disease, Heart Disease, Heart Attacks, Asthma, Low Birth Weight)	Health	10
Walkability Index (Standardized Index Score for Housing Density, Retail Density, Street Connectivity, and Land Use Mix)	Land Use	5
Complete Communities Index (Index Score of the Diversity of Amenities and Establishments)	Land Use	2.5
Multi-Modal Transportation Index (Walk and Bike Commuting, Transit Ridership, Street Connectivity, Bicycle Facilities, High-Frequency Transit Service, Collisions with Bicyclists and Pedestrians)	Transportation	7.5
Modified Retail Food Environment Index (Index Score of the Ratio of Healthy to Unhealthy Food Retailers)	Food	10
Crime Rate Index (Rate of Violent and Property Crime per 10,000 Residents)	Crime	7.5
Pollution Burden Index (Index Score for Pollution Exposure and Environmental Effects)	Environmental Health	7.5

Total	100

Subtotal: Demographic, Economic, Housing, and Education Indicators	35
Subtotal: Health	25
Subtotal: Land Use	7.5
Subtotal: Transportation	7.5
Subtotal: Food	10
Subtotal: Crime	7.5
Subtotal: Environmental Health	7.5

Figure 50.

Community Health and Equity Index (2013)
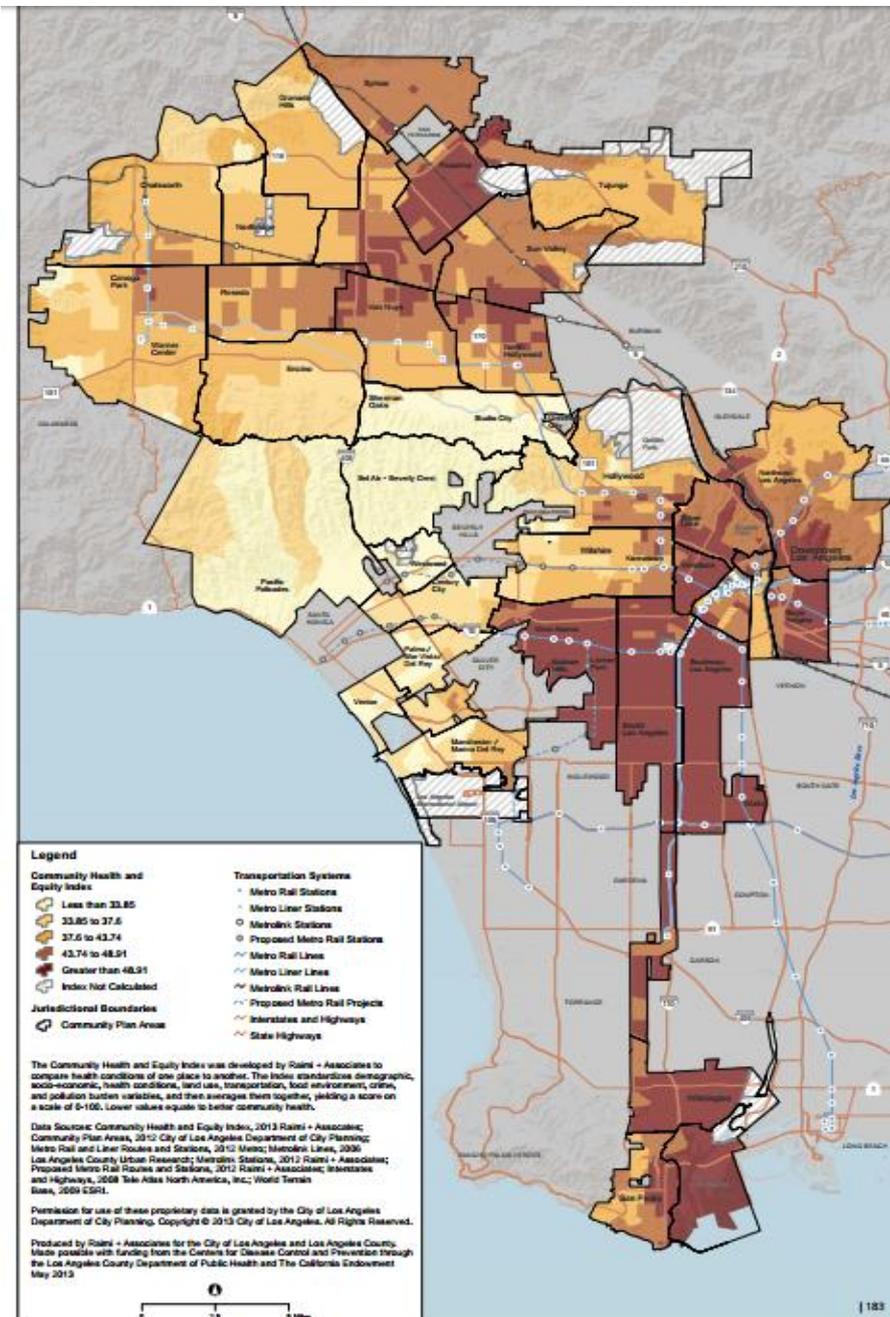
Although the LA Health Atlas did not publish serial reports after the 2013 Health Atlas for the City of Los Angeles, it was expected that the city could use indicators included in the report to monitor changes in population health conditions of the city and the neighborhood areas over time. This report provides

in-depth analysis that contributes to planning and implementing policies to improve health outcomes in Los Angeles.

"Tin-opner" or "Dial"

In terms of the function of this report as a policy tool, this report serves as a "tin-opener" rather than a "dial" considering the fact that it was designed to deliver data-based facts as reference for policymakers. Although the Community Health and Equity Index, which is the combined result of demographic, socio-economic, and health conditions, land use, transportation, food environment, crime, and pollution variables presented in the report, provided a broad illustration of the vulnerable communities, other health factors, and health outcomes that different areas of Los Angeles face, it did not include detailed policy recommendataions.

Table 13.

A summary of results from analysis of the LA Health Atlas

Criteria	Shown in the Atlas
Level of analysis	General trend
	Region-specific
Value perspective	Equity
Policy cycle	Identify causes of problem phase
Policy tool	Tin-opener

UK

Overview

In the UK, the National Health Service (NHS) has been publishing health atlases with various themes since 2010. Inspired by the first Dartmouth Atlas of Variation in 1996, NHS Right Care began to produce a series of atlases. They encompass various program budget categories and special version of atlases tha focus on particular health care conditions, population groups or services.

Meanwhile, a private organization, the Small Area Health Statistics Unit (SAHSU) established by Imperial College London, provides an environmental health atlas for England and Wales. It includes environmental factors such as gaseous pollutant or pesticide usage. However, the data used in environmental atlas represent specific time periods up to 2005. The health condition maps cover an average level of relative risk of some diseases. These atlases present a general trend of health and environmental conditions, and thus, are relatively limited in terms of regularity and range of analysis.

All in all, the NHS seems to be a leader health atlases initiatives in the UK and it provides insights on both universal and specific health-related conditions nationwide. In contrast to the US, there are fewer sources of atlases in the UK. Private efforts, in particular, were limited compared to other countries included in our analysis. Furthermore, contrast to the other countries such as the US and Canada, regional governments do not seem to be invovled in health atlas efforts.

In the next section, we will analyze one of the NHS atlases. Among many publications, we chose the one that was recently published as we aim to grasp current concerns around variations in health and health practices in the UK. As most of the NHS atlas reports have virtually the same structure, it will be useful to closely examine one of them.

2015 NHS Atlas of Variation in Health Care (Compendium)

Until now, the NHS has produced 10 health care atlases as follows. Three compendium versions have been published, and the other issues include specific themes.

Table 14.

The NHS atlas series 2010−2015 launched by the QIPP Right care program

2010	NHS Atlas of Variation in Health Care (Compendium)
2011	NHS Atlas of Variation in Health Care (Compendium)
2012	NHS Atlas of Variation in Health Care for Children and Young People
2012	NHS Atlas of Variation in Diabetes
2012	NHS Atlas of Variation in Health Care for People with Kidney Disease
2012	NHS Atlas of Variation in Health Care for People with Respiratory Disease
2013	NHS Atlas of Variation in Diagnostic service
2013	NHS Atlas of Variation for Liver Disease
2015	NHS Atlas of Variation in Health Care (Compendium)
2017	NHS Atlas of Variation in Diagnostic service

Topics

The 2015 NHS Atlas of Variation in Health Care includes 20 categories of health-related indicators as listed below. Each category has several indicators that are presented in maps. In every section, it provides explanation of the general context of the indicator (usually certain diseases or syptoms) and the magnitude of variation and options for action for future policy implementation.

Table 15.

