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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore

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Contributorship statement:
KSY, MK and YMH conceived and designed the study, carried out tasks related to ethics approval and data acquisition. WG completed statistical analysis and interpreted the results. WG drafted the manuscript and MK, YMH revised the manuscript. KSY reviewed and approved the final draft as submitted.

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore

ABSTRACT

Objective: To measure the extent of multi-specialty care fragmentation among outpatients receiving specialist care and identify associated risk factors for fragmented care.

Design: A retrospective cross-sectional study

Setting: Specialist outpatient clinics in a Singapore regional hospital

Participants: 40,333 patients aged 21 and above with at least 2 specialist outpatient clinic visits. Data for 146,792 physician consultation visits were used in the analysis and visits for allied health services and medical procedures were excluded.

Outcome Measures: The Fragmentation of Care Index (FCI) was used to measure care fragmentation for specialist outpatients. Log-linear regression with stepwise selection was used to investigate the association between FCI and patient age, gender, race and Most Frequently Visited Specialty (MFVS), controlling for number of different specialities seen.

Results: 36% experienced fragmented care (FCI>0) and their mean FCI was 0.70 (SD= 0.20). FCI was found to be positively associated with age ($p<0.001$). Patients who most frequently consulted with Haematology, Endocrinology and Anaesthesiology specialities were associated with more fragmented care while those who most frequently consulted with Medical Oncology, Ophthalmology and Orthopaedics Surgery specialities were associated with less fragmented care.

Conclusion: Multi-specialty care fragmentation was found to be moderately high in the outpatient specialist clinics, and was found to be associated with patients' age and certain medical specialties. With an ageing population and a rising prevalence of multi-morbidity, healthcare providers should seek to better co-ordinate and integrate patient care for those who are at higher risk of receiving fragmented care.

Key Words: care fragmentation, multi-specialty care, specialist outpatient clinic

Strengths and limitations of this study

- This is the first application of FCI to measure the care fragmentation in the hospital outpatient setting.
- The FCI measure not only accounts for frequency of outpatient visits but also the dispersion of such visits and the combination of different medical specialties involved thereby offering a balanced view of care fragmentation.
- The study identifies the association between fragmentation of care by outpatient specialities, providing valuable insights for multiple-specialty care management.

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- The accuracy of the estimates for the prevalence of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single healthcare entity.

INTRODUCTION

With a life expectancy that is third highest in the world,[1] Singapore like many developed countries is facing the challenges posed by an ageing population. With an increasing prevalence of chronic conditions in the population, chronic disease management has become vastly more complex and costly as more people require ongoing care over extended periods.[2-4] Co-ordinating and integrating care for the population has become one of the looming healthcare challenges in Singapore today.

A lack of integrated or coordinated care commonly referred to as care fragmentation,[5,6] has long thought to be associated with poorer clinical outcomes, compromised quality of care, increased healthcare cost and poorer overall patient satisfaction.[7-12] Patient care involving multiple providers or organisations often raises concerns about fragmentation of care.[5] Previous studies have shown that frequent care delivery through different providers could result in ineffective coordination across different aspects of care in individual entities.[11,13,14] Compounding the issue is the rise in multi-morbidity – defined by World Health Organization as the coexistence of two or more concurrent chronic conditions.[15,16] Estimates of global multi-morbidity prevalence ranged from 15% to 25% for the general population and 50% to 85% for the elderly.[17-19] In Singapore, about half of the residents aged 60 and above reported having multiple chronic conditions [18], which require medical expertise across multiple domains to provide the best patient care possible. For instance, patients with poorly controlled diabetes with complications and ischaemic heart disease may have to consult specialists from endocrinology, ophthalmology, nephrology and cardiology to manage their conditions.

Liu et al studied the extent of fragmented care of diabetic patients seeking care in both the primary care and specialist care settings.[20] Other studies looked at care fragmentation with a broader scope, for instance the extent of care fragmentation across tripartite care system in Hong Kong.[21] These studies focused on measuring care fragmentation either from a broader perspective across entities within healthcare systems or only a particular disease condition across multiple health care settings. However, the extent of multi-specialty care fragmentation within single entities has not been well explored.[5,22] This study therefore aims to determine the extent of multi-specialty care fragmentation in a specialist outpatient setting and explore patient risk factors that are associated with it.

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METHODS

Study Setting and Data

Anonymised hospital data of all patient visits to the specialist outpatient clinics (SOCs) in Ng Teng Fong General Hospital (NTFGH), Singapore for 2016 were extracted retrospectively from the hospital's patient management database. 355,328 attendances to the SOCs were made by 79,964 patients in 2016. 65% of the patient visits were from hospital internal referrals, 30% were from General Practitioners and government polyclinics' referrals, and the remaining were from other sources such as cross-hospital referrals. The study was approved by the Ethics Committee (National Healthcare Group, Domain Specific Review Board).

In order to accurately determine the number of different specialties attending to each patient, only physician or specialist consultations were included for analysis. Clinic visits for allied health services or medical procedures such as medical imaging, day surgery, renal dialysis and dental procedures were excluded. As the study focused on adult population, patients below the age of 21 were excluded. Only patients with atleast 2 or more attendances were included in the study. The study population consisted of 40,333 patients with 146,792 clinic visits. Data for patient demographics and clinical specialty of that consultation were available for analysis. The data included a total of 25 clinical specialties.

Measure of multi-specialty care fragmentation

The Fragmentation of Care Index (FCI) was developed from the Continuity of Care Index (CCI),[20,21] introduced by Bice and Boxerman[22,23] and validated by Saultz[22]. The FCI is a measure for dispersion of the patient care management based on the number of patient visits, number of different providers visited and number of visits to each provider. The FCI was used in this study to measure the extent of care fragmentation for individual patient, and was defined as:

$$\mathrm{FCI} = 1 - \mathrm{CCI} = \frac{n^2 - \sum_k^l n_k^2}{n(n-1)}$$

where n is the total number of outpatient visits; $n_{k,}$ is the number of visits to outpatient specialty k; and l is the total number of outpatient specialties visited. Different providers were defined by different outpatient specialities in the computation. The range of possible FCI values lie between 0 and 1 with a larger FCI corresponding to a larger amount of care fragmentation. In general, the FCI increase with the number of specialties visited and when there is greater dispersion in the distribution of visits to each specialty.

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Statistical Analysis

FCIs were calculated for each patient in our study population, and stratified by their age group, gender, race and the Most Frequently Visited Specialty (MFVS). Patients without a unique MFVS were classified as having multiple MFVSs. Mann Whitney test or Kruskal Wallis test was used to examine significant differences in FCI between the different subgroups as appropriate. Log-linear regression with stepwise selection was used to model the association between FCI and the following variables: age, gender, race and MFVS, adjusting for the number of specialties seen by each patient. A numerical constant of 1 was added to the FCI before modelling so as to account for patients with an FCI of 0. Statistical tests yielding a p-value of less than 0.05 were deemed to be statistically significant. Analyses were carried out in R Version 3.3.2.

RESULTS

The study population had a mean age of 55 years old, with 54% male, and 72% Chinese. The study population had an average of 3.5 outpatient visits per patient across 1.5 medical specialties per patient, and an overall mean FCI of 0.26. Females had slightly larger mean FCI compared to males (FCI_{female} = 0.26, FCI_{male} = 0.25, $p<0.001$), Chinese had the largest mean FCI among the different races ($FCI_{chinese}$ = 0.261, FCI_{malay} = 0.257, FCI_{indian} = 0.256, FCI_{others} = 0.216, $p<0.001$), and the mean FCI increased with increasing age ($p<0.001$). 64% of the patients had visits to only one medical specialty (i.e. FCI=0), and the remaining 36% with FCI > 0 had a mean FCI of 0.70 (SD = 0.20).The distribution of FCI among patients with FCI > 0 showed a peak (9% of the study population) at FCI = 0.67 (see Figure 1), and this group of patients had the most common visitation pattern of 3 visits across 2 different medical specialties. The study population had 7% with FCI=1, within which 87% had 2 visits, and the rest had 3 to 5 visits.

[Insert: **Figure 1.** Distribution of the FCI for patients with FCI>0]

Mean FCI was largest for patients without a unique MFVS ($FCI_{multiple}$ = 0.89). Patients with Medical Oncology and Radiation Oncology as their MFVS also had relatively larger mean FCIs ($FCI_{Med\ Onco}$ = 0.50, $FCI_{Rad\ Onco}$ = 0.46), even though each of these specialties were visited by less than 1% of all patients. MFVSs with the highest volume of patients were Orthopaedics, Ophthalmology, General Surgery and Otorhinolaryngology, and had mean FCIs of less than 0.20. Proportions and mean FCIs for each subgroup are summarised in Table 1.

