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Analyzing Patient-Sharing Network Using an Administrative Claim Database in Japan

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Abstract. We analyzed the behavior of patient with a focus on patient-sharing based on the methodology of network analysis. We used an administrative healthcare claims database from September of the years 2008-2020 to identify shared patients with hypertension. The patients' behavior of visiting multiple medical facilities was extracted as graphical data, and we calculated density and centrality as indicators to evaluate the structure of the patient sharing network. Our findings indicate that density, reciprocity, and transitivity increased over time, and that centrality and PageRank were correlated.

Keywords. Administrative claims database, patient-sharing network, network analysis

1. Introduction

The development of a treatment coordination system has been becoming a fundamental part of the healthcare delivery system. Patient sharing networks has been shown to contribute to both the efficiency and effectiveness of managing patient chronic conditions [1,2]. Given policies related to medical coordination include decisions regarding healthcare resource allocation by local area, it is crucial to evaluate how patient-sharing network have worked by each municipal region over time.

Previous studies have challenged social network analyses using administrative data to identify networks based on patient-sharing, a treatment system by coordination among physicians [3,4]. Previous studies have not deal with evaluation for changes of patient-sharing network over time. In addition, these studies may be unsatisfactory for generalization to patient-sharing among facilities due to several limitations. First, much of studies have focused on not network among facilities but among physicians. Second, they used administrative database targeted only specific insured populations who authorized based on mainly age or disability status [3]. Third, areas on these studies did not have hierarchical structure of facilities at healthcare delivery system [4]. In other words, these limitations cause issues that analyzing by selection partly patient population may be barriers for understanding the overall network structure. This issue is critical for Japan's healthcare delivery system, which is based on a universal health insurance system and requires to share roles by medical facilities.

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This study identified patient-sharing network among medical facilities and evaluated quantitatively its structure, aiming to propose a method to assess the overall sharing network. In this paper, we illustrated the availability of the method by case study of patient with hypertension.

2. Methods

2.1. Data Source

We obtained data from the administrative database of public health insurance claims in Mie Prefecture, Japan. The database stores information related to the National Health Insurance and Advanced Elderly Medical Service System [5]; those covered are self-employed individuals as well as retirees and their dependents aged 75 years or above. The database includes information of dates of visits, diagnoses, and expenditures. The diagnosis information is recorded using the International Classification of Diseases 10th Revision (ICD-10) codes and Japanese diagnosis codes. With links to insurance information, the database includes patients' sex, date of birth.

All information used was de-identified and this study was exempt from review by the Ethics Committee of Institute for Health Economics and Policy, Japan (approval number: H30-006). The requirement for informed consent was waived because of the anonymized nature of the data in the database.

2.2. Identifying the Patients and Facilities Constructing Sharing Network

In this study, we assumed that patient-sharing between medical facilities occurs when a patient visits multiple medical facilities for the same disease. The number of common patients reflects the degree of sharing between facilities. To identify this coordination, we used the data for September of each year from 2018 to 2021 and identified patients with hypertension by confirmed diagnosis record (ICD10: I10-I15). Patient age and sex as of the earliest date of visit during the observation period.

We identified the date of the patient's visit and the medical facility they visited on that time. Facilities were defined as nodes in the network graph. Paired facilities were considered to have links (i.e. edges) if same patient visit.

2.3. Variable Outcome: Network Structure Indicators

We calculate density, transitivity, and reciprocity as indicators to evaluate network structure [2,3,6,7].

Density of a network graph is the frequency of realized links relative to potential links. The density is the sum of the links divided by the number of possible links. A value of one means every directed relationship is present, and a lower value means fewer links.

Reciprocity describes the degree to which a member has mutual connections to another nodes, and it is an indicator for measurement of mutuality of patient-sharing network.

Transitivity describes the tendency between two nodes in the network to be connected if they share a common mutual neighbor node. For example, in direct relations

with three members, if A share with B, and B share with C, then A is likely to share C without direct connections.

2.4. Variable Outcome: Provider-Level Indicators

We calculated betweenness centrality, degree, and PageRank (PR), based on network ranking algorithms, as indicators to evaluate the importance of medical institutions in the patient-sharing network [7-10]. Degree, the simplest centrality measure, is the number of links incident on a node in a network—the number of ties a facility has in the network [9]. Betweenness centrality is centric-based indicators, and measures how influential a node is in maintaining the network structure [9]. A node with high betweenness centrality means that the node tends to exist on many shortest paths between other pair of nodes in the network. PR calculates the rank of a node by using the number of nodes with which it is connected [10]. This approach determines the importance of a facility based on the size of the hypothetical patients coming through the facility.

