Impact of a Patient-centered Medical Home on Healthcare Utilization for Patients With Complex Needs in Singapore: a Matched Cohort Study

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Abstract

Background: Patients with complex needs require greater biopsychosocial support. Fragmented services often result in gaps, duplication or incompatibility in treatments, leading to poorer health outcomes and higher utilization of costly hospital-based healthcare services. Patient-Centred Medical Home (PCMH) is a primary care model reform advocated as more appropriate for patients with complex needs. This analysis assessed the impact of a PCMH demonstration on healthcare utilization for patients with complex needs in Singapore.

Methods: This study assessed the Community for Successful Ageing (ComSA)-PCMH in Singapore that was launched in Nov'2016. ComSA-PCMH serves adults aged 40 and above with complex needs, delivering care integrated between its primary care clinic, home-based care management, an acute hospital and other community-based services.

This was a matched cohort analysis that used a difference-in-difference approach to compare quarterly healthcare utilization of PCMH study participants and controls. 165 PCMH study participants enrolled between Oct'2017 and Apr'2019 were compared against 5,385 controls selected using Coarsened Exact Matching from a neighbouring geographical precinct. Healthcare utilization data spanning Oct'2014 to Mar'2020 were extracted from a public regional health system, including primary care, specialist outpatient clinic and emergency department utilization, and inpatient admissions.

Two-part models were fitted, with controls for socio-demographics, Charlson Comorbidity Index, secular trends including effect of COVID-19, and between-group differences. Statistical inferences were based on cluster-robust standard errors at the individual level.

Results: At ≥ 4 four quarters post-enrolment, PCMH study participants had sustained reductions of 1.08 polyclinic visits ($p < 0.001$), 0.37 SOC visits ($p = 0.047$), 0.04 ED visits ($p = 0.013$) and 0.02 inpatient admissions ($p = 0.093$) per person-quarter, compared to the quarter before enrolment and controls.

Conclusions: ComSA-PCMH study participants reduced healthcare utilization after enrolment into the programme, adding to a growing global body of evidence supporting the benefits of PCMH for patients with complex needs and pointing to its potential in Asia.

Trial registration: This analysis is part of the ComSA Patient-Centered Care (COPACC) study, retrospectively registered with ClinicalTrials.gov in October 2020 (Protocol ID: NCT04594967; <https://clinicaltrials.gov/ct2/show/NCT04594967>).

1 Background

Globally, there is a rapid increase in the prevalence of multiple chronic conditions, which is associated with poorer physical function and quality of life, increased risk of morbidity, disability, and psychological stress.' It is increasingly acknowledged that a fragmented health system comprised of disease-specific

models of care is inadequate in managing these needs. When multiple conditions are managed in silos, issues such as unnecessary polypharmacy, adverse drug interactions and treatment gaps tend to arise.⁵ Fragmented care may also overlook non-medical influences that add complexity to the management of these patients, including socio-economic challenges, family stressors and mental health issues such as depression. This adds burden to patients and caregivers by requiring them to navigate between multiple service providers and reconcile various treatment and services, resulting in patients with complex needs falling through the cracks and/or presenting to inappropriate healthcare settings. Studies have shown that patients with multiple chronic conditions are far more likely to incur hospital admissions for ambulatory care-sensitive conditions, and found a curvilinear, almost exponential relationship between multiple chronic conditions and healthcare utilization and costs.

Singapore, a small developed country in Asia, faces similar challenges to its health system with increasing numbers of patients with complex needs. It is estimated that 1 out of 5 Singaporeans will be aged 65 and above by year 2030. The ageing trend is accompanied by increasing chronic disease burden. The proportion of Singaporeans with ≥ 3 chronic conditions rose from 19.8–37.6% within a decade, from 2009 to 2017. Over the same period, those with functional difficulties in ≥ 1 basic activity of daily living (ADL) rose from 6.3–9.3%, and those with difficulties in ≥ 3 instrumental activities of daily living (IADL) rose from 6.4–8.3%. Like most developed countries, Singapore's healthcare system was originally designed for the acute, episodic healthcare needs of a younger population of the past.⁶ With the evolving demographics and healthcare needs, it is acknowledged that a stronger primary care model is required to provide more appropriate care.