Table 1. Characteristics of the study population and FCI of the subgroups

	N	%	FCI Mean	FCI SD	P-value
Total	40,333	100%	0.256	0.358	
Gender					<0.001
Male	21,897	54.3%	0.251	0.357	
Female	18,436	45.7%	0.263	0.360	

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Race					<0.001
Chinese	28,979	71.8%	0.261	0.359	
Malay	4,399	10.9%	0.257	0.360	
Indian	3,545	8.8%	0.256	0.360	
Others	3,410	8.5%	0.216	0.342	
Age Group					<0.001
21 - 39	9,003	22.3%	0.150	0.303	
40 - 59	14,374	35.6%	0.247	0.355	
60 - 79	14,004	34.7%	0.310	0.371	
80 and above	2,952	7.3%	0.370	0.382	
Most Frequently Visited Specialty					<0.001
Orthopaedics Surgery	8,723	21.6%	0.101	0.230	
Ophthalmology	5,117	12.7%	0.123	0.248	
Multiple	4,838	12.0%	0.891	0.146	
General Surgery	4,548	11.3%	0.173	0.285	
Otorhinolaryngology	3,453	8.6%	0.158	0.284	
Urology	2,669	6.6%	0.161	0.280	
Cardiology	1,832	4.5%	0.218	0.316	
Respiratory Medicine	1,298	3.2%	0.246	0.317	
Endocrinology	1,288	3.2%	0.348	0.328	
Gastroenterology	1,178	2.9%	0.192	0.304	
Dermatology	780	1.9%	0.150	0.270	
Psychiatry	774	1.9%	0.203	0.295	
Rheumatology	694	1.7%	0.264	0.303	
Geriatric Medicine	652	1.6%	0.246	0.310	
Renal Medicine	610	1.5%	0.325	0.329	
Neurology	425	1.1%	0.263	0.329	
Neurosurgery	310	0.8%	0.254	0.319	
General Medicine	279	0.7%	0.275	0.326	
Obstetrics & Gynaecology	215	0.5%	0.196	0.302	
Medical Oncology	214	0.5%	0.496	0.227	
Plastic Surgery	179	0.4%	0.261	0.309	
Infectious Diseases	103	0.3%	0.348	0.319	
Anaesthesiology	92	0.2%	0.350	0.325	
Haematology	40	0.1%	0.359	0.321	
Palliative Medicine	16	< 0.1%	0.272	0.291	
Radiation Oncology	6	<0.1%	0.456	0.366	

The log-linear regression model chosen through stepwise selection, modelled FCI against age, gender and MFVS (Table 2). FCI was positively associated with age ($p<0.001$). No statistically significant difference in FCI was found between genders. Patients who visited Haematology, Endocrinology and Anaesthesiology specialties most frequently had relatively larger FCIs while those who visited Medical Oncology, Ophthalmology and Orthopaedics Surgery specialties most frequently had the smallest FCIs

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Table 2. Results of log-linear regression of FCI (Values represent back transformation of coefficients)

	Coefficient	95% Confidence Interval
Age	0.0003***	(0.0002, 0.0004)
Gender (Ref: Male)		
Female	0.0017	(-0.0007, 0.0041)
Most Frequently Visited Specialty (Ref: Otorhinolaryngology)		
Haematology	0.0743***	(0.0354, 0.1147)
Endocrinology	0.0477***	(0.0397, 0.0557)
Anaesthesiology	0.0457***	(0.0203, 0.0716)
Neurosurgery	0.0303***	(0.0162, 0.0446)
Obstetrics & Gynaecology	0.0282***	(0.0115, 0.0452)
Neurology	0.0260***	(0.0138, 0.0383)
Plastic Surgery	0.0198*	(0.0018, 0.0381)
Cardiology	0.0159***	(0.0091, 0.0228)
Respiratory Medicine	0.0109**	(0.0033, 0.0186)
General Medicine	0.0104	(-0.0041, 0.0251)
Gastroenterology	0.0028	(-0.0050, 0.0107)
Infectious Diseases	0.0010	(-0.0220, 0.0245)
Geriatric Medicine	0.0009	(-0.0092, 0.0112)
Palliative Medicine	0.0001	(-0.0564, 0.0600)
Urology	-0.0001	(-0.0061, 0.0060)
Renal Medicine	-0.0012	(-0.0114, 0.0091)
Rheumatology	-0.0017	(-0.0113, 0.0080)
Dermatology	-0.0069	(-0.0159, 0.0023)
General Surgery	-0.0073**	(-0.0125, -0.0021)
Psychiatry	-0.0105*	(-0.0196, -0.0013)
Orthopaedics Surgery	-0.0194***	(-0.0240, -0.0148)
Ophthalmology	-0.0222***	(-0.0272, -0.0171)
Radiation Oncology	-0.0262	(-0.1142, 0.0706)
Medical Oncology	-0.0647***	(-0.0800, -0.0491)
Multiple	0.3393***	(0.3320, 0.3465)
Number of Specialty	0.2332***	(0.2313, 0.2351)

Adjusted R-square = 0.80.
*** p<0.001 ** p<0.01 *p<0.05

DISCUSSION

As concerns surrounding fragmentation of care grow with the increasingly specialised and subspecialised medical care,[11,14] there is stronger impetus to measure and analyse multi-specialty care fragmentation in an outpatient setting. The FCI measure used accounts for both the frequency and dispersion of outpatient visits and the mixture of different medical

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specialties involved for an individual to offer a balanced view of care fragmentation in the outpatient population.

Studies related to fragmentation of care delivery across multiple providers have shown that a mean FCI of 0.50 corresponds to moderate levels of care fragmentation,[20,21] and a mean FCI of 0.70 corresponds to moderately high levels of care fragmentation.[20,21] While our study did not factor in care fragmentation associated with coordinating care across multiple healthcare entities and focused on multi-specialty care fragmentation in a single institution, we found that care fragmentation persists in around 36% of the outpatient population. Of which, 41% of these patients had moderately high levels of care fragmentation (FCI>0.7). Our findings underscored the possibility of underestimating the extent of care fragmentation in the healthcare system as most studies do not factor in care fragmentation that could occur within a single healthcare entity. The actual situation of care fragmentation could be more worrying than what was perceived.

Unsurprisingly, the literature suggests that the presence of multi-morbidity is more common among older adults,[24,25] and that this group of people are more likely to consume multi-specialty care and hence are at a higher risk of experiencing fragmented care. Our study made a similar finding that care fragmentation was positively associated with age. However, for every 10 years increase in age resulted only in a limited increase of 0.003 in FCI after controlling for gender, MFVS and number of specialties. This study found that outpatients with Haematology, Endocrinology and Anaesthesiology as their MFVS experienced the most fragmentation among the different medical specialties. Endocrinologists are commonly involved in the co-management of disease conditions such as diabetes along with other specialists from different medical disciplines.[20] In Haematology, clinical and laboratory services are typically consumed for the purpose of diagnosis or treatment of blood-related disorders which are also commonly associated with other systemic diseases thus involving more multiple specialties in the management of care.[26,27] The clinical practice of Anaesthesiology involves pain management and total care of surgical patients throughout the course of planning, preparation and post-recovery from a surgery. Close teamwork between anaesthetists and surgeons is needed for quality care delivery. Interestingly, the mean FCIs of Medical Oncology and Radiation Oncology before controlling for other factors were some of the largest but they were found to be negatively associated with fragmentation after adjustment. A plausible reason might be that patients who most frequently visited Medical Oncology or Radiation Oncology were generally older in age and would have visited a greater variety of specialties.

A limitation encountered with the use of the FCI as a measure of care fragmentation is the lack in its ability to differentiate the reasons for which care is fragmented among patients with an FCI of 1. For instance, it would not be able to differentiate between a patient with one visit to each of ten different specialties (FCI=1) who tends to have a higher risk of receiving fragmented care and another patient with one visit to each of two different specialties (FCI=1). Also, the accuracy of the estimates for the extent of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single hospital as patients in our study population might also have sought specialist care at other healthcare institutions. Our estimates for the extent of multi-specialty care fragmentation are thus conservative. While our findings shed light on the issue for the need for better care coordination, a greater variety and granularity in the data such as information on social status and clinical conditions, could allow us to give better recommendations to tackle the issue of multi-specialty care fragmentation.