We illustrated the association between three indicators in 2021 by bubble chart. Then, to limit the effects of scales and outliers, we corrected for them by log transformation. In addition, we visualized the density distribution of facilities in the betweenness for each group divided by PR quartiles.

3. Results

Table 1 shows characteristics of patients and facilities involved in patient-sharing. We identified 163,981 patients visit with hypertension in September of each year from 2018 to 2019. Of these, 33,057 (20.2%) visited multiple medical facilities. Patients who visited at least once with diagnosed hypertension decreased during the observation period. In contrast, the proportion of shared patients to the number of patients showed an increasing trend from 2018 to 2020.

Table 1. Characteristics of patients, facilities and network.

Characteristics	2018	2019	2020	2021	Overall
Patients					
n, visit	70,559	71,421	68,411	65,794	163,981
n, visit multiple facilities	11,352	11,833	11,582	11,438	33,057
Proportion of Shared Patients (%)	16.1%	16.6%	16.9%	17.3%	20.2%
Age, mean (SD)	78.1 (8.7)	78.5 (8.6)	78.4 (9.0)	78.5 (8.9)	78.6 (8.9)
Sex, Female (%)	6,090 (53.6%)	5,402 (45.7%)	5,466 (47.2%)	6,026 (52.7%)	17,589 (53.2%)
Facilities					
n, Facilities	1,685	1,649	1,563	1,492	2,532
Bed, mean (SD)	172.3 (211.7)	164.5 (202.6)	172.8 (207)	172.6 (207.2)	176.7 (198.3)

Table 2. The indicators of patient-sharing network.

Characteristics	2018	2019	2020	2021	Overall
Network					
Density	5.23×10^{-2}	5.81×10^{-2}	6.12×10^{-2}	6.13×10^{-2}	-
Reciprocity	4.39×10^{-1}	5.12×10^{-1}	6.07×10^{-1}	6.51×10^{-1}	-
Transitivity	7.09×10^{-2}	7.53×10^{-2}	8.32×10^{-2}	8.37×10^{-2}	-

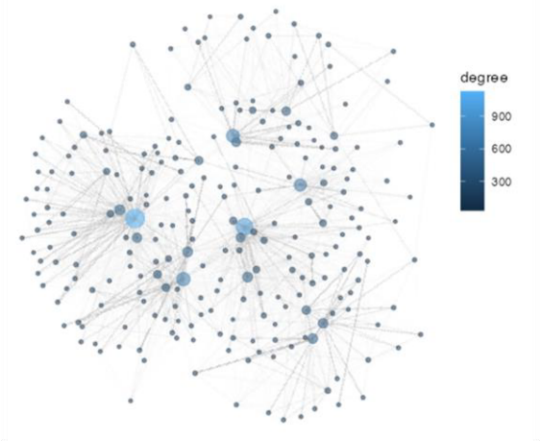

Figure 1. Patient-sharing network diagram in 2021.

Figure 1 depicts the patient-sharing network diagram in 2021. As shown Table 2, the indicators of this network structure (density, mutuality, and transitivity) increased during the observation period, respectively.

Figure 2 a bubble chart of the relationship between PR, centrality, and degree in 2021. The centrality and PR were statistically significantly correlated (0.930 [95% confidence interval: 0.919, 0.939], p<0.001). Similar correlations were found for 2018-2020. On the other hand, the deviation of centrality was necessarily higher in medical facilities with lower PR. The betweenness distribution divided by PR quartiles showed the betweenness was widely distributed in the lower PR group.