The Patient-Centered Medical Home (PCMH), a primary care model, has been advocated as a more appropriate model for patients with complex needs.⁸ Contrary to disease-specific models of care, the PCMH model aims for comprehensive management of healthcare needs, recognizing the interactions between various medical conditions and non-medical challenges such as social and financial needs. This is accomplished through improved communication and coordination between the patient, family and service providers.⁸ The PCMH model has been shown to reduce inappropriate hospital-based healthcare utilization with improved management of care needs in the primary care setting and coordination of referrals to more appropriate care settings.

Most evaluation studies have found the PCMH model to be most effective in populations that are older or have higher needs, resulting in better health outcomes and reduced hospital-based healthcare utilization. In contrast, studies that found non-significant changes tend to be amongst populations with lower needs, or examine very early stages of PCMH implementation.²¹ Moreover, implementation and evaluation of PCMH models have been carried out predominantly in the West, while less is known about its effectiveness in an Asian context.

This study aims to assess the impact of a PCMH demonstration on healthcare utilization for patients with complex needs in Singapore. This, to the authors' knowledge, is the first study to evaluate the impact

of PCMH on healthcare utilization in Singapore and in Asia. This study would address the existing knowledge gaps about the effectiveness of PCMH in an Asian context and contribute to the wider discussion on the delivery of primary care for adults with complex needs.

2 Methods

2.1 Study design

This is a matched cohort study using a difference-in-difference approach to analyse healthcare utilization of PCMH study participants.

2.2 Intervention

This study assessed the Community for Successful Ageing (ComSA)-PCMH, launched in November 2016 in a geographically defined central region of Singapore. Adults aged 40 and above identified to have high biopsychosocial needs by a locally-validated risk screening tool or clinical judgment, and residing within the geographic area were recruited to the clinic. These included referrals from specialist clinics and primary care clinics from the public regional health system, other private primary care and community partners as well as patients who walked in without referrals.

ComSA-PCMH consists of a primary care clinic led by family doctors trained in geriatric primary care and care coordination, as well as a home-based care management service led by medical social workers and nurses to support adherence to care plan, care coordination to manage financial problems, health behaviour challenges, family conflict, caregiver stress and social engagement. The initial visits comprise a comprehensive needs assessment and care plan development with patient and caregivers. This is followed by regular reviews and acute treatments if needed. ComSA-PCMH delivers care that is integrated between the primary care clinic, home-based care management, the referring acute hospital and other community-based services. Patients are empanelled within the integrated PCMH with a regular primary care physician and home care team for lifelong engagement, to facilitate continuity of care and sustained patient-provider relationship. Patients are only discharged if they had no contact with ComSA-PCMH for >18 months, became institutionalised in nursing homes, homebound or passed away.

2.3 Sample

This study recruited 184 patients within their initial visits to ComSA-PCMH, from October 2017 to April 2019. Controls were selected from a neighbouring geographical region with similar population-level demographics of age, ethnicity, housing type and disease prevalence, and is served by the same public regional health system that did not offer the PCMH model of care. As participants had complex medical and non-medical needs, the sampling frame for controls was derived from the administrative records of a wide range of healthcare services, namely five public primary care clinics (termed 'polyclinics' in Singapore) and specialist outpatient clinics (SOC), emergency department (ED) and inpatient services under the public regional health system, from 1 September 2014 to 31 March 2020. The sampling frame

consisted of 11,269 unique persons residing in the control region. Persons who had passed away during the period of analysis or had incomplete data were excluded for a complete case analysis (Figure 1).