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CONCLUSION

This study found that the multi-specialty care fragmentation in the outpatient specialist clinics was moderately high and it was associated with patient demographics and particular medical specialties. Coupled with an ageing population and earlier onset of chronic conditions, this situation seems likely to worsen in the future. Given the complex nature of chronic conditions and the rising prevalence of multi-morbidities, multi-specialty care is likely to be unavoidable. Nevertheless, healthcare providers could look into planning for better care coordination and integration across medical specialties to eliminate unnecessary referrals and make use of multidisciplinary care teams to reduce the extent of care fragmentation.

Other information

Funding:
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Competing interests:
None declared.

Ethics approval:
The NHG Domain Specific Review Board (DSRB)

Data sharing statement:
Statistical code and dataset are available upon reasonable request to the corresponding author.

Patient and Public Involvement:
Patients and or public were not involved. Only anonymised data were collected retrospectively from the hospital's patient management database.

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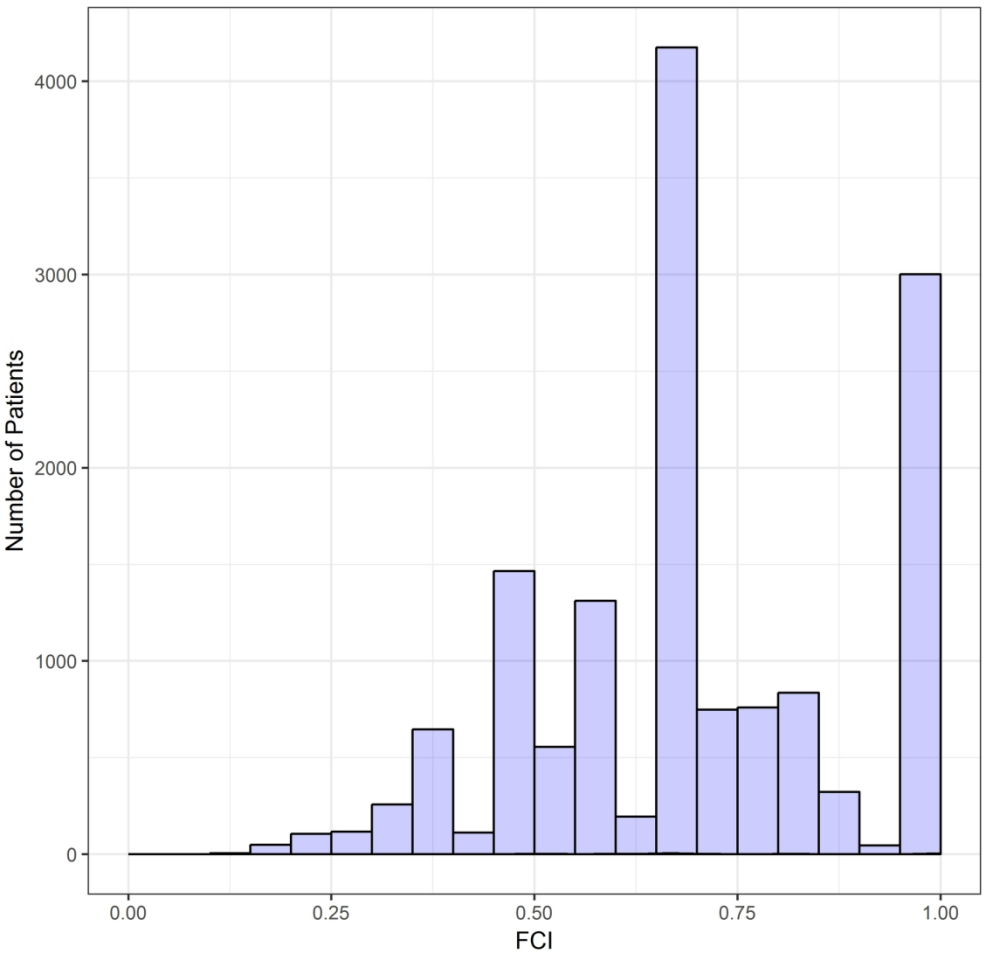

Figure 1. Distribution of the FCI for patients with FCI>0

162x162mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 & 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 & 5
Bias	9	Describe any efforts to address potential sources of bias	*4*
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4 & 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4 & 5
		(*b*) Describe any methods used to examine subgroups and interactions	N.A.
		(*c*) Explain how missing data were addressed	N.A.
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N.A.
		(*e*) Describe any sensitivity analyses	N.A.
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N.A.
		(b) Give reasons for non-participation at each stage	N.A.
		(c) Consider use of a flow diagram	N.A.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	N.A.
Outcome data	15*	Report numbers of outcome events or summary measures	5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5 & 6 & 7
		(*b*) Report category boundaries when continuous variables were categorized	5 & 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N.A.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N.A.
Discussion			
Key results	18	Summarise key results with reference to study objectives	7 & 8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8 & 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore: a Cross-sectional Study

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KSY, MK and YMH conceived and designed the study, carried out tasks related to ethics approval and data acquisition. WG completed statistical analysis and interpreted the results. WG drafted the manuscript and MK, YMH revised the manuscript. KSY reviewed and approved the final draft as submitted.

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore: a Cross-sectional Study

ABSTRACT

Objective: To measure the extent of multi-specialty care fragmentation among outpatients receiving specialist care and identify associated risk factors for fragmented care.

Design: A retrospective cross-sectional study

Setting: Specialist outpatient clinics in a Singapore regional hospital

Participants: 40,333 patients aged 21 and above with at least 2 specialist outpatient clinic visits in the year 2016. Data for 146,792 physician consultation visits were used in the analysis and visits for allied health services and medical procedures were excluded.

Outcome Measures: The Fragmentation of Care Index (FCI) was used to measure care fragmentation for specialist outpatients. Log-linear regression with stepwise selection was used to investigate the association between FCI and patient age, gender, race and Most Frequently Visited Specialty (MFVS), controlling for number of different specialities seen.

Results: 36% experienced fragmented care (FCI>0) and their mean FCI was 0.70 (SD= 0.20). FCI was found to be positively associated with age ($p<0.001$). Patients who most frequently visited Haematology, Endocrinology and Anaesthesiology specialities were associated with more fragmented care while those who most frequently visited Medical Oncology, Ophthalmology and Orthopaedics Surgery specialities were associated with less fragmented care.

Conclusion: Multi-specialty care fragmentation was found to be moderately high in the outpatient specialist clinics, and was found to be associated with patients' age and certain medical specialties. With an ageing population and a rising prevalence of multi-morbidity, healthcare providers should seek to eliminate unnecessary referrals to reduce the extent of care fragmentation.

Key Words: care fragmentation, multi-specialty care, specialist outpatient clinic

Strengths and limitations of this study

- This is the first application of FCI to measure care fragmentation in a hospital specialist outpatient setting.
- FCI not only accounts for frequency of outpatient visits but also the dispersion of such visits and the combination of different medical specialties involved, thereby offering a balanced view of care fragmentation.
- The study identifies the association between fragmentation of care and outpatient specialities, providing valuable insights for multiple-specialty care management.

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- The accuracy of estimates for the prevalence of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single healthcare entity.

INTRODUCTION

With a life expectancy that is third highest in the world,[1] Singapore like many developed countries is facing the challenges posed by an ageing population. Due to an increasing prevalence of chronic conditions in the ageing population, chronic disease management has become vastly more complex and costly as more people require ongoing care over extended periods.[2-4] Therefore, co-ordinating and integrating care has become one of the looming healthcare challenges in Singapore today.

A lack of integrated or coordinated care commonly referred to as care fragmentation,[5,6] is associated with compromised quality of care, increased healthcare cost, poor clinical outcomes and patient satisfaction.[7-12] Patient care involving multiple providers or organisations often raises concerns about fragmentation of care.[5] Previous studies have shown that frequent care delivery through different providers could result in ineffective coordination across different aspects of care.[11,13,14] Compounding the issue is the rise in multi-morbidity – defined by World Health Organization as the coexistence of two or more concurrent chronic conditions.[15,16] Estimates of global multi-morbidity prevalence ranged from 15% to 25% for the general population and 50% to 85% for the elderly.[17-19] In Singapore, about half of the residents aged 60 years and above reported having multiple chronic conditions. [18] Multi-morbidity requires medical expertise across multiple domains to provide the best patient care possible. For instance, a patient with poorly controlled diabetes and ischaemic heart disease may have to consult specialists from endocrinology, ophthalmology, nephrology and cardiology to manage his or her condition.

Previous studies have looked at the extent of fragmented care in certain group of patients seeking care in both primary and specialist care settings.[20,21] Other studies looked at care fragmentation with a broader scope, for instance, the extent of care fragmentation across tripartite care system in Hong Kong.[22] These studies focused on measuring care fragmentation either from a broader perspective across entities within healthcare systems or only specific disease conditions across multiple health care settings. However, patient care is prone to fragmentation even within a single entity due to the involvement of multiple providers as well as the influence of patient factors such as age, socioeconomic, education and health status. [23,24] In spite of that, the extent of multi-specialty care fragmentation within single entities has not been well explored.[5,25] This study therefore aims to determine the extent of multi-specialty care fragmentation in a public hospital's specialist outpatient setting and explore patient risk factors that are associated with it.