Categories of Indicators for Atlas

1	Cancer and Tumours
2	Endocrine, Nutritional and Metabolic Problems
3	Mental Disorders
4	Problems of Learning Disability
5	Neurological Problems
6	Problems of Vision
7	Problems of Hearing
8	Problems of Circulation
9	Problems of the Respiratory System
10	Dental Problems
11	Problems of the Gastro-Intestinal System
12	Problems of the Musculo-Skeletal System
13	Problems of the Genito-Urinary System
14	Maternity and Reproductive Health
15	Conditions of Neonates
16	Care of Alcohol-Related Conditions
17	Emergency Care
18	Care of Older People
19	End-of-Life Care
20	Imaging Services

As we analyzed the 2015 NHS Atlas of Variation in Health Care, the analsis criteria were identified as Table 16. Notably, in the 2015 NHS Atlas, "warranted variation" and "unwarranted variation" are highlighted throughout the report, and those variations are represented on disease-specific and target population-specific maps. Moreover, in terms of the value perspective, the NHS Atlas consistently emphasizes the equity issues related to access to care and service

provision. Likewise, quality of care and efficiency are also explored while customer or patient satisfaction with care is rarely indicated.

In terms of the policy cycle, the NHS Atlas seems to serve as a policy tool in various phases, such as problem definition, identifying causes of problems, and policy development. The Atlas not only describes the geographical variation itself, but also briefly analyzes the possible determinants of such variations, and then suggests potential actions for future policy implications.

Figure 51.

NHS Atlas of Variation 2015
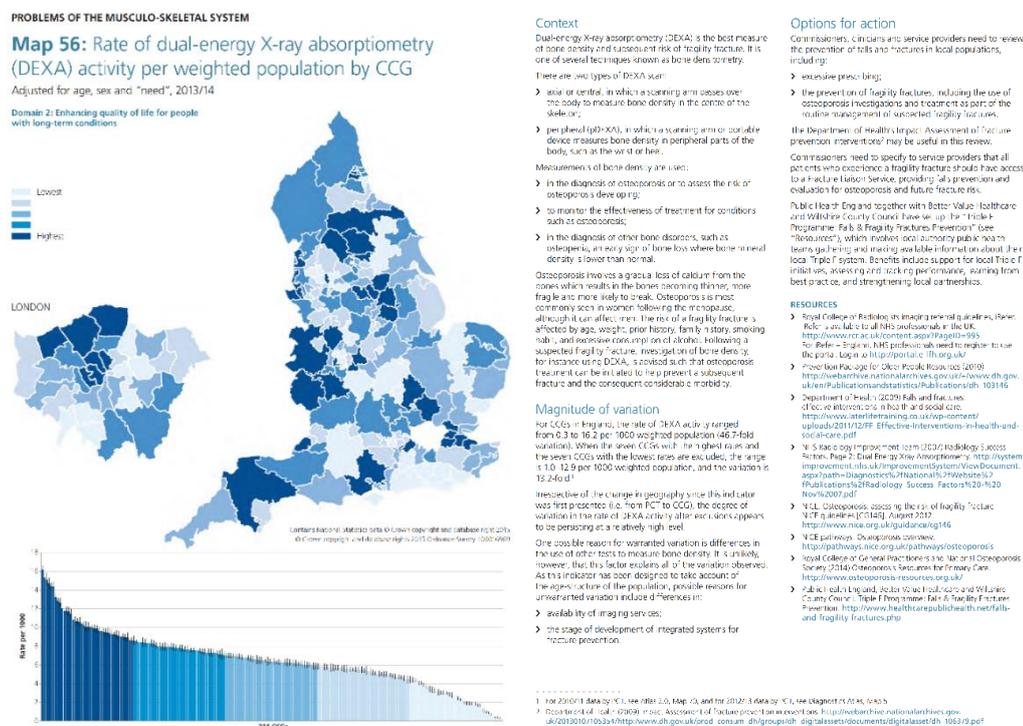
Table 16.

A summry results of analysis of the NHS 2016 Atlas

Criteria	Shown in the Atlas
Level of analysis	Disease-Specific
	Target population-specific
	Others
Value perspective	Equity
	Quality
	Efficiency
Policy cycle	Problem definition phase
	Identify causes of problem phase
	Policy development phase
Policy tool	Tin-opener

Other Commonwealth Countries (Autralia and Canada)

Overview

In Canada, there have been several health atlas initiatives since the mid-1990s. Similar to the US, private organizations and regional governments have regularly documented their own atlas reports. While British Columbia and Nova Scotia offer atlas maps using web-based systems, the Institute for Clinical Evaluative Sciences (ICES), a not-for-profit research institute[5], seems to be a leader of the Canadian health atlas initiatives. The institute has consistently published a series of health atlas reports on various themes and the majority of them focus on variations in health and health practices in Ontario area.

In Australia, various institutions, public as well as non-profit, are implementing health atlas initiatives. On the government side, the Australian Commission on Safety and Quality in Health Care is responsible for the Australian Atlas of

Healthcare Variation. Meanwhile, Women's Health Victoria (WHV)[6], a not-for-profit, state-wide service organization that promotes, provide information on, and advocates women's health, is also working to build a health atlas specifically for women's health. WHV collaborates with women, health professionals, policymakers and community organizations to influence health policy and service delivery for women. The Victorian Women's Health Atlas, a website operated by WHV, has been developed as a tool to assist in the identification of gender impacts on key health areas. It aims to increase the availability of reliable data for evidence-based decisions about service design, emerging priorities and program planning. On the website, they provide online information and maps on priority areas in health, namely, sexual and reproductive health, mental health, violence against women, cancer, avoidable mortality, and gender equality. Torrens University Australia[7] is another agent in building the Australian health atlas. They are a crucial partner of the Australian government in development of health atlases, as they present data for a range of population characteristics, including demographic and social indicators; health status, disability and deaths; and the use and provision of health and welfare services. Indicators are available by Quintiles of Socioeconomic Disadvantage of Area and Remoteness Area and for the Aboriginal & Torres Strait Islander Social Health Atlases of Australia, and they(indicators) are listed separately. In fact, the Australian government provides health atlas data through data.gov.au and its database is directly linked to Torrens University Australia.

In the next section, we examine the latest health atlas report by the ICES and the only atlas report by the Australian Commission on Safety and Quality in Health Care. Most of the reports published by the ICES share a similar framework, providing the background for each indicator, presenting maps, and suggesting possible determinants of such variation and policy implications. Therefore, considering this similarity, it is meaningful to select one of the reports for more thorough analysis. We excluded WHV works and Torrens University Australia from in-depth case analysis since they only provide online information.

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[6] http://victorianwomenshealthatlas.net.au/#!/

[7] http://phidu.torrens.edu.au/social-health-atlases/indicators-and-notes-on-the-data/social-health-atlases-of-australia-contents#demographic-social

Canada: The Atlas of Childhood Cancer in Ontario 1985-2004

Published in 2015, the "Atlas of Childhood Cancer in Ontario 1985-2004" encompasses the incidence of childhood cancer from 1985 to 2004 and the survival patterns over the period. It also shows the health service utilization patterns for the cohort as a whole as well as for the subsets of patients. It describes geographic variations of childhood cancer in Ontario and suggests policy actions at the end of each category of indicators. The indicators are listed in the Table 17.

Table 17.

Categories of Indicators in the Atlas of Childhood Cancer in Ontario 1985-2004

1	Incidence Patterns and Trends
2	Survival
3	Health Service Utilization
4	Leukemia
5	Lymphoma
6	Central Nervous System Tumours
7	Neuroblastoma
8	Renal Tumours

Results of analysis based on the criteria of the Atlas report are as follows. The report focuses on Ontario and specifically on childhood and their cancer occurrence. Therefore, it was categorized as region-specific, disease-specific, and target population-specific level of analysis. Also, it mostly emphasizes the quality of service provision and access to right care for childhood cancer and suggests several policy implications. However, in terms of the policy cycle perspective, it does not indicate the possible determinants of geographical variations and the trends in the indicators although it provides description of such variations and and proposes some possible policy actions. Therefore, the report seems to be relevant to the problem definition and policy development phase, not necessarily so during the stages in the middle. Lastly, in the policy

tool perspective, this report acts as a tin-opener, which raises various further inquiries about the childhood cancer in Ontario. However, they are not used as performance evaluation indicators.

Table 18.

A summary of results from analysis of the Atlas of Childhood Cancer in Ontario

Criteria	Coding
Level of analysis	Region-specific
	Disease-specific
	Target population-specific
Value perspective	Equity
	Quality
Policy cycle	Problem definition phase
	Policy development
Policy tool	Tin-opener

Figure 52.

