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Interactive data visualization based on conventional statistical findings for antihypertensive prescriptions using National Health Insurance claims data

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ABSTRACT

Background: Interactive visualization is an important approach to help to understand and to explain large amounts of data, particularly in light of decision support. Although data visualization have been introduced in healthcare and clinical fields, analytics has often been performed by data experts, focused on specific subjects, or insufficient statistical evidence. Therefore, this study suggests the procedures of effective and efficient visualization of big data for general healthcare researchers. Specifically, the procedure includes conventional regression analyses followed by interactive data visualization for prescription patterns of antihypertensive drugs.
Methods: As a large-scale nationally representative prescription data, the Korean National Health Insurance claims data were collected. Conventional descriptive and regression analyses were conducted for therapy decision and prescription patterns using the software R. Then, based on the statistically significant findings, dashboards were developed to visualize interactively the patterns of prescriptions using the software Tableau.
Results: Major characteristics (genders, age groups, healthcare institutions, and comorbidities) explained the differences in therapy and the average number of drugs prescribed as well as differences among most commonly prescribed drug classes. Two interactive dashboards were created for visualizing prescription patterns with incorporation of horizontal bar charts, packed bubble charts, treemaps, filled maps, radar charts, box and whisker plots, and filters.
Conclusion: In the current big data era, interactive data visualization offers substantial opportunities to have comprehensive view, extract insights and evidence from the flood of vast amounts of data. This study's interactive visualizations can provide healthcare professionals insight into prescription patterns and demonstrate the value of creating interactive dashboards to support informed and timely decision-making. Exploring big data using interactive visualization is expected to deliver many future benefits in healthcare fields.

What was known before the study

- Healthcare big data have an important role to provide information and knowledge. Understanding and utilizing the big data has the potential to improve care and lower costs by discovering associations and understanding patterns within the data.
- Although data visualization have been introduced in healthcare and clinical fields, analytics has often been performed by data experts, focused on specific subjects, or insufficient statistical evidence.
- Antihypertensive drug prescription patterns and trends have been changed according to time and analyzed with insufficiently explorative in terms of all integration points in Korea.

What the study has added to the body of knowledge

- This study suggested the procedures of effective and efficient visualization of big data for general healthcare researchers. Healthcare professionals can make interactive visualizations with easy and fast interfaces using Tableau.
- As a two-step approach, the analysis procedure includes conventional regression analyses followed by interactive data visualization for a variety of big data in health care fields.
- This study's interactive visualizations can provide healthcare professionals insight into prescription patterns and demonstrate the value of creating interactive dashboards to support informed and prompt decision-making.
- Interactive visualizations of healthcare big data enable healthcare professionals to reason and make sense of vast and complex claims

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data, to reveal and retrieve salient information, and ultimately to build fundamental knowledge.

1. Introduction

The volume of various data being digitally collected and stored, especially healthcare data that are very large and complex, is enormous and expanding rapidly. As a result, data management and analysis skills are also evolving to transform big data into information and knowledge [1]. The National Health Insurance (NHI) database is released as open public information in conformity with the "Government 3.0" initiative in Korea. Healthcare professionals are faced with the challenge of extracting salient information from healthcare big data to construct knowledge infrastructure and make appropriate and timely decisions [2]. To take advantage of healthcare big data, big data analytics are needed to create understanding and actionable conclusions. Understanding and utilizing big data has the potential to improve care and lower costs by discovering associations and understanding patterns within the data.

Although big data analytics has often been performed by data experts such as computer scientists or statisticians, healthcare professionals have also been interested in visualization methods to maximize the impact of the study results [3,4]. Therefore, several visualization methods have been introduced in healthcare and medicine fields. Most commonly, visualizations of text data were presented by extracting the frequencies of keywords and topics in the field [5,6], and a visual analytics system was proposed in medical diagnosis and computationally-enhanced analysis system applied to biomedical domain [7,8]. Visual data mining using interactive and scalable network and analytic techniques have also been used for effective exploration and communication of ideas within various biological and biomedical domains [9,10]. However, these methods are still too professional for general healthcare or clinical researchers to conduct big data analytics, especially interactive visualization approach.