In Singapore, subsidised referral to specialists in public hospitals are made either by primary care doctors in public sector based polyclinics or by other specialists through internal referral. Primary care doctors and specialists do not use the same electronic medical record. However, specialists are able to access important lab test results done at the polyclinics and some participating private general practitioners through a national electronic medical record.

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Public sector provides 80% of the secondary and tertiary healthcare services in Singapore.[26]

METHODS

Study Setting and Data

Anonymised hospital data of all patient visits to the specialist outpatient clinics (SOCs) in Ng Teng Fong General Hospital (NTFGH) for the year 2016 were extracted retrospectively from the hospital's patient management database. This does not include data on visits to family medicine or primary care. A total of 355,328 SOC attendances were made by 79,964 patients in 2016.Among them, about 65% of the patient visits were from hospital internal referrals, 30% were from General Practitioners and government polyclinics' referrals, and the remaining were from other sources such as cross-hospital referrals. SOC attendances at NTFGH constituted to about 7% of the total SOC attendances that were made in Singapore in the year 2016.[27]

In order to accurately determine the number of different specialties attending to each patient, only physician or specialist consultations were included for analysis. Clinic visits for allied health services or medical procedures such as medical imaging, day surgery, renal dialysis and dental procedures were excluded. As the study focused on adult population, patients below the age of 21 were excluded. Only patients with 2 or more attendances were included in the study. The study population consisted of 40,333 patients with 146,792 clinic visits. Data for patient demographics and clinical specialty of that consultation were available for analysis. The data included a total of 25 clinical specialties.

All the specialists in the hospital shared the same electronic medical record. However, the principal problems/ diagnoses for each visit were usually recorded as free text in the consult notes for outpatients unlike the inpatient setting where they are discrete fields. In the outpatient setting, care co-ordination programmes were only available for those patients with certain specific diagnosis such as diabetes and stable heart failure. Even these programmes serve to mainly right sight patients with stable conditions to the primary care setting.

This study was approved by the Ethics Committee (National Healthcare Group, Domain Specific Review Board).

Measure of multi-specialty care fragmentation

The Fragmentation of Care Index (FCI) was developed from the Continuity of Care Index (CCI) [20,22] introduced by Bice and Boxerman[25,28]. It is a measure of dispersion of the patient care based on the number of patient visits, number of different providers visited and number of visits to each provider. This measure was adopted from other studies [20,22] which had used either clinics or type of clinics as their unit of measurement. The FCI was used in this study to measure the extent of care fragmentation for individual patients, and was defined as:

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$$\text{FCI} = 1 - \text{CCI} = \frac{n^2 - \sum_k^l n_k^2}{n(n-1)}$$

where n is the total number of outpatient visits; n_k, is the number of visits to outpatient specialty k; and l is the total number of outpatient specialties visited. Different providers were defined as different outpatient specialities in the computation. The range of possible FCI values lie between 0 and 1 with a larger FCI corresponding to a greater extent of care fragmentation. In general, the FCI increases with number of specialties visited and with greater dispersion in the distribution of visits to each specialty.

Statistical Analysis

FCIs were calculated for each patient in our study population, and stratified by their age group, gender, race and the Most Frequently Visited Specialty (MFVS). The specialty that a patient visited most frequently in 2016 was termed as MFVS for that particular patient. As each patient may have visited multiple specialties, MFVS had to be used instead of type of specialty. Patients without a unique MFVS were classified as having multiple MFVSs. Mann Whitney test or Kruskal Wallis test was used to examine significant differences in FCI between the different subgroups. Log-linear regression with stepwise selection was used to model the association between FCI and the following variables: age, gender, race and MFVS, adjusting for the number of specialties seen by each patient. A numerical constant of 1 was added to the FCI before modelling so as to account for patients with an FCI of 0. Statistical tests yielding a p-value of less than 0.05 were deemed to be statistically significant. Analyses were carried out in R Version 3.3.2.

RESULTS

The mean age of the study population was 55 years; 54% were male; 72% were Chinese. The study population had an average of 3.5 outpatient visits per patient across 1.5 medical specialties per patient and an overall mean FCI of 0.26. Females had slightly larger mean FCI compared to males (FCI_{female} = 0.26, FCI_{male} = 0.25, p<0.001); Chinese had the largest mean FCI among the different races ($FCI_{chinese}$ = 0.261, FCI_{malay} = 0.257, FCI_{indian} = 0.256, FCI_{others} = 0.216, p<0.001); and the mean FCI increased with increasing age (p<0.001).

About 64% of the patients had visits to only one medical specialty (i.e. FCI=0). The remaining 36% with FCI > 0 had a mean FCI of 0.70 (SD = 0.20).The distribution of FCI among patients with FCI > 0 showed a peak (9% of the study population) at FCI = 0.67 (see Figure 1), and this group of patients had the most common visitation pattern of 3 visits across 2 different medical specialties. The study population had 7% with FCI=1, within which 87% had 2 visits, and the rest had 3 to 5 visits.

[Insert: **Figure 1.** Distribution of the FCI for patients with FCI>0]

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Proportions and mean FCIs for each subgroup are summarised in Table 1. Mean FCI was largest for patients without a unique MFVS ($FCI_{multiple}$ = 0.89). Patients with Medical Oncology and Radiation Oncology as their MFVS also had relatively larger mean FCIs ($FCI_{Med\ Onco}$ = 0.50, $FCI_{Rad\ Onco}$ = 0.46), even though each of these specialties were visited by less than 1% of all patients. Also, the mean age of these patients (65.8 years) was significantly ($p<0.001$) higher than the rest of the study population (55.3 years).

MFVSs with the highest volume of patients were Orthopaedics, Ophthalmology, General Surgery and Otorhinolaryngology. These patients had mean FCIs less than 0.20. Also, the average number of specialties visited by these patients (1.3) was significantly lower ($p<0.001$) compared to the rest of the study population (1.8).

Table 1. Characteristics of the study population and FCI of the subgroups

	N	%	FCI Mean	FCI SD	P-value
Total	40,333	100%	0.256	0.358	
Gender					<0.001
Male	21,897	54.3%	0.251	0.357	
Female	18,436	45.7%	0.263	0.360	
Race					<0.001
Chinese	28,979	71.8%	0.261	0.359	
Malay	4,399	10.9%	0.257	0.360	
Indian	3,545	8.8%	0.256	0.360	
Others	3,410	8.5%	0.216	0.342	
Age Group					<0.001
21 - 39	9,003	22.3%	0.150	0.303	
40 - 59	14,374	35.6%	0.247	0.355	
60 - 79	14,004	34.7%	0.310	0.371	
80 and above	2,952	7.3%	0.370	0.382	
Most Frequently Visited Specialty					<0.001
Orthopaedics Surgery	8,723	21.6%	0.101	0.230	
Ophthalmology	5,117	12.7%	0.123	0.248	
Multiple	4,838	12.0%	0.891	0.146	
General Surgery	4,548	11.3%	0.173	0.285	
Otorhinolaryngology	3,453	8.6%	0.158	0.284	
Urology	2,669	6.6%	0.161	0.280	
Cardiology	1,832	4.5%	0.218	0.316	
Respiratory Medicine	1,298	3.2%	0.246	0.317	
Endocrinology	1,288	3.2%	0.348	0.328	
Gastroenterology	1,178	2.9%	0.192	0.304	
Dermatology	780	1.9%	0.150	0.270	
Psychiatry	774	1.9%	0.203	0.295	
Rheumatology	694	1.7%	0.264	0.303	
Geriatric Medicine	652	1.6%	0.246	0.310	
Renal Medicine	610	1.5%	0.325	0.329	
Neurology	425	1.1%	0.263	0.329	

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Neurosurgery	310	0.8%	0.254	0.319
General Medicine	279	0.7%	0.275	0.326
Obstetrics & Gynaecology	215	0.5%	0.196	0.302
Medical Oncology	214	0.5%	0.496	0.227
Plastic Surgery	179	0.4%	0.261	0.309
Infectious Diseases	103	0.3%	0.348	0.319
Anaesthesiology	92	0.2%	0.350	0.325
Haematology	40	0.1%	0.359	0.321
Palliative Medicine	16	< 0.1%	0.272	0.291
Radiation Oncology	6	<0.1%	0.456	0.366

The log-linear regression model chosen through stepwise selection, modelled FCI against age, gender and MFVS (Table 2). FCI was positively associated with age ($p<0.001$). No statistically significant difference in FCI was found between genders. Patients who visited Haematology, Endocrinology and Anaesthesiology specialties most frequently had relatively larger FCIs while those who visited Medical Oncology, Ophthalmology and Orthopaedics Surgery specialties most frequently had the smallest FCIs.