Atlas of Childhood Cancer in Ontario 1985-2004
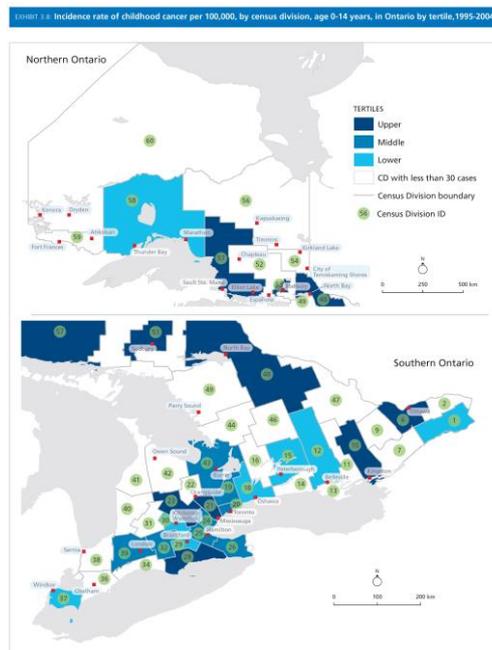
The Australian Atlas of Healthcare Variation (2015)

The Australian Atlas of Healthcare Variation was published by the Australian Commission on Safety and Quality in Healthcare (the Commission) in collaboration with the Australian, state and territory governments, specialists at medical colleges, clinicians and consumer representatives. This atlas is the first Australian atlas where healthcare variation across the country is presented alongside nation-wide recommendations for action. It aimed to provide a clear picture of substantial variation in healthcare use across the country and across many areas of health care.

This report is a valuable attempt, not only because this was the first in its series, but also because it was the first trial where data from the Medicare Benefits Schedule (MBS), Pharmaceutical Benefits Scheme (PBS), and Admitted Patient Care National Minimum Data Set (APC NMDS) were combined and used to explore variations across different healthcare settings.

This report begins with the recognition that the safety and quality of health care varies, both across geographic areas and among individual clinicians, and examining variation is an important first step in identifying and addressing unwarranted variation. The atlas provides information on 36 healthcare interventions grouped into six clinical areas, covering prescritive, diagnostic, medical and surgical interventions. Priority areas for investigation and action include use of antimicrobials and psychotropic medicines; variation in rates of fibre optic colonoscopy, knee arthroscopy, hysterectomy and endometrial ablation; and inequitable access to cataract surgery. The following is the list of indicators used in the report (see Table 19 below).

Table 19.

List of Indicators for Health Atlas

Antimicrobial dispensing	1	Antimicrobial dispensing
	2	Quinolone dispensing
	3	Amoxycillin and amoxycillin-clavulanate dispensing
Diagnostic interventions	4	Fibre optic colonoscopy
	5	Prostate biopsies for those aged 40 years and over
	6	Computed tomography of the lumbar spine
Surgical interventions	7	Knee arthroscopy hospital admissions for for those aged 55 years and over
	8	Cataract surgery for those aged 40 years and over
	9	Lumbar spine surgery hospital admissions for for those aged 18 years and over
	10	Radical prostatectomy hospital admissions for those aged 40 years and over
	11	Hysterectomy and endometrial ablation hospital admissions
	12	Tonsillectomy hospital admissions for those aged 17 years and under
	13	Myringotomy hospital admissions for those aged 17 years and under
	14	Hip fracture hospital admissions for those aged 65 years and over
	15	Hip fracture average length of stay in hospital by peer group – aged 65 years and over
Interventions for mental health and psychotropic medicines	16	General practitioner mental health treatment plans
	17	Antidepressant medicines dispensing for those aged 17 years and under
	18	Antidepressant medicines dispensing for those aged 18 to 64 years
	19	Antidepressant medicines dispensing for those aged 65 years and over

	20	Anxiolytic medicines dispensing for those aged 18 to 64 years
	21	Anxiolytic medicines dispensing for those aged 65 years and over
	22	Antipsychotic medicines dispensing for those aged 17 years and under
	23	Antipsychotic medicines dispensing for those aged 18 to 64 years
	24	Antipsychotic medicines dispensing for those aged 65 years and over
	25	Attention deficit hyperactivity disorder medicines dispensing for those aged 17 years and under
Opioid medicines	26	Opioid medicines dispensing
	27	Asthma medicines dispensing for those aged 3 to 19 years
	28	Asthma medicines dispensing for those aged 20 to 44 years
	29	Asthma and chronic obstructive pulmonary disease medicines dispensing for those aged 45 years and over
	30	Asthma and related respiratory hospital admissions for those aged 3 to 19 years
	31	Asthma hospital admissions for those aged 20 to 44 years
Interventions for chronic diseases	32	Asthma and chronic obstructive pulmonary disease hospital admissions for those aged 45 years and over
	33	Heart failure hospital admissions for those aged 40 years and over
	34	Diabetes-related lower limb amputation hospital admissions for those aged 18 years and over
	35	Stroke average length of stay in hospital by peer group – aged 65 years and over
	36	Anticholinesterase medicines dispensing for those aged 65 years and over

It is notable that this report not only contributes to providing a clear picture of the substantial variation in healthcare use across the country and across many areas of health care, but also delivers specific and practical policy recommendations for six clinical areas. Also, by providing detailed guidance on

how to interpret graphs and maps in the report, this report effectively helps readers understand the content of the report (see Figure 58 for details).

With hard evidence for policy intervention, this atlas could be seen as a a catalyst for generating future actions. It is quite evident that this report fulfilled its role, which was ultimately developed to improve the quality of health care service and health outcomes through improving the efficiency and effectiveness of the healthcare system. Therefore, this report, in terms of its function as a policy tool, could be categorized as a "dial" due to the depth of the analysis and policy recommendations that are presented in the report.

Table 20.

A summary of results of analysis of the Australian Atlas of Healthcare Variation

Criteria	Shown in the Atlas
Level of analysis	Program(theme) specific
Value perspective	Equity
	Efficiency
Policy cycle	Policy development
Policy tool	Dial

Figure 53.

Guide on how to read graphs[8]

Title of the figure describes what has been measured:
- Type of data (MBS, PBS or APC)
- Age
- Local area (SA3, SA4 or state/territory)
- Financial year of data

Figure 2: Number of PBS prescriptions dispensed for antimicrobials per 100,000 people, age standardised, by local area, 2013–14

Local area reported at SA3 or SA4 level

Legend describes the number of interventions, represented by a circle

For this item, **local area** refers to an ABS standard geographic region known as a **Statistical Area Level 3** (SA3)

The size of each circle represents the number of prescriptions dispensed in each local area

●	2,000
●	100,000
●	200,000
●	300,000
●	400,000

Area with the lowest rates (outliers)

Lowest rate areas

Highest rate areas

Areas with the highest rates (outliers)

Antimicrobial dispensing, by local area (each circle represents an area)

25,000   50,000   75,000   100,000   125,000   150,000   175,000

Local area	State	Rate	Prescriptions
Daly - Tiwi - West Arnhem	NT	14,895	2,271
East Arnhem	NT	26,772	3,702
Barkly	NT	31,106	1,896
Kimberley	WA	38,081	13,768
Katherine	NT	38,162	6,985
Alice Springs	NT	49,052	18,043
Pilbara	WA	65,839	36,645
Far North	Qld	67,807	20,117
Gascoyne	WA	68,924	6,771
Esperance	WA	70,832	12,042
Manjimup	WA	80,946	19,625

Local area	State	Rate	Prescriptions
Campbelltown	NSW	171,841	262,581
St Marys	NSW	168,152	90,560
Springwood - Kingston	Qld	167,787	133,531
Fairfield	NSW	165,119	312,902
Beenleigh	Qld	164,974	69,591
Ipswich Inner	Qld	164,172	169,158
Sunbury	Vic	163,852	62,472
Bribie - Beachmere	Qld	163,240	58,832
Bringelly - Green Valley	NSW	162,981	137,305
Browns Plains	Qld	162,856	123,680
Mount Druitt	NSW	162,133	171,617
Liverpool	NSW	161,121	178,766
Bankstown	NSW	160,702	283,735
Tullamarine - Broadmeadows	Vic	160,598	225,763

Local areas with the lowest and highest rates. The rate is age standardised (as per the technical supplement)

Rate per 100,000 population in each local area

Actual number of prescriptions, hospital admissions or services provided, depending on the data source, in each local area

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8 https://www.safetyandquality.gov.au/atlas/

Conclusion

Implications of Review of Jornal Articles and Reports

In total, we have reviewed 48 peer-reviewed journals and 6 reports on health atlases. It is hard to compare peer-reviewed journals and reports based on the same standards as they differ from each other in terms of the scope and level of analysis. However, we believe that it is worthwhile to draw comprehensive implications from both analyses. In this section, we will summarize the similarities and differences found in the review of journal articles and reports.

