

## Cost analysis of a Patient-Centred Medical Home for community-dwelling older adults with complex needs in Singapore

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### ABSTRACT

**Introduction:** The Patient-Centred Medical Home (PCMH) demonstration in Singapore, launched in November 2016, aimed to deliver integrated and patient-centred care for patients with biopsychosocial needs. Implementation was based on principles of comprehensiveness, coordinated care and shared decision-making.

**Method:** We conducted a prospective single-arm pre-post study design, which aimed to perform cost analysis of PCMH from the perspectives of patients, healthcare providers and society. We assessed short-to-intermediate-term health-related costs by analysing data on resource use and unit costs of resources.

**Results:** We analysed 165 participants enrolled in PCMH from November 2017 to April 2020, with mean age of 77 years. Compared to the 3-month period before enrolment, mean total direct and indirect participant costs and total health system costs increased, but these were not statistically significant. There was a significant decrease in mean cost for primary care (government primary care and private general practice) in the first 3-month and second 3-month periods after enrolment, accompanied by a significant decrease in service utilisation and mean costs for PCMH services in the second 3-month period post-enrolment. This suggested a shift in resource costs from primary care to community-based care provided by PCMH, which had added benefits of both clinic-based primary care and home-based care management. Findings were consistent with a lower longer-term cost trajectory for PCMH after the initial onboarding period. Indirect caregiving costs remained stable.

**Conclusion:** The PCMH care model was associated with reduced costs to the health system and patients for usual primary care, and did not significantly change societal costs.

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### INTRODUCTION

The Patient-Centred Medical Home (PCMH) is a model of chronic care that replaces episodic primary care, with the delivery of primary care to patients, families and communities. It is guided by the principles of first-contact accessibility, comprehensiveness and whole-person orientation, integration and care coordination, sustained clinician-patient relationships, and quality and safety.<sup>1,2</sup>

The PCMH care model shifts from a disease-specific approach to a comprehensive biopsychosocial model that recognises the interplay of physical illnesses, mental disorders, and social and home environmental problems.<sup>3</sup> This biopsychosocial perspective allows for management options that consider tailored preferences and aims for the healthcare of each patient, clinician-patient relationships, patient engagement and quality of life (QoL).<sup>4</sup>

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## CLINICAL IMPACT

### What is New

- To the best of our knowledge, this is the first cost analysis of a Patient-Centred Medical Home (PCMH) care model in Singapore from the patient, healthcare provider and societal perspectives.

### Clinical Implications

- Early evidence suggested that the PCMH care model reduced the out-of-pocket expenses to patients and resource cost to providers for usual primary care, by shifting costs towards community-based primary care delivery.
- The PCMH had added benefits of comprehensive and individualised care for community-dwelling adults.

A few knowledge gaps on the integrated PCMH model still exist. While integrated PCMH models have been shown to improve patient outcomes,<sup>5,6</sup> the impact on overall costs and the relative burden on various stakeholders (patients, healthcare providers and society at large) remain less well-understood. Existing literature has focused on costs to the healthcare system and providers, rather than costs from a patient-centric perspective.<sup>7,8</sup> Studies have also focused on the PCMH model for specific subgroups of patients, including older adults with multimorbidity or diabetic patients only.<sup>9,10</sup> While these studies have merit, their findings may not be generalisable to community-dwelling older adults with a combination of physical, psychological and social care needs. Additionally, it is challenging to draw conclusions on cost outcomes from current studies, due to the mixed findings across different target populations and settings. To illustrate, a pre-post study with controls in the US compared 8 practices that adopted the PCMH model with a group of 24 non-PCMH practices in 2010 to 2011, and reported no significant difference in costs.<sup>11</sup> Other studies showed that the PCMH programme was cost-effective when provided to patients with more chronic conditions or whose conditions were poorly managed at baseline.<sup>9,10</sup> Lastly, there is a dearth of literature on PCMH models in the Asian context. Current findings may not be generalisable to Asia due to differences in health systems and cultural backgrounds.<sup>12</sup>