Matched controls were selected using Coarsened Exact Matching (CEM) on variables that may affect healthcare utilization patterns: birth year, gender, housing type, ethnicity, weighted Charlson Comorbidity Index (CCI) and whether the person had any inpatient admission or specialist outpatient clinic visit in the quarter before enrolment. Variables were temporarily coarsened into substantively meaningful groups (Table 1) and all exact matches were identified from the control group. Original, un-coarsened values were retained for analysis. CEM was selected over Propensity Score Matching as it can achieve lower levels of covariate imbalance, model dependence and bias. This matching method yielded different proportions of PCMH study participants and controls across the different coarsened typologies. All matched units were included in the analysis and weighting was used to account for the unequal strata sizes. The final sample consisted of n=165 PCMH study participants and n=5,385 controls (Figure 1).

Table 1
Variables involved in Coarsened Exact Matching

Variable	Coarsened categories
Birth year	≤1940, 1941-1950, 1951-1960, 1961-1970, ≥1971
Gender	Male, Female
Ethnicity	Chinese, Malay, Indian & Sikh Based on Singapore’s ethnic categorization
Housing type	Public, Private
CCI	0, 1-2, 2-4, ≥5 Based on categorization by Menendez et al. 2014 Note: Calculation for PCMH study participants based on individual enrolment date. Calculation for controls based on earliest enrolment date into ComSA-PCMH amongst study participants
Had inpatient admission or specialist outpatient clinic visits in the quarter before enrolment	Yes, No

2.4 Outcome measures

The study assessed outcomes in healthcare utilization at public healthcare providers. Public providers are major players in Singapore’s healthcare scene, with polyclinics serving approximately 40% of chronic disease-related visits in primary care and public hospitals providing approximately 80% or more of tertiary inpatient services.’

Healthcare utilization outcomes assessed were polyclinic visits, SOC visits, ED visits and inpatient admissions. We included visits from 1 October 2014 to 31 March 2020, to cover at least 3 years before the first PCMH study participant's enrolment and 1 year after the last study participant's enrolment into PCMH.

2.5 Data sources

The study extracted administrative records from a public regional health system. This included records of polyclinic visits, SOC visits, ED visits, inpatient admissions and demographic data. From these records, we calculated the unique number of visits per person, per calendar-quarter (i.e. person-quarter) and CCI for all PCMH study participants and controls.

For study participants who were not in the public regional health system's administrative records, we derived demographic data and CCI from the PCMH clinic administrative database.

2.6 Data analysis

Difference-in-differences was used to identify changes in healthcare utilization of PCMH study participants pre- and post-enrolment into PCMH, relative to matched controls. This design enables assessment of whether enrolment into PCMH was associated with changes in healthcare utilization over time that were statistically different from the secular trend.

Regression analysis was conducted by fitting a two-part model for each outcome measure. For the first part, a logistic regression model was fitted where the dependent variable was whether there was any (i.e. ≥ 1) healthcare utilization event (binary yes/no) per person-quarter. For the second part, a Poisson regression was fitted, where the dependent variable was the number of healthcare utilization events per study person-quarter, among those who had any healthcare utilization events. This was conducted to handle the high number of person-quarters with zero healthcare utilization events in the data."

The main independent variable assessed is time since enrolment into PCMH. This was modelled using dummy variables to identify any non-linear effects over time. We included individual controls for each quarter, up to 7 quarters pre-enrolment and 3 quarters post-enrolment. Effects for time periods 8 quarters or more pre-enrolment and 4 quarters or more post-enrolment were treated as constant and grouped. In this analysis, enrolment refers to the calendar quarter (3 months) in which the PCMH study participant was enrolled into PCMH. Baseline referred to the quarter before enrolment. Controls were never enrolled into PCMH and hence took zero values for all dummy variables indicating time since enrolment.

Potential confounders were controlled for in both parts of the model: birth year, gender, ethnicity, housing type, CCI and treatment group (PCMH, control) to account for any unobserved difference between groups. Calendar time was also adjusted for, to account for secular changes in healthcare utilization, modelled using dummy variables to identify any non-linear trends. The last calendar quarter in this analysis (i.e. 2020Q1) is of particular interest as COVID-19 had spread to Singapore during that period. An interaction term ($2020 \times \text{PCMH}$) was included to account for any differential effects that PCMH study participants

sustained in 2020Q1 compared to controls. Cluster-robust standard errors at person-level were used to account for potential within-person correlation of healthcare utilization over time.