First of all, to our surprise, over half of peer-reviewed articles focused on health variation in developing countries while the majority of reports were drated based on the research in Western developed countries. Though we only analzed 6 reports in the final in-depth analysis, it was clear from the searching process that there are only a few countries where health atlases are being used at the policy level. From our serach results, all of the representative cases were from developed countries such as the USA, UK and other Commonwealth countries, and some European countries (Germany, Netherlands, and etc.). Some developing countries such as the Philippines seem to have tried to develop national health atlas systems, but now they are either not operating or not managed properly.

It is interesting to find that although health variation issue is more frequently discussed in the context of developing countries, health atlases as a policy tool to address health variation issues are more commonly utilized in developed countries. We believe it is attributed to the fact that a health atlas requires a vast amount of accumulated data including demographic, health, and geographic information. In fact, most of the health atlas institutions in developed countries were estabilshed based on a solid national database. For instance, the NHS Health Atlas of the United Kingdom and the Dartmouth Health Atlas have published a variety of health atlas reports using the NHS health data and Medicare data. Although not all health atlas reports published by developed countries thata are regularly used collected national data, it is clear that a reliable source of information is a prerequisite to produce a credible health atlas. On the contrary, as can be seen from the result of journal analysis, most of the data used in articles focusing on developing countries were one-off data rather than serial data. Thus, using health atlases as a policy tool seems to be generally the case for developed countries where well-structured health

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database is available. This again emphasizes that regular data collection plays a pivotal role in utilizing health atlases as a policy tool.0020

Secondly, it seems that in the previous health atlas literature, both peer-reviewed journals and reports tend to focus on micro-level questions such as program- specific, disease-specific, or target population-specific issues rather than macro-level policy issues. In case of peer-reviewed journals, over 75% of studies were focused on the geographic variation of specific diseases. In review of health atlas reports, there were no atlas reports that focused on the variations in health policies. In contrast, most studies were program-specific, disease-specific, or target population-specific.

Thirdly, in terms of value perspective on health care, equity was dealt with most importantly in both peer-reviewed journals and reports. Over 70% of peer-reviewed journals examined geographical variations from equity perspective and almost all of the reports included in the analysis focused on the equity issue in the atlas reports. Quality of care and efficiency in healthcare services were also considered critical. However, no journals or reports paid attention to satisfaction with health care. Relatively fewer studies dealt with from certain value perspectives, such as variation of medical quality or consumer satisfaction, or from an efficiency perspective, suggesting that further research needs to be conducted in these areas. Considering that healthcare administration should take into account such values, atlas studies that indicate variation of quality and efficiency of, and satisfaction with, health care could serve as a more useful policy tool.

In addition, in both cases, health atlases were more frequently utilized as a tin-opener rather than a dial. This may be because health atlas development is still at the early stage in many countries. Using health atlases as a tin-opener can provide a solid, logical background when initiating a health policy or program. Also, it helps to draw public attention to a specific health issue. For example, the LA Health Atlas published a health atlas for the City of Los Angeles in 2013. This report carries economic as well as societal information of the city and provides detailed information and maps by county. This report is pulbished by the regional government and accessible online by the public. The regional government's initiative to publish health atlas reports implies that health variation is a critical issue in LA and thus signifies health policy focus of the city. Therefore, a health atlas that functions as tin-opener could envoke public attention and discussion on the issue in the respective society. In many cases, a

dial, as a policy tool, cannot be easily defined and found in the real-life policy environment. However, it can function as a useful performance indicator in healthcare policy assessment. Ideally, a health atlas that functions as a *dial* provides logical models of health services or intervention that will reduce unwarranted health variation. Therefore, it can be a useful guide to monitor and provide feedback for better performance. For example, a specific regional healthcare program can be assessed using a health atlas by describing the variation in utilization of the healthcare services or varation of certain illness before and after a health intervention. In this case, changes indicated on the health atlas can reflect the performance of the policy. Therfore, using health atlases as a "dial" can encourage systematic performance management.

By nature, the purpose of peer-reviewed articles and reports are different. While journal articles are designed to study the causes and underlying factors of health variation in a research setting, most reports focus on defining the problem itself and describing the status quo. Reports tend to contain more comprehesive and accessible information that enables readers to understand the current situation. Therefore, reports would be more appropriate for the general public to have a grasp on an issue. On the other hand, research articles can serve as a technological or theoretical base of atlas reports. All in all, both peer-reviewed articles and reports on health atlases have been continuously published since 1996 in many countries. Results of our analyses conclude thate regular data collection is necessary to develop and study health atlases. Accumlating demographic data on health can be a good start to keeping track of changing variation on important health indicators and subsequently can contribute to developing health atlases. However, a health atlas itself is a useful tool to provide health variation information to the general public as well as policymakers despite the weight of information it carries. Visualized information can be an effective policy tool to draw public attention and measure performance. Promoting research on health atlases can be also encourage utilization of health atlases. In addition, our results also indicate that the function of health atlases is not limited to merely describing the status quo, but it can also serve as a pratical tool in an actual policy-making process.

Recommendation

Accountability of the Health Atlas as a Policy Tool

Arguably, the most critical purpose of effective performance measurement systems like a health atlas, as Smith (1990) pointed out (p.53), is accountability. The principal, an entity that provides finances (or pay taxes in the public sector), have the right to be informed of and judge the performance of the agent, who acts on the principal's behalf. Using health atlases as a policy tool signals a "move from data awareness to decisions to improve quality and value in health care" (Schang, et al., 2014) with a tool to promote accountability of decisions to allocate resources for health care provision. In the private sector, defining accountability is relatively simple as the principal, which, in this case, equates to investors and management, is clear. However, in the public sector, the complexity of the principal-agent relationship has made the use of performance indicators for accountability not so straightforward (Figure 59).

Figure 54.

A map of accountability relationships in the health system
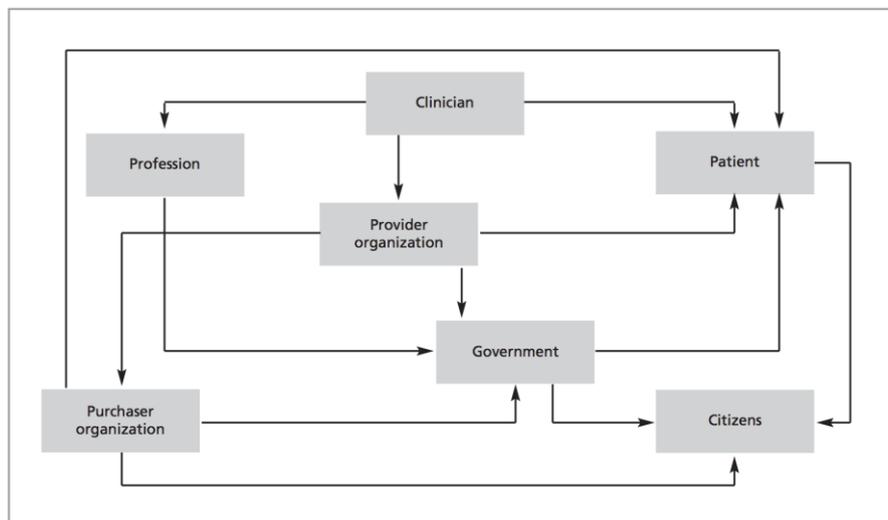
Source: Smith, P. C., Mossialos, E., & Papanicolas, I. (2008).

To promote accountability through a health atlas as a policy tool, measurement should be periodically conducted at the geographical level so that improvements in organizational capacity, service provisions, and health-related outcomes are defined at that level. However, the most important concern regarding performance measurement is the lack of reliable measures of quality to assess the performance.

In order to generate more efficient resources allocation, a "conceptual framework" of performance indicators is needed for collection of reliable and valid data. According to the framework suggested by Schang et al (2014), for health atlas to become a useful policy tool, there are at least 4 steps to be taken: 1) become aware of data, 2) accept the data, 3) perceive the data as applicable to the current situation, and 4) equip sufficient capacity to use the data" (See Figure 60).

Figure 55.