Table 2. Results of log-linear regression of FCI (Values represent back transformation of coefficients)

	Coefficient	95% Confidence Interval
Age	0.0003***	(0.0002, 0.0004)
Gender (Ref: Male)		
Female	0.0017	(-0.0007, 0.0041)
Most Frequently Visited Specialty (Ref: Otorhinolaryngology)		
Haematology	0.0743***	(0.0354, 0.1147)
Endocrinology	0.0477***	(0.0397, 0.0557)
Anaesthesiology	0.0457***	(0.0203, 0.0716)
Neurosurgery	0.0303***	(0.0162, 0.0446)
Obstetrics & Gynaecology	0.0282***	(0.0115, 0.0452)
Neurology	0.0260***	(0.0138, 0.0383)
Plastic Surgery	0.0198*	(0.0018, 0.0381)
Cardiology	0.0159***	(0.0091, 0.0228)
Respiratory Medicine	0.0109**	(0.0033, 0.0186)
General Medicine	0.0104	(-0.0041, 0.0251)
Gastroenterology	0.0028	(-0.0050, 0.0107)
Infectious Diseases	0.0010	(-0.0220, 0.0245)
Geriatric Medicine	0.0009	(-0.0092, 0.0112)
Palliative Medicine	0.0001	(-0.0564, 0.0600)
Urology	-0.0001	(-0.0061, 0.0060)
Renal Medicine	-0.0012	(-0.0114, 0.0091)
Rheumatology	-0.0017	(-0.0113, 0.0080)
Dermatology	-0.0069	(-0.0159, 0.0023)
General Surgery	-0.0073**	(-0.0125, -0.0021)
Psychiatry	-0.0105*	(-0.0196, -0.0013)

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Orthopaedics Surgery	-0.0194***	(-0.0240, -0.0148)
Ophthalmology	-0.0222***	(-0.0272, -0.0171)
Radiation Oncology	-0.0262	(-0.1142, 0.0706)
Medical Oncology	-0.0647***	(-0.0800, -0.0491)
Multiple	0.3393***	(0.3320, 0.3465)
Number of Specialty	0.2332***	(0.2313, 0.2351)

Adjusted R-square = 0.80.
*** p<0.001 ** p<0.01 *p<0.05

DISCUSSION

With the growing concerns of care fragmentation in medical care,[11,14] there is a greater need to measure and analyse multi-specialty care fragmentation in an outpatient setting. The advantage of using FCI to measure care fragmentation is that it accounts for both frequency and dispersion of outpatient visits to different medical specialties to offer a balanced view of care fragmentation.

Studies related to fragmentation of care delivery across multiple providers have shown that a mean FCI of 0.50 corresponds to moderate levels of care fragmentation and a mean FCI of 0.70 corresponds to moderately high levels of care fragmentation.[20,22] While our study did not factor in care fragmentation associated with coordinating care across multiple healthcare entities and focused on multi-specialty care fragmentation in a single institution, we found that moderately high (FCI $\geq$ 0.7) levels of care fragmentation persists in around 36% of the outpatient population. Our findings underscore the possibility of underestimating the extent of care fragmentation in the healthcare system as most studies do not factor in care fragmentation that could occur within a single healthcare entity. The actual situation of care fragmentation could be more worrying than what is perceived.

Our study shows that care fragmentation is positively associated with age. This concurs with the literature findings that there is an increased prevalence of multi-morbidity among older adults,[29,30] that they are more likely to consume multi-specialty care and hence are at a higher risk of experiencing fragmented care. However, every 10-year increase in age only resulted in a limited increase of 0.003 in FCI after controlling for gender, MFVS and number of specialties. Outpatients with Haematology, Endocrinology and Anaesthesiology as their MFVS experienced the most fragmentation among the different specialties. This could be because endocrinologists are commonly involved in the co-management of disease conditions such as diabetes along with other specialists from different medical disciplines.[20] Similarly, blood-related disorders referred to haematology are often associated with other systemic diseases and/ or involve multiple specialties in their management.[31,32] As for anaesthesiology, the specialty's clinical practice usually includes pain management and total care of surgical patients throughout the course of planning, preparation and post-recovery from a surgery. Close teamwork between anaesthetists and other specialty doctors are needed for quality care delivery. Interestingly, patients with MFVS- Medical Oncology and Radiation Oncology are associated with smallest FCIs after controlling for other factors. This could be because the patients who most frequently visited Medical Oncology or Radiation Oncology were generally older in age.

A limitation encountered with the use of the FCI as a measure of care fragmentation is the lack in its ability to differentiate the reasons for which care is fragmented among patients with an FCI of 1. For instance, it would not be able to differentiate between a patient

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with one visit each to five different specialties (FCI=1) and another patient with one visit each to two different specialties (FCI=1). The accuracy of the estimates for the extent of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single hospital as patients in our study population might also have sought specialist care at other healthcare institutions. Also, a patient is likely to experience more fragmentation in their care when primary care or family medicine visits are included. Hence, our estimates for the extent of multi-specialty care fragmentation are conservative. Moreover, our use of specialty instead of provider (for example, a patient seeing 2 different cardiologists) might also under-estimate care fragmentation. However, the usual practice is for the patient to visit the same specialist unless the doctor is unavailable due to certain reasons. Another limitation is that the data on case mix, social factors such as social support, socioeconomic status couldn't be extracted as they are not available as discrete data in the electronic medical records for outpatients. Therefore, there is limited information available to analyse the causes or reasons of fragmentation of care. Nevertheless, this index could still be used to flag out those at higher risk of receiving fragmented care. These patients may then be referred to care co-ordination team who could then profile the patients, elicit a detailed history to identify the issues and address them with relevant interventions.

CONCLUSION

This study found that multi-specialty care fragmentation in the outpatient specialist clinics was moderately high and it was associated with patient's age and particular medical specialties. Coupled with an ageing population and earlier onset of chronic conditions, this situation seems likely to worsen in the future. Given the complex nature of chronic conditions and the rising prevalence of multi-morbidities, multi-specialty care is probably unavoidable. Nevertheless, healthcare providers could look into ways to eliminate unnecessary referrals to reduce the extent of care fragmentation.

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Data sharing statement:
Statistical code and dataset are available upon reasonable request to the corresponding author.

Patient and Public Involvement:

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Patients and or public were not involved. Only anonymised data were collected retrospectively from the hospital's patient management database.

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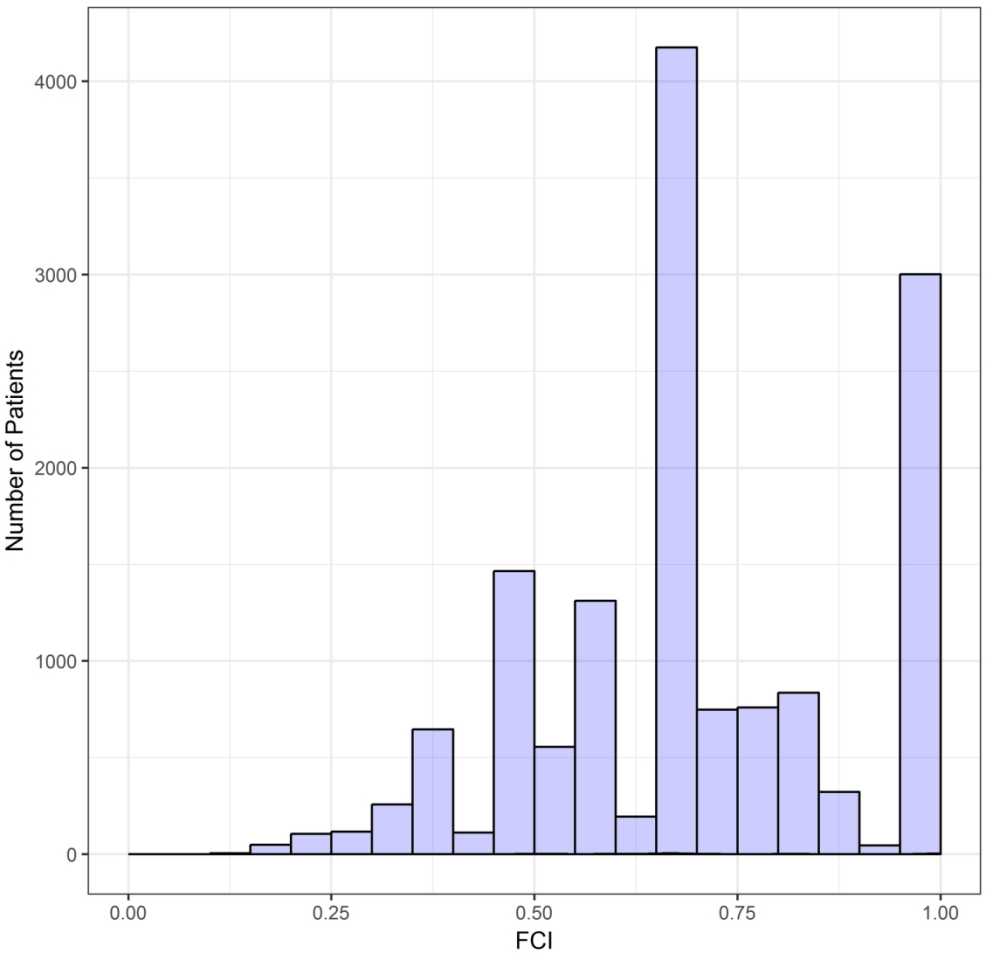