The integrated PCMH care model in this study is part of a community-wide initiative (Community for Successful Ageing) on an integrated care system of comprehensive programmes and services promoting the well-being and health of older adults in Singapore.<sup>6,13,14</sup> Our integrated PCMH model differs from current advanced primary care models in Singapore that centres on a multidisciplinary team to deliver chronic disease management,<sup>15</sup> or Family Medicine Clinics that provide a “one-stop platform” for individualised chronic condition prevention and management by general practitioners.<sup>16</sup> The integrated PCMH model in this article targets community-dwelling older adults with complex biopsychosocial needs, assessed via social health, psychological and medical evaluations.<sup>6,13,14</sup> Our model follows overarching principles on ageing in place (growing old at home), life-course approach (promoting the earlier implementation of interventions for health), socioecological model of care (health as an outcome of an individual’s interaction with family, caregivers and community), and population health management.<sup>6,13,14</sup>

Our study aimed to address gaps in the literature on the evaluation of costs associated with the implementation of an integrated PCMH model for community-dwelling older adults with complex needs. Our study examined costs not only from the health system perspective, but also from the perspectives of patients and the wider society. Findings will also be more generalisable to older populations across Asia.

## METHOD

### Study design and participants

This study was part of an evaluation of a PCMH demonstration in Singapore that involved concurrent quantitative and qualitative components.<sup>6,14</sup> We applied a prospective single-arm pre-post design that examined 2 time-points of the intervention compared to baseline. First, a true experimental design with randomisation of patients into intervention and control arms was impractical, due to the PCMH being a complex intervention with multiple care components. It would have been challenging to implement, as well as time-consuming and resource-intensive. Second, having a non-randomised parallel control arm was also challenging due to limited resources to involve a control study site that provided usual care, and high refusal rates and low recruitment were expected from patients of the control site. In addition, there were challenges in

identifying a suitable control study site that would capture older adults with similar characteristics and health status profiles as the intervention group, but would only deliver usual care. Lastly, the option of utilising historical datasets to act as controls had possible limitations, such as systematic differences between groups due to the time difference in data collection, poor performance of matching techniques as the dataset may not contain suitable controls, and lack of clarity on what constituted usual care for controls.

Study participants were recruited from 1 November 2017 to 30 April 2019. Informed consent was taken from participants or proxies. As mentioned in our previous publications, these were the eligibility criteria included:<sup>6,13</sup>

(1) Patients with high biopsychosocial health risk defined by the 37-item BioPsychoSocial Risk Screener validated in the Singapore setting,<sup>17</sup> pre-existing risk stratification criteria used by referring healthcare institutes, and/or clinical assessment. Functional ability and frailty were not part of the inclusion and exclusion criteria.

(2) Patients aged  $\geq 40$  years.<sup>6,13</sup> Cut-off age was chosen to reflect the life-course approach. PCMH services could be provided to patients with complex needs from their fourth decade of life prior to entering old age, for early intervention to prevent further adverse health outcomes.<sup>6,13</sup>

(3) Patients who resided in Whampoa, a geographically defined district in Singapore (total population of 41,000) where the PCMH was located.<sup>6,13</sup>

## Intervention

There are advanced primary care models in Singapore, such as the Family Medicine Clinics where family medicine physicians provide individualised care for patients and the Teamlet Care Model where a multidisciplinary team manages non-communicable diseases.<sup>15,16</sup> Our PCMH model differed by targeting community-dwelling older adults with biopsychosocial needs, and has 2 integrated parts: medical care in primary care and psychosocial care in home-based care management.

The intervention was described in detail in our earlier publication.<sup>6</sup> Implementation was based on PCMH values on patient-centredness, comprehensive and coordinated care, accessible services, shared decision-making, and quality and safety.<sup>1</sup> The PCMH was an integrated care intervention comprising physician-led primary care clinics, and home-based care management services led by medical social workers and nurses.<sup>12</sup>

Briefly, the intervention involved a multidisciplinary care team (doctors, registered nurses, programme coordinators and care managers), comprehensive needs assessment, and individualised care plans.<sup>6</sup> The initial clinic visit involved comprehensive biopsychosocial assessment and the development of a preliminary individualised care plan with the patient and family members. Subsequent clinic visits reviewed individualised care plans and treated acute conditions.<sup>6</sup> The development of care plans and reviews were discussed at interdisciplinary team meetings. PCMH primary care providers also partnered geriatric specialists from the tertiary acute hospital to provide shared care. Patients determined to have complex biopsychosocial needs at the first or subsequent clinic visits were given home-based care management services.<sup>6</sup> Home-based care management provided extended care in the home setting, and addressed the physical home environment, financial needs, behavioural needs, and support systems by caregivers.<sup>6,13</sup>