A Framework for Moving from Data on Geographic Variations

to Resource Allocation Decisions
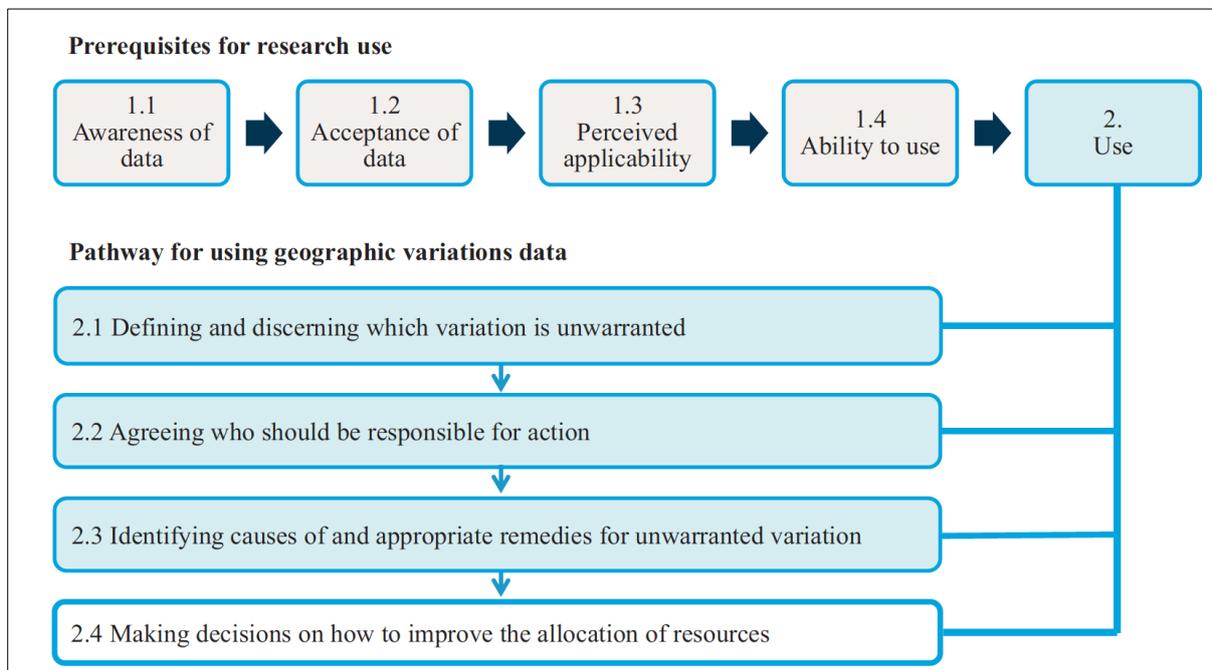
Source: Schang, et al. (2014): 79-87.

When the four pre-requisites are fulfilled, then data presented on the health atlas are ready to be utilized for policy decision-making. Yet, the data should go through the following pathway (Schang, et al., 2014).

1) Examine and detect which variation is unwarranted
2) Reach a consensus on who should be responsible for actions
3) Detect the types and causes of and remedies for unwarranted variations
4) Decide how to improve resource allocation

When moving along the policy cycle, from the initial stage of collecting and disseminating data to analyzing them for decision-making, monitoring and evaluating the performance of the policy decisions and publicly publishing the results is highly recommended to generate widespread changes, especially to facilitate better communication and information sharing among various stakeholders suc as clinicians, policymakers, and patients (J. Appleby et al., 2011).

Choice of Indicators for a Health Atlas

Choice of indicators for a health atlas is a critical step as it reflects the objectives and values that are embedded and the intended effects that are to be generated by the atlas as a policy tool. Indicators should be relevant and valid to the purpose of an atlas. With reliable and valid indicators, objectives of the program, services, policies and organizations in charge of health service provision can be clarified. They can serve as agreed measures of activities, help to understand the process to produce intended outcomes, facilitate comparison of performance with other areas and organizations, allow for setting appropriate targets for the programs, policies, and services, and promote accountability for stakeholders (Smith, 2009).

In the literature on performance management, performance indicators are an essential part of performance management, such as making a decision for a progam or deciding whether to continue, expand or repeal a policy. An organization benefits from performance indicators in the following aspects: (1) clarifying the objectives of the organization, (2) developing agreed measures of activity, (3) gaining an understanding of the processes, (4) facilitating comparison with other organizations, (5) facilitating the setting of targets for organizations and managers, and (6) promoting accountability of organizations to stakeholders (Smith, 1990).

Indicators that are used for heealth atlases have similar functions. First, they can show variations in the health problems of the population and health conditions in geographic areas, distribution of important healthcare resources and performances of medical practices across geographical regions, thus helping to set up relevant and prominent policy goals for the areas. With policy goals that are set up based on evidence, policymakers can develop agreed measures of activities to address inequalities in health problems, remedy inappropriate resource allocations, and correct overuse or underuse of medical practices. By providing visual linkage between the outcomes and baseline problems or between remedying practices and available resources, a health atlas can facilitate understanding on how policy implementation does or does not create intended outcome. In particular, geographic comparisons of visual indicators across regions may push local governments and public officials to set policy goals and targets, which promotes the accountability of policymakers and medical providers to stakeholders as well as the public.

Choosing the right performance indicators entails several important questions to consider. First, what counts as a good performance? Indicators do not only measure performance, but also work as targets to achieve. Thus, it becomes important to define achievement to what level for a given period of time can constitute a "*good performance*". Also, defining and selecting dimensions of performance is another important question to ask. There are a variety of dimensions to performance depending on various diseases, medical practices, and available resources for activities to improve health status of the region. Selection of dimensions may depend on various macro-level factors such as key health policy goals in the national health strategy for the next 10 years. At the same time, which value factors, such as efficiency, sustainability, equality, and effectiveness, are pursued and prioritized should also be considered. In addition, who determines what is good performance and who is the audience of performance indicators are the last but not the least important question that should be considered when performance indicators are selected (Carter et al., 1995) for a health atlas.

Indicators should be selected based on the following criteria (Holloway, et al, 1995):

> 1) timeliness, which is whether our data for indicators are available regularly and immediately at appropriate time intervals for detection of important trends and cycles;
> 2) sensitivity, to show direction and pace of important changes of key variables at intended levels;
> 3) specificity, which indicates a degree of certainty of causal relationship between variables;

4) validity, the level of confidence on goodness of the indicator, whether we are measuring what we intended to measure;

5) reliability, the degree to which the repeated measures of same objectives will not deviate much and produce the same results, other things being equal;

6) clarity, not ambiguous so that measurement is clear and explicit;

7) being accurate and free from potential contamination of results, such as Hawthorn effects;

8) cost-effectiveness, not too expensive to collect and analyze the data; and

9) feasibility so that data collection for the indicators can actually occur.

Selecting invalid or irrelevant indicators can bring unintended consequences like the followings (Smith, 1993). First, there can be *misrepresentation* of the underlying facts, such as manipulated accounting and fraud. Wrong choice of indicators can produce "creative" reporting that is not representative of the reality, especially when the reality is not successful or in a desirable status. This can lead to *gaming*, which is deliberate distortion of a measure, in order to secure strategic advantages. Deliberate choices of low or easy targets are such examples. Also, *misinterpretation,* biased understanding of facts, can occur due to the complexity of the environment in which the healthcare system operates. Similarly, *myopic judgment* can be a problem when longer-term objectives are neglected. Also, for conveniences or path-dependence reasons, *fixation of certain measures*, even if they are not effective to achieve specific performance indicators, can occur. By focusing on fixed measures, underlying objectives can be neglected. Also, *tunnel vision* can be a problem when some performance measures are unduly focused to the detriment of other important areas. It occurs when perspectives of implementers are limited by indicators, thus not paying attention to other important areas that the indicators do not cover. *Sub-optimisation* is another issue when managers pursue their own objectives without maximized attention to other objectives. Global objectives can be ignored by focusing on narrow and local ones. Finally, *ossification*, which is a strong unwillingness to change the conventional performance measure, can be undesirable consequences of wrong choice of indicators.

<Example: NHS 2016 Health Atlas Indicators>

One of the critical characteristics of the NHS Health Atlas is that the Atlas involves many stakeholders in the process of its creation, such as the National Clinical Directors at the NHS England, clinical leaders who are responsible for program budget categories, groups of patients, and those who practice certain types of services that are measured and presented in the Atlas, a number of Intelligence Teams at Public Health England, academics from the Rotal Colleges, staff members from the national audits, an etc.


In the Atlas 3.0, indicators reflected those of the programme budget categories (PBCs). Data of indicators are shown, for variation, as a column chart and map. The charts and maps are classified with colors, and the data are geographically specified as areas. Areas were divided into 5 ranking groups or "quintiles", where each group has a similar number of areas.