Figure 1. Distribution of the FCI for patients with FCI>0

162x162mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 & 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 & 5
Bias	9	Describe any efforts to address potential sources of bias	*4*
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4 & 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4 & 5
		(*b*) Describe any methods used to examine subgroups and interactions	N.A.
		(*c*) Explain how missing data were addressed	N.A.
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N.A.
		(*e*) Describe any sensitivity analyses	N.A.
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N.A.
		(b) Give reasons for non-participation at each stage	N.A.
		(c) Consider use of a flow diagram	N.A.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	N.A.
Outcome data	15*	Report numbers of outcome events or summary measures	5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5 & 6 & 7
		(*b*) Report category boundaries when continuous variables were categorized	5 & 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N.A.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N.A.
Discussion			
Key results	18	Summarise key results with reference to study objectives	7 & 8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8 & 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore: a Cross-sectional Study

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore: a Cross-sectional Study

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Contributorship statement:
KSY, MK and YMH conceived and designed the study, carried out tasks related to ethics approval and data acquisition. WG completed statistical analysis and interpreted the results. WG drafted the manuscript and MK, YMH revised the manuscript. KSY reviewed and approved the final draft as submitted.

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Prevalence of Care Fragmentation among Outpatients Attending Specialist Clinics in a Regional Hospital in Singapore: a Cross-sectional Study

ABSTRACT

Objective: To measure the extent of multi-specialty care fragmentation among outpatients receiving specialist care and identify associated risk factors for fragmented care.

Design: A retrospective cross-sectional study

Setting: Specialist outpatient clinics in a Singapore regional hospital

Participants: 40,333 patients aged 21 and above with at least 2 specialist outpatient clinic visits in the year 2016. Data for 146,792 physician consultation visits were used in the analysis and visits for allied health services and medical procedures were excluded.

Outcome Measures: The Fragmentation of Care Index (FCI) was used to measure care fragmentation for specialist outpatients. Log-linear regression with stepwise selection was used to investigate the association between FCI and patient age, gender, race and Most Frequently Visited Specialty (MFVS), controlling for number of different specialities seen.

Results: 36% experienced fragmented care (FCI>0) and their mean FCI was 0.70 (SD= 0.20). FCI was found to be positively associated with age ($p<0.001$). Patients who most frequently visited Haematology, Endocrinology and Anaesthesiology specialities were associated with more fragmented care while those who most frequently visited Medical Oncology, Ophthalmology and Orthopaedics Surgery specialities were associated with less fragmented care.

Conclusion: Multi-specialty care fragmentation was found to be moderately high in the outpatient specialist clinics, and was found to be associated with patients' age and certain medical specialties. With an ageing population and a rising prevalence of multi-morbidity, healthcare providers should seek to eliminate unnecessary referrals to reduce the extent of care fragmentation.

Key Words: care fragmentation, multi-specialty care, specialist outpatient clinic

Strengths and limitations of this study

- This is the first application of FCI to measure care fragmentation in a hospital specialist outpatient setting.
- FCI not only accounts for frequency of outpatient visits but also the dispersion of such visits and the combination of different medical specialties involved, thereby offering a balanced view of care fragmentation.
- The study identifies the association between fragmentation of care and outpatient specialities, providing valuable insights for multiple-specialty care management.

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- The accuracy of estimates for the prevalence of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single healthcare entity.

INTRODUCTION

With a life expectancy that is third highest in the world,[1] Singapore like many developed countries is facing the challenges posed by an ageing population. Due to an increasing prevalence of chronic conditions in the ageing population, chronic disease management has become vastly more complex and costly as more people require ongoing care over extended periods.[2-4] Therefore, co-ordinating and integrating care has become one of the looming healthcare challenges in Singapore today.

A lack of integrated or coordinated care commonly referred to as care fragmentation,[5,6] is associated with , compromised quality of care, increased healthcare cost, poor clinical outcomes and patient satisfaction.[7-12] Patient care involving multiple providers or organisations often raises concerns about fragmentation of care.[5] Previous studies have shown that frequent care delivery through different providers could result in ineffective coordination across different aspects of care.[11,13,14] Compounding the issue is the rise in multi-morbidity – defined by World Health Organization as the coexistence of two or more concurrent chronic conditions.[15,16] Estimates of global multi-morbidity prevalence ranged from 15% to 25% for the general population and 50% to 85% for the elderly.[17-19] In Singapore, about half of the residents aged 60 years and above reported having multiple chronic conditions. [18] Multimorbidity requires medical expertise across multiple domains to provide the best patient care possible. For instance, a patient with poorly controlled diabetes and ischaemic heart disease may have to consult specialists from endocrinology, ophthalmology, nephrology and cardiology to manage his or her condition. Previous studies have looked at the extent of fragmented care in certain group of patients seeking care in both primary and specialist care settings.[20,21] Other studies looked at care fragmentation with a broader scope, for instance, the extent of care fragmentation across tripartite care system in Hong Kong.[22] These studies focused on measuring care fragmentation either from a broader perspective across entities within healthcare systems or only specific disease conditions across multiple health care settings. However, patient care is prone to fragmentation even within a single entity due to the involvement of multiple providers as well as the influence of patient factors such as age, socioeconomic, education and health status. [23,24] In spite of that, the extent of multi-specialty care fragmentation within single entities has not been well explored.[5,25] This study therefore aims to determine the extent of multi-specialty care fragmentation in a public hospital's specialist outpatient setting and explore patient risk factors that are associated with it.

In Singapore, subsidised referral to specialists in public hospitals are made either by primary care doctors in public sector based polyclinics or by other specialists through internal referral. Primary care doctors and specialists do not use the same electronic medical record. However, specialists are able to access important lab test results done at the polyclinics and some participating private general practitioners through a national electronic medical record.

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Public sector provides 80% of the secondary and tertiary healthcare services in Singapore.[26]

METHODS

Study Setting and Data

Anonymised hospital data of all patient visits to the specialist outpatient clinics (SOCs) in Ng Teng Fong General Hospital (NTFGH) for the year 2016 were extracted retrospectively from the hospital's patient management database. This does not include data on visits to family medicine or primary care. A total of 355,328 SOC attendances were made by 79,964 patients in 2016.Among them, about 65% of the patient visits were from hospital internal referrals, 30% were from General Practitioners and government polyclinics' referrals, and the remaining were from other sources such as cross-hospital referrals. SOC attendances at NTFGH constituted to about 7% of the total SOC attendances that were made in Singapore in the year 2016.[27]

In order to accurately determine the number of different specialties attending to each patient, only physician or specialist consultations were included for analysis. Clinic visits for allied health services or medical procedures such as medical imaging, day surgery, renal dialysis and dental procedures were excluded. As the study focused on adult population, patients below the age of 21 were excluded. Only patients with 2 or more attendances were included in the study. The study population consisted of 40,333 patients with 146,792 clinic visits. Data for patient demographics and clinical specialty of that consultation were available for analysis. The data included a total of 25 clinical specialties.

All the specialists in the hospital shared the same electronic medical record. However, the principal problems/ diagnoses for each visit were usually recorded as free text in the consult notes for outpatients unlike the inpatient setting where they are discrete fields. In the outpatient setting, care co-ordination programmes were only available for those patients with certain specific diagnosis such as diabetes and stable heart failure. Even these programmes serve to mainly right site care of patients with stable conditions to the primary care setting.

This study was approved by the Ethics Committee (National Healthcare Group, Domain Specific Review Board).