The adjusted average marginal effects which combines Part 1 (logistic) and Part 2 (Poisson) were calculated.

3 Results

3.1 Descriptive statistics

PCMH study participants had a mean age of 76 years [SD=9.61] and mean age-adjusted CCI of 4.51 [SD=2.01] as of 2017, which were not statistically significantly different from controls (Table 2). Both PCMH study participants and controls had similar prevalence of diabetes with and without complications, cerebrovascular disease and renal disease as comorbidities, although PCMH study participants had significantly higher prevalence of dementia ($\chi^2 = 3.39$, $p < 0.001$) compared to controls (Figure 2).

Table 2
Post-matching case-control characteristics

Variable	PCMH Study Participants (n=165)	Controls (n=5385, weighted ¹)	t-test score (2-tailed, weighted ¹)
Age (mean [SD], as of 2017)	76 [9.61]	75 [9.03]	t(173)=-0.60, p=0.55
Gender, Female (%)	55.8 92.7 2.4	55.8 99.4	NA due to exact matching
Ethnicity, Chinese (%)	92.7	92.7	
Ethnicity, Malay (%)	2.4	2.4	
Ethnicity, Indian & Sikh (%)	4.8	4.8	
Housing, Public (%)	99.4	99.4	
Age-adjusted CCI (mean [SD])	4.51 [2.01]	4.53 [2.83]	t(176)=-0.14, p=0.89
Baseline no. of polyclinic visits (mean [SD], per person-quarter)	0.61 [1.02]	0.88 [1.16]	t(177)=-3.25, p=0.001
Baseline no. of SOC visits (mean [SD], per person-quarter)	1.47 [2.17]	1.22 [1.78]	t(171)=1.48, p=0.14
Baseline no. of ED visits (mean [SD], per person-quarter)	0.16 [0.55]	0.08 [0.17]	t(165)=1.88, p=0.06
Baseline no. of inpatient admissions (mean [SD], per person-quarter)	0.11 [0.37]	0.05 [0.13]	t(165)=1.95, p=0.05
¹ Weighting was used to account for unequal strata sizes			

At baseline, both PCMH study participants(P) and controls(C) had highest utilization in SOC (P:1.47visits/person-quarter; C:1.22visits/person-quarter), followed by polyclinics (P:0.61visits/person-

quarter; C:0.88visits/person-quarter), ED (P:0.16visits/person-quarter; C:0.08visits/person-quarter) and inpatient admissions (P:0.11visits/person-quarter; C:0.05visits/person-quarter). PCMH study participants had significantly fewer polyclinic visits ($t(177)=-3.25, p=0.001$) and marginally more ED visits ($t(165)=1.88, p=0.06$) and inpatient admissions ($t(165)=1.95, p=0.05$) per person-quarter compared to controls. (Table 2).

3.2 Difference-in-difference

Figures 3-6 plot the marginal effects of the two-part model for polyclinic visits, SOC visits, ED visits and inpatient admissions respectively.

Relative increases in the healthcare utilization of PCMH study participants compared to controls were observed over the pre-enrolment quarters. Then, relative reductions were first observed in polyclinic visits in the quarter before enrolment, followed by SOC visits two quarter after enrolment and ED visits three quarters after enrolment, continuing till the end of the analysis period.

At ≥ 4 quarters post-enrolment, PCMH study participants had sustained significant reductions of 1.08 polyclinic visits ($dy/dx: -1.08, p<0.001$), 0.37 SOC visits ($dy/dx: -0.37, p=0.047$), 0.04 ED visits ($dy/dx: -0.04, p=0.013$), and showed marginally-significant reductions of 0.02 inpatient admissions per person-quarter ($dy/dx: -0.02, p=0.093$), compared to the quarter before enrolment and controls. Estimates of the full model are reported in the Appendices.