All indicators have error terms that represent the uncertainty level, mentioned as confidence intervals. As indicators are based on a random sample, uncertainties would be generated. Each indicator is relevant with 5 NHS Outcomes Framework 2015/16 Domains. Domain 1 represents prevention of people from premature death. Domain 2 is improving the quality of medical care for patients with long-term conditions. Domain 3 shows helping people recover from illness or injuries. Domain 4 means ensuring that people have a good healthcare service. Finally, Domain 5 shows treating people in a safe environment and protecting them from avoidable harms. All indicators belong to one or more of the following five categories: activity, cost, equity, outcome, performance quality, and safety (Figure 61).

Source: Public Health England, NHS England and NHS RightCare (2011).

Figure 56.

Category of Indicators in the NHS 2016 Health Atlas
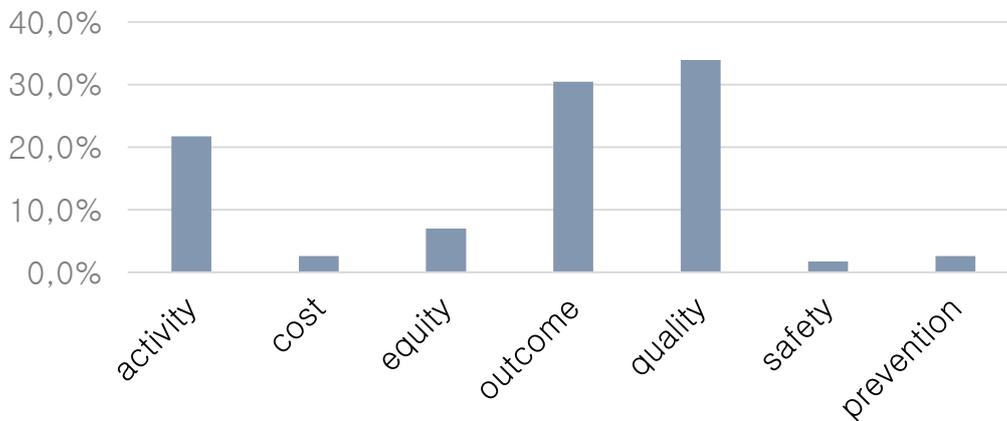
Source: The NHS 2016

Principle of Participatory Approach

When Kravchuk and Schack (1996) defined fundamental principles of performance-measurement design, the principles emphasized the importance of taking participatory approach. While it is important for performance measurement to start from a clear and systematic mission and develop explicit measurement strategies, Kravchuk and Schack noted that the strategies should include needs of all principals-users and the requirements of agents, or in other words, intergovernmental bodies. In doing so, to obtain credibility and avoid misunderstandings from key users and interested parties, the participation of *all* relevant stakeholders is recommendable. The active participation of every stakeholder can boost the measurement system improvement. One-size-fits-all measures should be avoided, and multiple users with diverse needs should not be neglected. Performance measurement in the public sector is required to specify the needs of all concerned parties. Lastly, throughout the whole process of measurement, all customers or interested parties should be involved. Especially, it is important to match the needs of customers with the requirements of the measures. In addition, balancing between the satisfaction and the needs of users is significant to meet both efficiency and quality of results.

Conclusion

Health atlases can be an effective health policy tool for various purposes. First of all, health atlases are useful tools for detecting and reducing unwarranted variations in health conditions and practices (Schang et al. 2014; P Boyle et al., 2008). Through effective communication and sharing of information among stakeholders (clinicians, policy makers, patient, and etc.), health atlases can generate health policy changes (Sir Muir Gray et al., 2010; J. Appleby et al., 2011). In addition, health atlases can be used as an effecive tool for evidence-based policy decision making along the stages of the policy cycle (PEW, 2014). They can be used for program assessment by allowing systematic review of information on the program effectiveness. By incorporating evidence of effectiveness of medical practices and health service programs, a health atlas can assist setting the priorities for resource allocation and budget development. At the same time, a health atlas can be used as an implementation oversight tool by ensuring effective implementation of health service programs and practices. Through routine measurement and reporting of the data on health conditions and performance outcomes, a health atlas can be used as a monitoring tool to determine if policy changes are producing intended outcomes.

Despite these advantages of health atlases as a policy tool for evidence-based decision-making, it seems that they are not utilized as much as they should be. Our systematic review of journal articles and grey literature related to health atlases shows that even when health atlases are used, they are used mostly as a "tin-opner" rather than a "dial". In most cases, health atlases are used to draw attention to the issues at hand and place the important issues on the policy agenda.

It is unfortunate that utlization of health atlases as a "dial" measure is still limited. To produce intended policy changes by using health atlases, not only financial and technical challenges, but also political challenges should be identified and resolved.

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[Appendix A] Search terms

#	Collective terms	Search terms
1	Health	medical, healthcare, health
2	Variation	care OR service OR treatment OR intervention OR access* OR uptake OR utili* OR use OR outcome
3	Atlas	atlas OR map OR 'geograph* variation'
Full search string		(#1[anywhere] AND #2[anywhere] AND #3[anywhere])

[Appendix B] Bibliographic information of all search results

#	Author	Year	Title	Journal
1	R. A. Hahn, G. W. Heath and M. H. Chang	1998	Cardiovascular disease risk factors and preventive practices among adults--United States, 1994: a behavioral risk factor atlas. Behavioral Risk Factor Surveillance System State Coordinators	MMWR CDC Surveill Summ
2	N. Gupta, P. Zurn, K. Diallo and M. R. Dal Poz	2003	Uses of population census data for monitoring geographical imbalance in the health workforce: snapshots from three developing countries	International Journal for Equity in Health
3	S. McLafferty and S. Grady	2004	Prenatal care need and access: a GIS analysis	J Med Syst
4	E. P. Havranek, P. Wolfe, F. A. Masoudi, S. S. Rathore, H. M. Krumholz and D. L. Ordin	2004	Provider and hospital characteristics associated with geographic variation in the evaluation and management of elderly patients with heart failure	Arch Intern Med
5	G. Raso, B. Matthys, E. K. N'Goran, M. Tanner, P. Vounatsou and J. Utzinger	2005	Spatial risk prediction and mapping of Schistosoma mansoni infections among schoolchildren living in western Cote d'Ivoire	Parasitology
6	M. Pollan, R. Ramis, N. Aragones, B. Perez-Gomez, D. Gomez, V. Lope, J. Garcia-Perez, J. M. Carrasco, M. J. Garcia-Mendizabal and G. Lopez-Abente	2007	Municipal distribution of breast cancer mortality among women in Spain	Bmc Cancer
7	N. Aragones, R. Ramis, M. Pollan, B. Perez-Gomez, D. Gomez-Barroso, V. Lope, E. I. Boldo, J. Garcia-Perez and G. Lopez-Abente	2007	Oesophageal cancer mortality in Spain: a spatial analysis	BMC Cancer
8	J. Friedly, L. Chan and R. Deyo	2008	Geographic variation in epidural steroid injection use in medicare patients	J Bone Joint Surg Am
9	P. Magan, A. Otero, A. Alberquilla and J. M. Ribera	2008	Geographic variations in avoidable hospitalizations in the elderly, in a health system with universal coverage	BMC Health Serv Res
10	R. A. Neff, F. C. Curriero and T. A. Burke	2008	Just in the wrong place...?: geographic tools for occupational injury/illness surveillance	Am J Ind Med
11	B. Goldsmith, J. Dietrich, Q. L. Du and R. S. Morrison	2008	Variability in Access to Hospital Palliative Care in the United States	Journal of Palliative Medicine
12	T. Pouliou and S. J. Elliott	2009	An exploratory spatial analysis of overweight and obesity in Canada	Preventive Medicine
13	N.-B. Kandala, J. B. Emina, P. D. K. Nzita and F. P. Cappuccio	2009	Diarrhoea, acute respiratory infection, and fever among children in the Democratic Republic of Congo	Social Science & Medicine
14	D. G. Moriarty, M. M. Zack, J. B. Holt, D. P. Chapman and M. A. Safran	2009	Geographic Patterns of Frequent Mental Distress: U.S. Adults, 1993–2001 and 2003–2006	American Journal of Preventive Medicine
15	C. Armero, A. Forte and A. López-Quílez	2009	Geographical variation in pharmacological prescription	Mathematical & Computer Modelling
16	C. Faure, A. Mollie, S. Bellec, A. Guyot-Goubin, J. Clavel and D. Hemon	2009	Geographical variations in the incidence of childhood acute leukaemia in France over the period 1990-2004	European Journal of Cancer Prevention
17	C. Tottrup, B. P. Tersbol, W. Lindeboom and D. Meyrowitsch	2009	Putting child mortality on a map: towards an understanding of inequity in health	Trop Med Int Health