Measure of multi-specialty care fragmentation

The Fragmentation of Care Index (FCI) was developed from the Continuity of Care Index (CCI),[20,22] introduced by Bice and Boxerman[25,28]. It is a measure of dispersion of the patient care based on the number of patient visits, number of different providers visited and number of visits to each provider. This measure was adopted from other studies [20,22] which had used either clinics or type of clinics as their unit of measurement. The FCI was used in this study to measure the extent of care fragmentation for individual patients, and was defined as:

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$$\text{FCI} = 1 - \text{CCI} = \frac{n^2 - \sum_k^l n_k^2}{n(n-1)}$$

where n is the total number of outpatient visits; n_k, is the number of visits to outpatient specialty k; and l is the total number of outpatient specialties visited. Different providers were defined as different outpatient specialities in the computation. The range of possible FCI values lie between 0 and 1 with a larger FCI corresponding to a greater extent of care fragmentation. In general, the FCI increases with number of specialties visited and with greater dispersion in the distribution of visits to each specialty.

Statistical Analysis

FCIs were calculated for each patient in our study population, and stratified by their age group, gender, race and the Most Frequently Visited Specialty (MFVS). The specialty that a patient visited most frequently in 2016 was termed as MFVS for that particular patient. As each patient may have visited multiple specialties, MFVS had to be used instead of type of specialty. Patients without a unique MFVS were classified as having multiple MFVSs. Mann Whitney test or Kruskal Wallis test was used to examine significant differences in FCI between the different subgroups. Log-linear regression with stepwise selection was used to model the association between FCI and the following variables: age, gender, race and MFVS, adjusting for the number of specialties seen by each patient. A numerical constant of 1 was added to the FCI before modelling so as to account for patients with an FCI of 0. Statistical tests yielding a p-value of less than 0.05 were deemed to be statistically significant. Analyses were carried out in R Version 3.3.2.

RESULTS

The mean age of the study population was 55 years; 54% were male; 72% were Chinese. The study population had an average of 3.5 outpatient visits per patient across 1.5 medical specialties per patient and an overall mean FCI of 0.26. Females had slightly larger mean FCI compared to males (FCI_{female} = 0.26, FCI_{male} = 0.25, p<0.001); Chinese had the largest mean FCI among the different races ($FCI_{chinese}$ = 0.261, FCI_{malay} = 0.257, FCI_{indian} = 0.256, FCI_{others} = 0.216, p<0.001); and the mean FCI increased with increasing age (p<0.001).

About 64% of the patients had visits to only one medical specialty (i.e. FCI=0). The remaining 36% with FCI > 0 had a mean FCI of 0.70 (SD = 0.20).The distribution of FCI among patients with FCI > 0 showed a peak (9% of the study population) at FCI = 0.67 (see Figure 1), and this group of patients had the most common visitation pattern of 3 visits across 2 different medical specialties. The study population had 7% with FCI=1, within which 87% had 2 visits, and the rest had 3 to 5 visits.

[Insert: **Figure 1.** Distribution of the FCI for patients with FCI>0]

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Proportions and mean FCIs for each subgroup are summarised in Table 1. Mean FCI was largest for patients without a unique MFVS ($FCI_{multiple}$ = 0.89). Patients with Medical Oncology and Radiation Oncology as their MFVS also had relatively larger mean FCIs ($FCI_{Med\ Onco}$ = 0.50, $FCI_{Rad\ Onco}$ = 0.46), even though each of these specialties were visited by less than 1% of all patients. Also, the mean age of these patients (65.8 years) was significantly ($p<0.001$) higher than the rest of the study population (55.3 years).

MFVSs with the highest volume of patients were Orthopaedics, Ophthalmology, General Surgery and Otorhinolaryngology. These patients had mean FCIs less than 0.20. Also, the average number of specialties visited by these patients (1.3) was significantly lower ($p<0.001$) compared to the rest of the study population (1.8).

Table 1. Characteristics of the study population and FCI of the subgroups

	N	%	FCI Mean	FCI SD	P-value
Total	40,333	100%	0.256	0.358	
Gender					<0.001
Male	21,897	54.3%	0.251	0.357	
Female	18,436	45.7%	0.263	0.360	
Race					<0.001
Chinese	28,979	71.8%	0.261	0.359	
Malay	4,399	10.9%	0.257	0.360	
Indian	3,545	8.8%	0.256	0.360	
Others	3,410	8.5%	0.216	0.342	
Age Group					<0.001
21 - 39	9,003	22.3%	0.150	0.303	
40 - 59	14,374	35.6%	0.247	0.355	
60 - 79	14,004	34.7%	0.310	0.371	
80 and above	2,952	7.3%	0.370	0.382	
Most Frequently Visited Specialty					<0.001
Orthopaedics Surgery	8,723	21.6%	0.101	0.230	
Ophthalmology	5,117	12.7%	0.123	0.248	
Multiple	4,838	12.0%	0.891	0.146	
General Surgery	4,548	11.3%	0.173	0.285	
Otorhinolaryngology	3,453	8.6%	0.158	0.284	
Urology	2,669	6.6%	0.161	0.280	
Cardiology	1,832	4.5%	0.218	0.316	
Respiratory Medicine	1,298	3.2%	0.246	0.317	
Endocrinology	1,288	3.2%	0.348	0.328	
Gastroenterology	1,178	2.9%	0.192	0.304	
Dermatology	780	1.9%	0.150	0.270	
Psychiatry	774	1.9%	0.203	0.295	
Rheumatology	694	1.7%	0.264	0.303	
Geriatric Medicine	652	1.6%	0.246	0.310	
Renal Medicine	610	1.5%	0.325	0.329	
Neurology	425	1.1%	0.263	0.329	

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Neurosurgery	310	0.8%	0.254	0.319
General Medicine	279	0.7%	0.275	0.326
Obstetrics & Gynaecology	215	0.5%	0.196	0.302
Medical Oncology	214	0.5%	0.496	0.227
Plastic Surgery	179	0.4%	0.261	0.309
Infectious Diseases	103	0.3%	0.348	0.319
Anaesthesiology	92	0.2%	0.350	0.325
Haematology	40	0.1%	0.359	0.321
Palliative Medicine	16	< 0.1%	0.272	0.291
Radiation Oncology	6	<0.1%	0.456	0.366

The log-linear regression model chosen through stepwise selection, modelled FCI against age, gender and MFVS (Table 2). FCI was positively associated with age ($p<0.001$). No statistically significant difference in FCI was found between genders. Patients who visited Haematology, Endocrinology and Anaesthesiology specialties most frequently had relatively larger FCIs while those who visited Medical Oncology, Ophthalmology and Orthopaedics Surgery specialties most frequently had the smallest FCIs.

Table 2. Results of log-linear regression of FCI (Values represent back transformation of coefficients)

	Coefficient	95% Confidence Interval
Age	0.0003***	(0.0002, 0.0004)
Gender (Ref: Male)		
Female	0.0017	(-0.0007, 0.0041)
Most Frequently Visited Specialty (Ref: Otorhinolaryngology)		
Haematology	0.0743***	(0.0354, 0.1147)
Endocrinology	0.0477***	(0.0397, 0.0557)
Anaesthesiology	0.0457***	(0.0203, 0.0716)
Neurosurgery	0.0303***	(0.0162, 0.0446)
Obstetrics & Gynaecology	0.0282***	(0.0115, 0.0452)
Neurology	0.0260***	(0.0138, 0.0383)
Plastic Surgery	0.0198*	(0.0018, 0.0381)
Cardiology	0.0159***	(0.0091, 0.0228)
Respiratory Medicine	0.0109**	(0.0033, 0.0186)
General Medicine	0.0104	(-0.0041, 0.0251)
Gastroenterology	0.0028	(-0.0050, 0.0107)
Infectious Diseases	0.0010	(-0.0220, 0.0245)
Geriatric Medicine	0.0009	(-0.0092, 0.0112)
Palliative Medicine	0.0001	(-0.0564, 0.0600)
Urology	-0.0001	(-0.0061, 0.0060)
Renal Medicine	-0.0012	(-0.0114, 0.0091)
Rheumatology	-0.0017	(-0.0113, 0.0080)
Dermatology	-0.0069	(-0.0159, 0.0023)
General Surgery	-0.0073**	(-0.0125, -0.0021)
Psychiatry	-0.0105*	(-0.0196, -0.0013)

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Orthopaedics Surgery	-0.0194***	(-0.0240, -0.0148)
Ophthalmology	-0.0222***	(-0.0272, -0.0171)
Radiation Oncology	-0.0262	(-0.1142, 0.0706)
Medical Oncology	-0.0647***	(-0.0800, -0.0491)
Multiple	0.3393***	(0.3320, 0.3465)
Number of Specialty	0.2332***	(0.2313, 0.2351)

Adjusted R-square = 0.80.
*** p<0.001 ** p<0.01 *p<0.05

DISCUSSION

With the growing concerns of care fragmentation in medical care,[11,14] there is a greater need to measure and analyse multi-specialty care fragmentation in an outpatient setting. The advantage of using FCI to measure care fragmentation is that it accounts for both frequency and dispersion of outpatient visits to different medical specialties to offer a balanced view of care fragmentation.