## Outcome measures

We conducted the cost analysis from the perspectives of patients (out-of-pocket expenditures [OOPE] by patients), healthcare provider (resource cost to the health system) and society:

**Patient perspective** = (a) OOPE on PCMH and non-PCMH health services + (b) OOPE of paid care services from domestic helpers or other professional carers + (c) work productivity loss by participants due to ill health

**Healthcare provider perspective** = (d) Resource cost of providing PCMH and non-PCMH health services

**Societal perspective** = (b) + (c) + (d) + work productivity loss and leisure time loss from providing caregiving to participants by family members

Supplementary Table S1 (online Supplementary Material) shows the categories of direct and indirect costs under each perspective.

Cost outcomes included the direct costs of PCMH services, and direct medical and non-medical costs. Healthcare utilisation data in this study was self-reported. Specifically, an adapted Client Service Receipt Inventory (CSRI) survey was administered to participants to collect self-reported data on healthcare utilisation in the past 3-month period from the date of surveys.<sup>18</sup> Surveys were conducted at baseline and repeated at 3 months and 6 months post-enrolment.

## Cost to patients (out-of-pocket expenditures by patients)

Table 1 displays how unit prices were derived and unit price of each item.

Table 1. Cost from the patient perspective: Items and unit prices

| Items                                                            | How this study derived price                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Unit price (SGD)                                             |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| <b>PCMH services</b>                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                              |
| PCMH clinic services                                             | For each participant, the total PCMH patient payments were extracted from administrative billing information, inclusive of consultation fees, procedure fees and medication fees.                                                                                                                                                                                                                                                                                                               | NA                                                           |
| PCMH home-based care management services                         | Home-based care management services were of no charge to patients.                                                                                                                                                                                                                                                                                                                                                                                                                              | 0                                                            |
| <b>Non-PCMH services</b>                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                              |
| Government primary care                                          | Based on National Healthcare Group government primary care consultation fee. <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                       | 13.20 per visit                                              |
| Private general practice                                         | Based on National Healthcare Group family physician clinic consultation fee.                                                                                                                                                                                                                                                                                                                                                                                                                    | 30.00 per visit                                              |
| Accident and emergency (A&E)                                     | Based on fees charged by the acute hospital under National Health Group (Tan Tock Seng Hospital, Singapore) that referred patients to the PCMH clinic in this study.                                                                                                                                                                                                                                                                                                                            | 120.00 per visit                                             |
| Specialist outpatient clinic (SOC)                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 38.00 for 1 <sup>st</sup> visit, 36.00 for subsequent visits |
| Outpatient allied health                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 22.50 per visit                                              |
| Day surgery                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 49.00 per session                                            |
| Inpatient admission                                              | Based on inpatient charges for Singapore citizens per bed day, according to hospital class wards.                                                                                                                                                                                                                                                                                                                                                                                               | 35 to 43 for C Class wards                                   |
| <b>Non-PCMH community care</b>                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                              |
| Social day care                                                  | Out-of-pocket expenses for community care services were based on the total costs given by the Agency for Integrated Care under the Ministry of Health of Singapore, and assumed to be 40% of the total costs based on Graham & Bilger. <sup>19</sup>                                                                                                                                                                                                                                            | 17.20 per visit                                              |
| Day rehabilitation                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 24.20 per visit                                              |
| Dementia day care                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 23.40 per visit                                              |
| Home medical care                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 50.00 per visit                                              |
| Hospice care                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 50.00 per visit                                              |
| Escort services                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 30.40 per visit                                              |
| Community development council/<br>Family service centre services |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | No charge to patients                                        |
| Hiring domestic helpers for caregiving                           | We collected self-reported estimated time contributions from informal household-based caregivers (both paid domestic helpers and family caregivers) related to assisting with Activities of Daily Living and Instrumental Activities of Daily Living, supervision of study participants, and/or providing child and elderly care on behalf of study participants.<br><br>The hourly cost of care provided by domestic helpers at home was based on figures reported by Woo et al. <sup>20</sup> | 3.45 per hour                                                |
| Work productivity loss due to ill health by study participants   | Work productivity loss was valued at the median gross monthly income of a full-time employed worker in Singapore, converted to hourly wages based on national average weekly total paid hours worked per employee.                                                                                                                                                                                                                                                                              | 20.22 per hour                                               |

PCMH: Patient-Centred Medical Home

<sup>a</sup> The National Healthcare Group is one of the 3 healthcare clusters in Singapore, and the PCMH was under this healthcare cluster.