4 Discussion

Reductions in the healthcare utilization assessed were observed after enrolment into PCMH. These effects were robust even after adjusting for potential confounders, secular trends and differential changes in healthcare utilization that PCMH study participants and controls might have during the first quarter of Covid-19 outbreak in Singapore.

At ≥ 4 four quarters post-enrolment, PCMH study participants had sustained reductions of 1.08 polyclinic visits ($p<0.001$), 0.37 SOC visits ($p=0.047$), 0.04 ED visits ($p=0.013$) and 0.02 inpatient admissions ($p=0.093$) per person-quarter, compared to the quarter before enrolment and controls.

These findings are aligned with previous evaluation studies that also found reductions in SOC visits, ED visits and inpatient admissions associated with PCMH interventions for patients with higher needs.^{15, 16, 17, 18, 19, 20, 21, 22}. Possible mechanisms for reduction in hospital-based healthcare utilization could be explained by the qualitative findings of the larger study. Participants and caregivers reported that they were able to consolidate care at PCMH, as they received comprehensive care at PCMH that was of similar or better quality compared to their previous usual providers. The positive care experience was attributed to the continuity, personalisation and holistic management of care, and a sustained patient-provider relationship. These findings were triangulated by findings reported in other studies. A qualitative study with patients, payers, implementation staff and experts identified that continuity of care and adoption of

care plan were amongst high-value elements that reduce healthcare utilization. Another cohort study observed that patients with continuity of care were less likely to have ED visits.

The one-year time lag before significant reductions was also consistent with the literature. A previous randomized controlled trial in the United States found that amongst patients at high risk for hospitalization, non-significant changes were observed in the first year but significant reductions in inpatient admissions and ED visits were observed in the second year. The authors proposed that a period of engagement was needed to develop trust between the care team and the patients, before patients would reduce utilization of other healthcare services.¹⁶

This study had various strengths. Firstly, this study used administrative data from a reliable public regional health system to calculate healthcare utilization. This afforded good coverage of the study participants' healthcare utilization, as public providers are major players in Singapore's healthcare scene, with public hospitals providing approximately 80% or more of tertiary inpatient services.²⁹ Administrative data also provided an accurate and objective measure that is not affected by recall error or other response biases.

Secondly, this analysis used a difference-in-difference approach. This design enabled assessment of whether enrolment into PCMH was associated with changes in healthcare utilization over time that were statistically different from the secular trend, combining the strengths of a case-control comparison and cohort study.

Thirdly, analysis of quarterly healthcare utilization provided more granular insights compared to commonly-seen measures of yearly healthcare utilization, while retaining sufficient aggregation to tolerate 'noise' in the data.

There were also some limitations to this study. Firstly, the controls are matched only on available observables, and hence may not be ideal counterfactuals, as we did not have sufficient data to match on psychological and social needs. Several indicators suggest that PCMH study participants had higher needs than controls. For example, PCMH study participants had significantly fewer polyclinic visits and more inpatient admissions and ED visits at baseline, compared to the controls. The higher inpatient admissions and ED visits at baseline were contributed by increases over 8 quarters or more before enrolment. This points to a prolonged increase in complexity of medical needs rather than an acute crisis episode, and is unlikely to be followed by recovery with usual care. . In addition, PCMH study participants had a higher prevalence of dementia (P:18%; C:6%), which is strongly associated with higher long-term psychosocial needs and healthcare utilization. Accordingly, relative improvements after enrolment into PCMH would likely be larger if compared to a group with more similar needs.

Causal inference of the estimated reduction of polyclinic visits should also be interpreted with caution, since a small, marginally-significant reduction was observed even before enrolment into PCMH (Q_{-2} dy/dx: 0.24, $p=0.076$). This reduction occurred with concomitant increases in SOC visits, inpatient admissions and ED visits before enrolment. As ComSA-PCMH enrolled patients with complex care needs,

it could be postulated that by the time of enrolment, polyclinic visits might have become inadequate to support the increase in complexity of care needs. Some care substitution with hospital services may have occurred.