18	M. Movahedi, B. Hajarizadeh, A. Rahimi, M. Arshinchi, K. Amirhosseini and A. A. Haghdoost	2009	Trends and geographical inequalities of the main health indicators for rural Iran	Health Policy and Planning
19	A. C. Hegarty, A. E. Carsin and H. Comber	2010	Geographical analysis of cancer incidence in Ireland: a comparison of two Bayesian spatial models	Cancer Epidemiol
20	P. Odton, C. Choonpradub and K. Bundhamcharoen	2010	GEOGRAPHICAL VARIATIONS IN ALL-CAUSE MORTALITY IN THAILAND	Southeast Asian Journal of Tropical Medicine and Public Health
21	S. M. Cramb, K. L. Mengersen and P. D. Baade	2011	Developing the atlas of cancer in Queensland: methodological issues	Int J Health Geogr
22	B. Ibanez-Beroiz, J. Librero-Lopez, S. Peiro-Moreno and E. Bernal-Delgado	2011	Shared component modelling as an alternative to assess geographical variations in medical practice: gender inequalities in hospital admissions for chronic diseases	Bmc Medical Research Methodology
23	W. Tu, S. Tedders and J. Tian	2011	An exploratory spatial data analysis of low birth weight prevalence in Georgia	Applied Geography
24	W. C. Chan, J. Law and P. Seliske	2012	Bayesian spatial methods for small-area injury analysis: a study of geographical variation of falls in older people in the Wellington-Dufferin-Guelph health region of Ontario, Canada	Injury Prevention
25	L. Kazembe, A. Clarke and N. B. Kandala	2012	Childhood mortality in sub-Saharan Africa: cross-sectional insight into small-scale geographical inequalities from Census data	Bmj Open
26	G. Martin, C. P. Keller and L. T. Foster	2012	Constructing a Composite Adolescent Health and Wellness Index for British Columbia, Canada Using a Spatial Multi-Criteria Analysis Approach	Child Indicators Research
27	R. J. S. Magalhaes, A. Langa, J. C. Sousa-Figueiredo, A. C. A. Clements and S. V. Nery	2012	Finding malaria hot-spots in northern Angola: the role of individual, household and environmental factors within a meso-endemic area	Malaria Journal
28	Y. T. Zhang, M. A. Steinman and C. M. Kaplan	2012	Geographic Variation in Outpatient Antibiotic Prescribing Among Older Adults	Archives of Internal Medicine
29	J. M. Whedon and Y. J. Song	2012	GEOGRAPHIC VARIATIONS IN AVAILABILITY AND USE OF CHIROPRACTIC UNDER MEDICARE	Journal of Manipulative and Physiological Therapeutics
30	A. Earnest, S. B. Tan, N. Shahidah and M. E. H. Ong	2012	Geographical Variation in Ambulance Calls Is Associated With Socioeconomic Status	Academic Emergency Medicine
31	R. A. Cooper, M. A. Cooper, E. L. McGinley, X. Fan and J. T. Rosenthal	2013	Poverty, wealth, and healthcare utilization: a geographic assessment	J Urban Health
32	B. W. Wheeler, G. Kothencz and A. S. Pollard	2013	Geography of non-melanoma skin cancer and ecological associations with environmental risk factors in England	British Journal of Cancer
33	K. Deribe, S. J. Brooker, R. L. Pullan, A. Hailu, F. Enquselassie, R. Reithinger, M. Newport and G. Davey	2014	Spatial distribution of podoconiosis in relation to environmental factors in Ethiopia: a historical review	PLoS One
34	T. L. Penney, D. G. C. Rainham, T. J. B. Dummer and S. F. L. Kirk	2014	A spatial analysis of community level overweight and obesity	Journal of Human Nutrition & Dietetics

35	N. B. Kandala, T. P. Mandungu, K. Mbela, K. P. D. Nzita, B. B. Kalambayi, K. P. Kayembe and J. B. O. Emina	2014	Child mortality in the Democratic Republic of Congo: cross-sectional evidence of the effect of geographic location and prolonged conflict from a national household survey	Bmc Public Health

36	F. Smieliauskas, H. MacMahon, R. Salgia and Y. C. T. Shih	2014	Geographic Variation in Radiologist Capacity and Widespread Implementation of Lung Cancer CT Screening	Journal of Medical Screening
37	P. Hystad, M. Brauer, P. A. Demers, K. C. Johnson, E. Setton, A. Cervantes-Larios, K. Poplawski, A. McFarlane, A. Whitehead and A. M. Nicol	2014	Geographic variation in radon and associated lung cancer risk in Canada	Canadian Journal of Public Health-Revue Canadienne De Sante Publique
38	R. L. Pullan, J. L. Smith, R. Jasrasaria and S. J. Brooker	2014	Global numbers of infection and disease burden of soil transmitted helminth infections in 2010	Parasites & Vectors
39	E. T. Mwase, A. S. Stensgaard, M. Nsakashalo-Senkwe, L. Mubila, J. Mwansa, P. Songolo, S. T. Shawa and P. E. Simonsen	2014	Mapping the Geographical Distribution of Lymphatic Filariasis in Zambia	Plos Neglected Tropical Diseases
40	S. Clouston, R. Kidman and T. Palermo	2015	Social inequalities in vaccination uptake among children aged 0-59 months living in Madagascar: an analysis of Demographic and Health Survey data from 2008 to 2009	Vaccine
41	K.-S. Lee and H.-J. Kwon	2015	Analyzing the geographic distribution of major medical equipment with smart geographic system	Journal of Supercomputing
42	Z. Tatalovich, L. Zhu, A. Rolin, D. R. Lewis, L. C. Harlan and D. M. Winn	2015	Geographic disparities in late stage breast cancer incidence: results from eight states in the United States	Int J Health Geogr
43	S. Y. Gebreab, S. K. Davis, J. Symanzik, G. A. Mensah, G. H. Gibbons and A. V. Diez-Roux	2015	Geographic Variations in Cardiovascular Health in the United States: Contributions of State- and Individual-Level Factors	Journal of the American Heart Association
44	Z. Maigeng, T. Astell-Burt, B. Yufang, F. Xiaoqi, J. Yong, L. Yichong, A. Page, W. Limin, X. Yu, W. Linhong, Z. Wenhua and N. Guang	2016	Geographical Variation in Diabetes Prevalence and Detection in China: Multilevel Spatial Analysis of 98,058 Adults	Diabetes Care
45	J. R. Ehrlich, R. Anthopolos, J. Tootoo, C. A. Andrews, M. L. Miranda, P. P. Lee, D. C. Musch and J. D. Stein	2016	Assessing Geographic Variation in Strabismus Diagnosis among Children Enrolled in Medicaid	Ophthalmology
46	T. Setegn, Y. Lakew and K. Deribe	2016	Geographic Variation and Factors Associated with Female Genital Mutilation among Reproductive Age Women in Ethiopia: A National Population Based Survey	PLoS One
47	M. C. Schroeder, Y. Y. Tien, K. Wright, T. R. Halfdanarson, T. Abu-Hejleh and J. M. Brooks	2016	Geographic variation in the use of adjuvant therapy among elderly patients with resected non-small cell lung cancer	Lung Cancer
48	K. L. Bassil, J. M. Yang, L. Arbour, R. Moineddin, M. E. Brindle, E. Hazell and E. D. Skarsgard	2016	Spatial variability of gastroschisis in Canada, 2006-2011: An exploratory analysis	Canadian Journal of Public Health-Revue Canadienne De Sante Publique

[Appendix C] A List of Health Atlas Reports

Note: Yellow cells are the representative reports of each categories

#	Organization	Country	Year	Report
1	The Dartmouth Atlas of Healthcare	USA	2016	Our Parents, Ourselves: Healthcare for an Aging Population
2	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions
3	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: Prostate Cancer
4	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: End-Stage Renal Disease
5	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: Spinal Stenosis
6	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: Diabetes and Peripheral Arterial Disease
7	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: Cerebral Aneurysms
8	The Dartmouth Atlas of Healthcare	USA	2014	Variation in the Care of Surgical Conditions: Obesity
9	The Dartmouth Atlas of Healthcare	USA	2013	The Dartmouth Atlas of Children's Healthcare in Northern New England
10	The Dartmouth Atlas of Healthcare	USA	2013	The Dartmouth Atlas of Medicare Prescription Drug Use
11	The Dartmouth Atlas of Healthcare	USA	2013	Trends in Cancer Care Near the End of Life: A Dartmouth Atlas of Healthcare Brief
12	The Dartmouth Atlas of Healthcare	USA	2013	Measuring Up? End-of-Life Cancer Care in California
13	The Dartmouth Atlas of Healthcare	USA	2013	Tracking Improvement in the Care of Chronically Ill Patients: A Dartmouth Atlas Brief on Medicare Beneficiaries Near the End of Life
14	The Dartmouth Atlas of Healthcare	USA	2013	End-of-Life Care in California: You Don't Always Get What You Want