Superscript numbers: Refer to REFERENCES

### ***Cost to healthcare providers (resource cost to health system)***

Table 2 shows the derivation of unit resource costs and unit resource cost for each item, drawing on previous work by Abdin et al.<sup>18</sup> and Graham and Bilger.<sup>19</sup>

### ***Costs to informal caregivers***

Table 2 shows the derivation of unit costs for work productivity loss and leisure time loss from caregiving, based on a local study by Woo et al.<sup>20</sup> and the labour statistics from the 2017 Singapore Yearbook of Manpower Statistics.<sup>21</sup>

### **Data analysis**

To assess the short to intermediate-term health-related cost from different perspectives, we analysed cumulative health-related costs incurred over the quarter (3-month period) immediately before enrolment, from the first quarter post-enrolment (i.e. first 3-month period post-enrolment), and the second quarter post-enrolment from 3 months post-enrolment to 6 months post-enrolment (i.e. second 3-month period post-enrolment). We estimated the change in quarterly costs in the latter 2 periods, with the quarter immediately before enrolment. Costs were converted to 2017's Singapore Dollar amount using the consumer price index for Singapore from the Monetary Authority of Singapore. We reported mean and median costs per-person per-quarter.

### ***Statistical analysis***

Sample characteristics of the 165 participants analysed were presented, and data were summarised descriptively as mean and standard deviation. We used multivariable linear regression models with random intercepts and fixed slopes to compare the difference between mean costs per-participant per-quarter, during the first 3-month period post-enrolment and second 3-month period post-enrolment, compared to the 3-month period prior to enrolment. The multivariable regression models had random intercepts to allow for variation by individuals (i.e. between-participant variation), but slopes were fixed as time was not a continuous variable in this study. We recognised that each participant may act as its own control in this single-arm pre-test post-test study design. However, this study still aimed to adjust for observed and unobserved time-invariant differences between participants. The random intercept accounted for such time-invariant between-participant differences by adjusting for a list of covariates. The estimates and statistical significance of estimates would be similar in the unadjusted (not presented) and adjusted models, and we presented results that adjusted for between-

participants differences. These methods were consistent with an earlier article that conducted a before-after study without controls to examine the changes in quality of life and patient activation (knowledge, skills, and confidence for self-management) of older adults, and applied multivariable regression modelling to adjust for between-participant differences.<sup>6</sup>

Specifically, this study adjusted for age at enrolment, sex, weighted Charlson Comorbidity Index (CCI) at baseline, having received any formal education (yes/no), housing types in Singapore (1-, 2- and 3-room Housing and Development Board [HDB] apartments; 4-room or larger HDB apartments and Housing and Urban Development Company apartments and executive condominiums) and baseline 13-item Patient Activation Measure (PAM-13) score. Covariates were selected based on plausible relationships with healthcare utilisation. Ethnicity was not included as the sample was predominantly Chinese. Baseline PAM-13 measure was adjusted to account for differences in study participants' underlying knowledge, skills and confidence integral to managing one's own health and healthcare,<sup>22</sup> and was also applied as a covariate in our previous publication.<sup>6</sup>

Statistical significance was determined at  $P < 0.05$ . All analyses were performed on Stata version 14.0 (StataCorp, College Station, US).

## **RESULTS**

### **Participant characteristics**

A total of 238 patients were enrolled into PCMH from 1 November 2017 to 30 April 2019, of which 16 did not fulfil study eligibility criteria. After excluding patients who did not consent to the study ( $n=34$ , 14.3%) and were uncontactable ( $n=3$ ), this study recruited 184 study participants. The final sample analysed was 165 study participants after loss to follow-up at 3 months post-enrolment ( $n=11$ , 6.0%) and 6 months post-enrolment ( $n=8$ , 4.3%). There were 6 deaths; 1 patient who was retrospectively found to be ineligible; and 12 withdrawals from PCMH due to being housebound, admitted to a long-term care facility, or relocated to be out of the PCMH service boundary. Participant flow diagram has been published previously.<sup>12</sup>

Table 3 displays the sociodemographic characteristics of study participants ( $n=165$ ). The mean age of study participants was 77 years, with 93.9% aged 60 years and above. The proportion of males was 43.6%, 51.5% were married, a majority of 93.3% were ethnic Chinese, 48.5% had no formal education, and 58.8% stayed in a smaller housing type.