In addition, this analysis did not differentiate between avoidable and unavoidable hospital visits. Avoidable visits include those due to social reasons or milder conditions that could be treated in primary care, or due to escalations that could have been avoided if the conditions had been better managed in primary care. As such, the reductions for avoidable visits could be expected to be more pronounced compared to reductions in all hospital visits, as PCMH is expected to reduce hospital visits via improved management of ambulatory-care sensitive conditions as well as consolidation and coordination of care.¹⁵ This can be assessed in future research to improve understanding of the mechanisms that contributed to the reductions in health utilization.

Lastly, this analysis assessed healthcare utilization in a limited time period post-enrolment. Our findings suggest that a longer follow-up period may allow us to capture more comprehensive effects.

5 Conclusions

Our study findings support the hypothesis that enrolment into PCMH is associated with reductions in hospital-based healthcare utilization. While further research is needed to assess its longer-term effectiveness, sustainability and generalizability to other parts of Asia, these findings add to a growing body of evidence supporting the benefits of PCMHs for adults with complex needs globally and point to the potential of PCMH in Asia.

Abbreviations

ADL: Activities of Daily Living

C: Controls

CCI: Charlson Comorbidity Index

CEM: Coarsened Exact Matching

ComSA: Community for Successful Ageing

ED: Emergency Department

IADL: Activities of Daily Living

P: Participants

PCMH: Patient-Centered Medical Home

Declarations

i. Ethics Approval

This study was approved by the Domain Specific Review Board (DSRB) of National Healthcare Group (NHG), Singapore (protocol ID 2017/00352, approved 1 August 2017). The Domain Specific Review Board's policies are based on local and international ethical guidelines, including Belmont Report, Declaration of Helsinki, and Ministry of Health Singapore Code of Ethical Practice in Human Biomedical Research.

NHG DSRB approved a waiver of consent for extraction of administrative data from the public regional health system, as study findings would not change the care which the participants would have already received. Written informed consent was obtained from study participants who were not in the public regional health system's administrative records, for extraction of their records from the PCMH clinic administrative database.

ii. Consent for publication

Not applicable – this manuscript does not contain any personally-identifiable information.

iii. Availability of data and materials

The data presented in this study are not publicly available to protect patients' privacy.

iv. Competing interests

CHW is currently employed at Tsao Foundation. The employment commenced after the completion of the study and analysis, and did not have any impact on manuscript preparation. All other authors had no conflict of interests relating to the subject matter discussed in this manuscript.

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vi. Authors' contribution

CHW was principal investigator, while MLG and ZZBL were co-investigators of the study. SYHS and SHH analysed and interpreted the data with advice from JC, JY and all authors. SYHS wrote the first draft of the manuscript and subsequently edited with inputs from all authors JC, SHH, MLG, ZZBL, GS, JY and CW. All authors read and approved the final manuscript.

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Figures

Figure 1

Study Flow for study sample selection

Figure 2

Post-matching case-control prevalence of comorbidities

Weighted chi-square tests conducted to assess if differences were statistically-significant. *p*-value: ** <0.01, * <0.05, ^ <0.1

Figure 3

Polyclinic visits two-part model (Combined), difference-in-difference:

Difference in no. of polyclinic visits per person-quarter between PCMH study participants and controls, by time since enrolment

Figure 4

visits two-part model (Combined), difference-in-difference:

Difference in no. of SOC visits per patient-quarter between PCMH study participants and control patients, by time since enrolment

Figure 5

Emergency department visits two-part model (Combined), difference-in-difference:

Difference in no. of ED visits per patient-quarter between PCMH study participants and control patients, by time since enrolment

Figure 6

Inpatient admissions two-part model (Combined), difference-in-difference:

Difference in no. of inpatient admissions per person-quarter between PCMH study participants and control patients, by time since enrollment

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AppendixTableTwo.docx](#)