Studies related to fragmentation of care delivery across multiple providers have shown that a mean FCI of 0.50 corresponds to moderate levels of care fragmentation and a mean FCI of 0.70 corresponds to moderately high levels of care fragmentation.[20,22] While our study did not factor in care fragmentation associated with coordinating care across multiple healthcare entities and focused on multi-specialty care fragmentation in a single institution, we found that moderately high (FCI $\geq$ 0.7) levels of care fragmentation persists in around 36% of the outpatient population. Our findings underscore the possibility of underestimating the extent of care fragmentation in the healthcare system as most studies do not factor in care fragmentation that could occur within a single healthcare entity. The actual situation of care fragmentation be more worrying than what is perceived.

Our study shows that care fragmentation is positively associated with age. This concurs with the literature findings that there is an increased prevalence of multi-morbidity among older adults,[29,30] that they are more likely to consume multi-specialty care and hence are at a higher risk of experiencing fragmented care. However, every 10-year increase in age only resulted in a limited increase of 0.003 in FCI after controlling for gender, MFVS and number of specialties. Outpatients with Haematology, Endocrinology and Anaesthesiology as their MFVS experienced the most fragmentation among the different specialties. This could be because endocrinologists are commonly involved in the co-management of disease conditions such as diabetes along with other specialists from different medical disciplines.[20] Similarly, blood-related disorders referred to haematology are often associated with other systemic diseases and/ or involve multiple specialties in their management.[31,32] As for anaesthesiology, the specialty's clinical practice usually includes pain management and total care of surgical patients throughout the course of planning, preparation and post-recovery from a surgery. Close teamwork between anaesthetists and other specialty doctors are needed for quality care delivery. Interestingly, patients with MFVS- Medical Oncology and Radiation Oncology are associated with smallest FCIs after controlling for other factors. This could be because the patients who most frequently visited Medical Oncology or Radiation Oncology were generally older in age.

A limitation encountered with the use of the FCI as a measure of care fragmentation is the lack in its ability to differentiate the reasons for which care is fragmented among patients with an FCI of 1. For instance, it would not be able to differentiate between a patient

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with one visit each to five different specialties (FCI=1) and another patient with one visit each to two different specialties (FCI=1). The accuracy of the estimates for the extent of multi-specialty care fragmentation in this study is limited by its scope within specialist outpatients from a single hospital as patients in our study population might also have sought specialist care at other healthcare institutions. Hence, our estimates for the extent of multi-specialty care fragmentation are conservative. Primary care is the first point of contact in the provision of care and serves to integrate specialist care. Hence, it is not considered as a specialty in the calculation of FCI. This study does not address the issue of a patient visiting different providers within the same specialty as team based care is the main model of subsidised care in Singapore. Another limitation is that the data on case mix, social factors such as social support, socioeconomic status couldn't be extracted as they are not available as discrete data in the electronic medical records for outpatients. Therefore, there is limited information available to analyse the causes or reasons of fragmentation of care. Nevertheless, this index could still be used as a first step to flag out those at higher risk of receiving fragmented care. These patients may then be referred to care co-ordination team who could then profile the patients, elicit a detailed history to identify the issues and address them with relevant interventions. In addition, further qualitative and quantitative studies could be done to deep dive into the causes of such fragmentation.

CONCLUSION

This study found that multi-specialty care fragmentation in the outpatient specialist clinics was moderately high and it was associated with patient's age and particular medical specialties. Coupled with an ageing population and earlier onset of chronic conditions, this situation seems likely to worsen in the future. Given the complex nature of chronic conditions and the rising prevalence of multi-morbidities, multi-specialty care is probably unavoidable. Nevertheless, healthcare providers could look into ways to eliminate unnecessary referrals to reduce the extent of care fragmentation.

Other information

Funding:
This work was supported by JurongHeath Fund Research and Development Grant.

Competing interests:
None declared.

Ethics approval:
The NHG Domain Specific Review Board (DSRB)

Data sharing statement:
Statistical code and dataset are available upon reasonable request to the corresponding author.

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Patient and Public Involvement:

Patients and or public were not involved. Only anonymised data were collected retrospectively from the hospital's patient management database.

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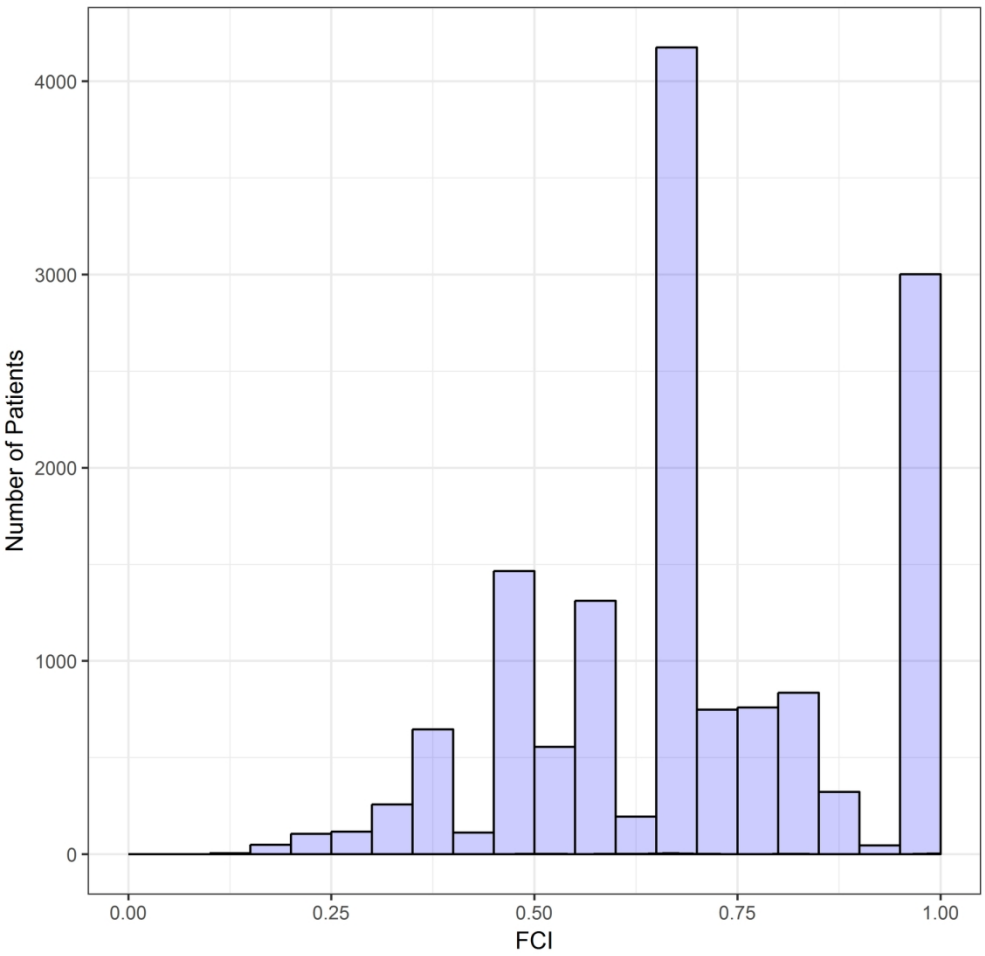

Figure 1. Distribution of the FCI for patients with FCI>0

162x162mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 & 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 & 5
Bias	9	Describe any efforts to address potential sources of bias	*4*
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4 & 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4 & 5
		(*b*) Describe any methods used to examine subgroups and interactions	N.A.
		(*c*) Explain how missing data were addressed	N.A.
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N.A.
		(*e*) Describe any sensitivity analyses	N.A.
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N.A.
		(b) Give reasons for non-participation at each stage	N.A.
		(c) Consider use of a flow diagram	N.A.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	N.A.
Outcome data	15*	Report numbers of outcome events or summary measures	5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5 & 6 & 7
		(*b*) Report category boundaries when continuous variables were categorized	5 & 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N.A.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N.A.
Discussion			
Key results	18	Summarise key results with reference to study objectives	7 & 8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8 & 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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