15	The Dartmouth Atlas of Healthcare	USA	2013	The Revolving Door: A Report on U.S. Hospital Readmissions
16	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the Pacific States
17	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the Mountain States
18	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the West South Central Region
19	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the Great Plains Region
20	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the East South Central Region
21	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the Great Lakes Region
22	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the South Atlantic Region
23	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the Middle Atlantic Region
24	The Dartmouth Atlas of Healthcare	USA	2012	Improving Patient Decision-Making in Healthcare: A 2012 Dartmouth Atlas Report Highlighting the New England Region
25	The Dartmouth Atlas of Healthcare	USA	2012	What Kind of Physician Will You Be? Variation in Healthcare and Its Importance for Residency Training
26	The Dartmouth Atlas of Healthcare	USA	2012	What Kind of Physician Will You Be? End-of-Life Care and Its Effect on Residency Training
27	The Dartmouth Atlas of Healthcare	USA	2011	After Hospitalization: A Dartmouth Atlas Report on Post-Acute Care for Medicare Beneficiaries

28	The Dartmouth Atlas of Healthcare	USA	2011	Care About Your Care: Tips for Patients When They Leave the Hospital
29	The Dartmouth Atlas of Healthcare	USA	2011	A New Series of Medicare Expenditure Measures by Hospital Referral Region: 2003-2008
30	The Dartmouth Atlas of Healthcare	USA	2011	Trends and Variation in End-of-Life Care for Medicare Beneficiaries with Severe Chronic Illness
31	The Dartmouth Atlas of Healthcare	USA	2011	Improving Patient Decision-Making in Healthcare: A 2011 Dartmouth Atlas Report Highlighting Minnesota
32	The Dartmouth Atlas of Healthcare	USA	2010	Quality of End-of-Life Cancer Care for Medicare Beneficiaries: Regional and Hospital-Specific Analyses
33	The Dartmouth Atlas of Healthcare	USA	2010	Regional and Racial Variation in Primary Care and the Quality of Care Among Medicare Beneficiaries
34	The Dartmouth Atlas of Healthcare	USA	2010	Trends and Regional Variation in Hip, Knee, and Shoulder Replacement
35	The Dartmouth Atlas of Healthcare	USA	2010	Trends and Regional Variation in Carotid Revascularization
36	The Dartmouth Atlas of Healthcare	USA	2009	Hospital and Physician Capacity Update
37	The Dartmouth Atlas of Healthcare	USA	2009	Healthcare Spending, Quality, and Outcomes: More Isn't Always Better
38	The Dartmouth Atlas of Healthcare	USA	2009	The Policy Implications of Variations in Medicare Spending Growth
39	The Dartmouth Atlas of Healthcare	USA	2008	An Agenda for Change: Improving Quality and Curbing Healthcare Spending: Opportunities for the Congress and the Obama Administration
40	The Dartmouth Atlas of Healthcare	USA	2008	Regional and Racial Variation in Healthcare Among Medicare Beneficiaries
41	The Dartmouth Atlas of Healthcare	USA	2008	Disparities in Health and Healthcare Among Medicare Beneficiaries
42	The Dartmouth Atlas of Healthcare	USA	2008	Tracking the Care of Patients with Severe Chronic Illness: The Dartmouth Atlas of Healthcare 2008

43	The Dartmouth Atlas of Healthcare	USA	2007	Effective Care
44	The Dartmouth Atlas of Healthcare	USA	2007	Preference-Sensitive Care
45	The Dartmouth Atlas of Healthcare	USA	2007	Supply-Sensitive Care
46	The Dartmouth Atlas of Healthcare	USA	2006	Spine Surgery
47	The Dartmouth Atlas of Healthcare	USA	2006	The Care of Patients with Severe Chronic Illness: A Report on the Medicare Program: The Dartmouth Atlas of Healthcare 2006
48	The Dartmouth Atlas of Healthcare	USA	2006	Trends and Regional Variations in Abdominal Aortic Aneurysm Repair
49	The Dartmouth Atlas of Healthcare	USA	2005	Cardiac Surgery
50	The Dartmouth Atlas of Healthcare	USA	2000	The Dartmouth Atlas of Healthcare in Virginia
51	The Dartmouth Atlas of Healthcare	USA	2000	The Dartmouth Atlas of Healthcare in Michigan
52	The Dartmouth Atlas of Healthcare	USA	2000	The Dartmouth Atlas of Musculoskeletal Healthcare
53	The Dartmouth Atlas of Healthcare	USA	2000	The Dartmouth Atlas of Vascular Healthcare
54	The Dartmouth Atlas of Healthcare	USA	1999	The Dartmouth Atlas of Cardiovascular Healthcare
55	The Dartmouth Atlas of Healthcare	USA	1999	The Quality of Medical Care in the United States: A Report on the Medicare Program: The Dartmouth Atlas of Healthcare 1999
56	The Dartmouth Atlas of Healthcare	USA	1998	The Dartmouth Atlas of Healthcare 1998
57	The Dartmouth Atlas of Healthcare	USA	1998	The Dartmouth Atlas of Healthcare in Pennsylvania
58	LA Health atlas	USA	2013	Health atlas for the city of Los Angeles
59	California Health atlas	USA	2004	California Perspectives In Healthcare
60	Australian Commission on Safety and Quality in	Australria	2015	Australian Atlas of Healthcare Variation

	Healthcare			
61	The Environment and Health Atlas for England and Wales	UK	1985~2009	The Environment and Health Atlas for England and Wales
62	NHS atlas_UK	UK	2010	The NHS Atlas of Variation in Healthcare
63	NHS atlas_UK	UK	2011	The NHS Atlas of Variation in Healthcare
64	NHS atlas_UK	UK	2015	The NHS Atlas of Variation in Healthcare
65	NHS atlas_UK	UK	2012	NHS Atlas of Variation in Healthcare for Children and Young People
66	NHS atlas_UK	UK	2012	NHS Atlas of Variation in Diabetes
67	NHS atlas_UK	UK	2012	NHS Atlas of Variation in Healthcare for People with Kidney Disease
68	NHS atlas_UK	UK	2012	NHS Atlas of Variation in Healthcare for People with Respiratory Disease
69	NHS atlas_UK	UK	2013	The NHS Atlas of Variation in Diagnostic Services
70	NHS atlas_UK	UK	2013	NHS Atlas of Variation for Liver Disease
71	NHS atlas_UK	UK	2017	The NHS Atlas of Variation in Diagnostic Services
72	CANADA_ Institute for Clinical Evaluative Sciences	Canada	1999	Supply of Physicians' Services in Ontario
73	CANADA_ Institute for Clinical Evaluative Sciences	Canada	1999	Cardiovascular Health and Services in Ontario: An ICES Atlas
74	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2000	Fiscal Changes for Core Mental Health Services Delivered by Fee-for-Service Physicians
75	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2000	Fee-for-Service Core Mental Health Services: Changes in Provider Source and Visit Frequency

76	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2001	Outpatient Health Services Use by Children in Ontario
77	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2001	Inpatient and Day Surgery Use by Children in Ontario
78	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2001	Emergency Department Services in Ontario
79	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2001	Adding Years to Life and Life to Years: Life and Health Expectancy in Ontario
80	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2003	Diabetes in Ontario: An ICES Practice Atlas
81	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2004	Use of Large Bowel Procedures in Ontario
82	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2004	Arthritis and Related Conditions in Ontario: ICES Research Atlas. 2nd Edition
83	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2005	Injuries in Ontario: ICES Atlas
84	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2005	Access to Health Services in Ontario: ICES Atlas
85	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2006	Primary Care in Ontario: ICES Atlas
86	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2006	Access to Health Services in Ontario: ICES Atlas. 2nd Edition
87	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2007	Neighbourhood Environments and Resources for Healthy Living — A Focus on Diabetes in Toronto: ICES Atlas.
88	CANADA_ Institute for Clinical Evaluative	Canada	2008	Cancer Surgery in Ontario: ICES Atlas

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	Sciences			
89	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2006	CCORT Canadian Cardiovascular Atlas
90	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2013	Atlas on the Primary Care of Adults with Developmental Disabilities in Ontario
91	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2015	Atlas of Childhood Cancer in Ontario 1985-2004
92	CANADA_ Institute for Clinical Evaluative Sciences	Canada	2015	Head and Neck Cancer Surgery in Ontario, 2003–2010: An ICES Atlas
93	Canada_British Columbia Health Atlas	Canada	2007-2011	British Columbia Community Health Atlas