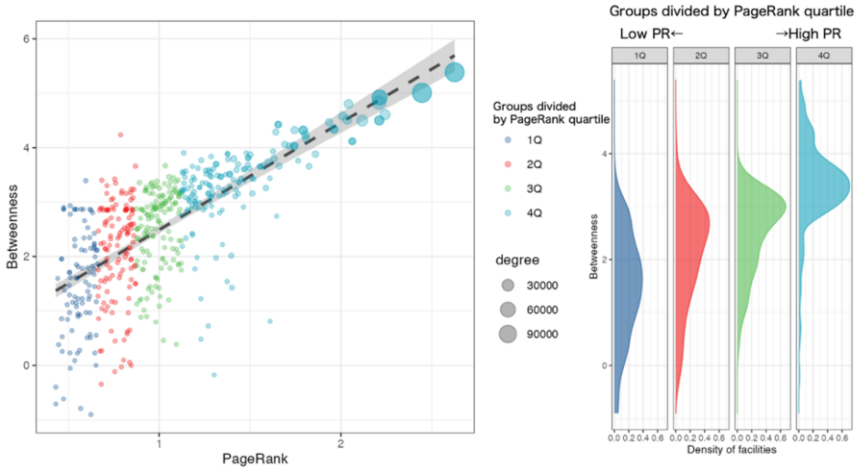

Figure 2. Bubble chart between three indicators and density of facilities betweenness by PR quartile in 2021.

4. Discussion

The increase in the proportion of patients shared by multiple facilities may indicate an increase in the demand for patient-sharing. This finding is supported by the increase in the density in the network structure. Furthermore, our results showed increasing tendency for facilities to share patients with each other rather than in a one-to-one relationship as suggested by the increase in reciprocity and transitivity over time. These results are consistent with Japanese healthcare policy, which includes additional reimbursement to promote medical collaboration.

The patient sharing network diagram enabled us to confirm hub facilities of the collaboration. The relationship between PR and centrality was evaluated, and it was confirmed correlation between them. Therefore, being connected to many facilities is considered to play a major role in constructing the patient-sharing network. The deviation of the betweenness distribution may indicate that a low PR does not necessarily indicate low betweenness. Therefore, further analysis of the function of facilities with few links would provide a more detailed understanding of facility collaboration.

5. Conclusions

We challenged network analysis using the claims database to assess a structure of the patient-sharing network. Although facilities with many links play a major role in the construction of the network , some facilities with few links also have an influence.

References

[1] Du X, Patel A, Anderson CS, Dong J, Ma C. Epidemiology of cardiovascular disease in China and opportunities for improvement: JACC international. J Am Coll Cardiol. 2019 Jun;73(24):3135-47, doi: 10.1016/j.jacc.2019.04.036.

[2] Barnett ML, Christakis NA, O'Malley AJ, Onnela JP, Keating NL, Landon BE. Physician patient-sharing networks and the cost and intensity of care in US hospitals. Med Care. 2012 Feb;50(2):152-60, doi: 10.1097%2FMLR.0b013e31822dcef7.

[3] Landon BE, Keating NL, Barnett ML, Onnela JP, Paul S, O'Malley AJ, Keegan T, Christakis NA. Variation in patient-sharing networks of physicians across the United States. JAMA. 2012 Jul;308(3):265-73, doi: 10.1001/jama.2012.7615.

[4] Hu H, Zhang Y, Zhu D, Guan X, Shi L. Physician patient-sharing relationships and healthcare costs and utilization in China: social network analysis based on health insurance data. Postgrad Med. 2021 Oct;133(7):798-806, doi: 10.1080/00325481.2021.1944650.

[5] Sato J, Goda K, Kitsuregawa M, Nakashima N, Mitsutake N. Novel analytics framework for universal healthcare insurance database. AMIA Jt Summits Transl Sci Proc. 2019 May;2019:353-62.

[6] Jason LA, Stevens E, Kassanits J, Reilly A, Bobak T, Guerrero M, Doogan NJ. Recovery homes: A social network analysis of Oxford Houses for Native Americans. J Ethn Subst abuse. 2020 Apr;19(2):174-89, doi: 10.1080/15332640.2018.1489748.

[7] Uddin S, Hossain L, Kelaher M. Effect of physician collaboration network on hospitalization cost and readmission rate. Eur J Public Health. 2012 Oct;22(5):629-33, doi: 10.1093/eurpub/ckr153.

[8] Nguyen T, Yue Z, Slominski R, Welner R, Zhang J, Chen JY. WINNER: a network biology tool for biomolecular characterization and prioritization. In: AI and data science in drug development and public health: highlights from the MCBIOS 2022 conference, Vol. 16648714; 2023 Mar 27; Frontiers Media SA. p. 66, doi: 10.3389/fdata.2022.1016606.

[9] Newman ME. A measure of betweenness centrality based on random walks. Soc Netw. 2005 Jan;27(1):39-54, doi: 10.1016/j.socnet.2004.11.009.

[10] Page L, Brin S, Motwani R, Winograd T. The PageRank citation ranking: Bringing order to the web. Stanford InfoLab; 1999 Nov.