Table 2. Cost from the healthcare provider and societal perspectives: Health services and unit resource costs

| Items                                                            | Resource cost                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Unit cost (SGD)                          |
|------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| <b>PCMH services</b>                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Doctor                                                           | Unit costs of the PCMH doctor, nurse and care manager services were from the manpower cost per minute for government primary care doctors and other restructured hospital staff from a study in Singapore by Abdin et al. <sup>18</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 8.71 per minute                          |
| Nurse                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1.80 per minute                          |
| Care manager                                                     | We calculated the unit cost of PCMH clinic visits based on attending professionals and recorded durations of each visit.<br><br>For home-based care management services, the duration of each home visit was assumed to be 1 hour.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1.80 per minute                          |
| <b>Non-PCMH services</b>                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Government primary care                                          | Unit costs were based on the study in Singapore by Abdin et al. <sup>18</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 8.71 per minute, 130.65 per visit        |
| Private general practice                                         | The data were presented in manpower of physician cost per minute. To compute per-visit cost estimates, we assigned durations of visit for patients that were representative of our study population from consultations with local experts (A&E visit: 15 minutes; SOC visit: 15 minutes; outpatient allied health visit: 25 minutes; non-PCMH primary care visit: 15 minutes).                                                                                                                                                                                                                                                                                                                                            | (sensitivity analysis: 261.30 per visit) |
| Accident and emergency (A&E)                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 18.16 per minute, 272.40 per visit       |
| Specialist outpatient clinic (SOC)                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | (sensitivity analysis: 544.80 per visit) |
| Outpatient allied health                                         | <u>Sensitivity analysis</u><br>We conducted sensitivity analyses for resource cost from the healthcare provider perspective, by applying a longer duration of 30 minutes for non-PCMH primary care (government primary care, private general practice), SOC and A&E visits. The main objective of conducting the sensitivity analysis was to present alternative scenarios with higher resource cost estimations from the healthcare provider perspective, to reflect the additional resources needed to provide care to more complex patients. Note: This sensitivity analysis was not applied for price calculations from the patient perspective (Table 1), as these services are likely at a fixed price to patients. | 1.80 per minute, 45.00 per visit         |
| Day surgery                                                      | Estimates for the total resource cost associated with day surgery were based on price estimates provided by Tan Tock Seng Hospital in Singapore, due to the lack of data from the local study by Abdin et al. <sup>18</sup> and other literature.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 132.00 per procedure                     |
| Inpatient admission                                              | Unit costs were based on the study in Singapore by Abdin et al. <sup>18</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1109.62 per bed per day                  |
| <b>Non-PCMH community care</b>                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Social day care                                                  | Unit costs of providing community care was based on the study in Singapore by Abdin et al. <sup>18</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 35.62 per session                        |
| Day rehabilitation                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Dementia day care                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Home medical care                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Hospice care                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Escort services                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |
| Community development council/<br>Family service centre services |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |

Table 2. Cost from the healthcare provider and societal perspectives: Health services and unit resource costs (Cont'd)

| Items                                                    | Resource cost                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Unit cost (SGD) |
|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Work productivity loss from caregiving by family members | Based on estimates of time during which family members engaged in caregiving activities and time lost from work to provide caregiving. These were self-reported by study participants, family members and proxies.<br><br>We used the opportunity cost approach to calculate the value of working time foregone by family members due to their caregiving responsibilities.<br><br>Based on labour statistics from the 2017 Singapore Yearbook of Manpower Statistics, <sup>21</sup> work productivity loss was valued at the median gross monthly income of a full-time employed worker in Singapore, converted to hourly wages based on national average weekly total paid hours worked per employee (i.e. SGD20.22 per hour). | 20.22           |
| Leisure time loss from caregiving by family members      | The remaining hours spent on caregiving duties by family members were valued as lost leisure time, and calculated using the replacement cost approach, i.e. to the labour market price of a professional caregiver.<br><br>Unit cost of caregiving during family member's leisure hours was assumed to be SGD6.31, based on a contemporaneous local study by Woo et al. <sup>20</sup>                                                                                                                                                                                                                                                                                                                                            | 6.31            |

A&E: accident and emergency; PCMH: Patient-Centred Medical Home; SOC: specialist outpatient clinic  
Superscript numbers: Refer to REFERENCES

### Cost to patients

Table 4 presents the 3-month cumulative cost per-participant per-quarter from a patient perspective. Compared to the 3-month period prior to enrolment, there was a statistically significant decrease in mean cost for non-PCMH primary care (government primary care, private general practice) by SGD9.40 (41.4%) in the first 3-month period post-enrolment and by SGD3.60 (15.9%) in the second 3-month period post-enrolment based on the multivariable regression model.