Visualization is an overarching theme across applications of healthcare big data analytics [11]. Especially, interactive visualization is an important approach to helping big data analytics get a comprehensive view of data and discover information. It also enables researchers to gain insights and evidence for improved outcomes and supports better informed decision-making through the analysis of large-scale data [12,13]. Moreover, it can facilitate and expedite knowledge translation and dissemination [2]. Big data visualization approaches are used to display more than one view per representation, with dynamic changes in the numbers of factors and filtering [14].

Data visualization software offers the ability to handle large data sets even in situations with limited human and financial resources [15]. With Tableau software using interactive visualization, users can drag and drop, drill down, and filter data to create visualizations easily and make interactive dashboards quickly, connect to more data such as SQL databases, spreadsheets, cloud apps, and so on. Tableau Desktop can be used for free for academic purposes. Also, interactive dashboards which are easy to publish and share on Tableau Public blogs help users find hidden insights with multiple views.

From health care and clinical perspectives, hypertension shows high prevalence worldwide, and it leads to related chronic diseases with a high risk of mortality. It is important to control blood pressure to prevent hypertension-related diseases, and drug therapy has been found to be cost-effective to control blood pressure [16]. Expenditures for patients with hypertension who are treated with medication and antihypertensive drugs have increased, and antihypertensive drug prescription patterns and trends change over time [17–20].

It is vital to explore the healthcare big data and recent trends in antihypertensive medication use and changes in drug use patterns within data. Based on this exploration, clear interactive visualizations can be made through the analysis of big data, insights can be obtained, and conclusions may be drawn based on these insights. Therefore, interactive visualization is an important approach to help to understand and to explain large-scale nationally representative prescription data, particularly in light of decision support.

For effective and efficient visualization of big data, this study followed a two-step approach. In the first step, conventional regression models are constructed to evaluate significant factors on therapy and prescription patterns. In the second step, based on the statistical findings of the first step, interactive dashboards are suggested for visualizing prescription patterns such as volume and composition of drugs.

2. Methods

2.1. Database and patients

This study analyzed the Korean NHI claims data, the 3% patient sample which is extracted from the national population using a stratified randomized sampling method by Health Insurance Review and Assessment Service (HIRA). The HIRA-NPS (national patient sample) is a relational database of five tables: (1) a table for general information of prescription specification (Table 20) containing demographic information, such as gender, age, and indicators for inpatient and outpatient services; (2) a table for specific information on services provided (Table 30); (3) a table for diagnostic information (Table 40); (4) a table for outpatient prescriptions (Table 53) with each unique key ID; and (5) a table for information on healthcare service providers (Table of providers). All tables are linkable using a key ID [21].

Hypertension patients were those diagnosed I10, I11, I12, I13, and I15 according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10). The final database includes 1,550,273 prescriptions of 204,917 hypertensive outpatients prescribed antihypertensive drugs.

2.2. Antihypertensive drugs and their classification

All antihypertensive drugs defined in this study are based on related research and definitions [19,20,22–24]. To extract antihypertensive drugs, we used the Anatomical Therapeutic Chemical (ATC) classification system of the World Health Organization (WHO) Collaborating Centre for Drug Statistics Methodology and a drug list from the Korea Pharmaceutical Information Service (KPIS) center [25,26]. The ATC codes of antihypertensive drugs used in this study are the following: antihypertensives (C02), diuretics (C03), beta-blocking agents (C07), calcium channel blockers (C08), agents acting on the renin–angiotensin system (C09), terazosin (G04CA03), and combinations (C03EA, C07BB, C07CB, C07FB, C09B, C09D). The KPIS drug list includes the ATC codes and the Korean main ingredient codes of Ministry of Health and Welfare. We extracted 6471 drugs using the ATC codes of antihypertensive drugs, but the main-ingredient codes of 1467 drugs were missing. We reviewed and mapped 150 main-ingredient codes manually using the Korean drug information database websites [26,27]. The final antihypertensive drugs list contains 204 main-ingredient codes of 6332 drugs mapped with HIRA-NPS.

We reclassified the extracted ATC codes as the following six drug types called antihypertensive drug classes: angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), beta blockers (BB), calcium channel blockers (CCB), diuretics, and others (alpha blockers, vasodilators, and so on). In addition, therapy is defined as the number of antihypertensive drug classes in prescriptions. Prescribing drugs from one drug class is considered monotherapy, whereas prescribing drugs from two or more drug classes is considered combination therapy. Single pill combinations are also considered combination therapy except for thiazide diuretics/aldosterone antagonists, which were categorized as diuretics in monotherapy.

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