Compared to the 3-month period prior to enrolment, the mean total cost to study participants was SGD123.10 (13.8%) higher in the first 3-month period post-enrolment and SGD180.20 (20.3%) higher in the second 3-month period post-enrolment, but these were not statistically significant based on the multivariable regression model. There were no statistically significant changes in mean costs from outpatient services (accident & emergency, specialist outpatient clinic, outpatient allied health, day surgery), inpatient admissions, work productivity loss and paid caregiving.

Compared to the first 3 months post-enrolment, there was a statistically significant decrease by SGD12.20 (35.0%) for PCMH services in the second 3 months post-enrolment based on the multivariable regression model.

### Cost to healthcare providers (resource cost)

Table 5 presents the 3-month cumulative cost per-participant per-quarter from a healthcare provider perspective. Compared to the 3-month period prior to enrolment, there was a statistically significant decrease in mean cost for non-PCMH primary care (government primary care, private general practice) by SGD50.70 (38.8%) in the first 3-month period post-enrolment and by SGD29.30 (22.4%) in the second 3-month period post-enrolment, which remained significant (but with a larger quantum) in the sensitivity analysis.

Compared to the 3-month period prior to enrolment, mean total cost increased by SGD414.50 (19.0%) at the first 3-month period post-enrolment and by SGD194.70 (8.9%) at the second 3-month period post-enrolment, but these were not significant based on the multivariable regression model. There were no statistically significant changes in mean cost for outpatient services, inpatient admissions, and community care.

Compared to the first 3 months post-enrolment, there was a statistically significant decrease in mean cost by SGD427.30 (51.2%) for PCMH services in the second 3-month period post-enrolment based on the multivariable regression model.

Table 3. Sociodemographic characteristics of study participants

| Sociodemographic characteristic          | n=165       |
|------------------------------------------|-------------|
| Age at enrolment, mean (SD), years,      | 77.0 (9.88) |
| Age group, no. (%), years,               |             |
| 40–49                                    | 2 (1.21)    |
| 50–59                                    | 8 (4.85)    |
| 60–69                                    | 26 (15.76)  |
| 70–79                                    | 63 (38.18)  |
| 80–89                                    | 49 (29.70)  |
| ≥90                                      | 17 (10.30)  |
| Sex, no. (%)                             |             |
| Male                                     | 72 (43.64)  |
| Female                                   | 93 (56.36)  |
| Ethnicity, no. (%)                       |             |
| Chinese                                  | 154 (93.33) |
| Malay                                    | 3 (1.82)    |
| Indian                                   | 7 (4.24)    |
| Others                                   | 1 (0.61)    |
| Marital status, no. (%)                  |             |
| Single                                   | 14 (8.48)   |
| Married                                  | 85 (51.52)  |
| Widowed                                  | 53 (32.12)  |
| Divorced                                 | 13 (7.88)   |
| Education, no. (%)                       |             |
| No formal education                      | 80 (48.48)  |
| Primary school                           | 51 (30.91)  |
| Secondary school                         | 23 (13.94)  |
| Post-secondary (non-tertiary)            | 8 (4.85)    |
| Diploma and professional                 | 3 (1.82)    |
| Housing type, no. (%)                    |             |
| Smaller housing type                     |             |
| 1–2 room HDB apartment                   | 16 (9.70)   |
| 3-room HDB apartment                     | 81 (49.09)  |
| Larger housing type                      |             |
| 4-room HDB apartment                     | 47 (28.48)  |
| 5-room HDB apartment, HUDC apartment, EC | 20 (12.12)  |
| Private condominium/private others       | 1 (0.61)    |

Table 3. Sociodemographic characteristics of study participants (Cont'd)

| Sociodemographic characteristic     | n=165       |
|-------------------------------------|-------------|
| Employment status, no. (%)          |             |
| Employed full-time                  | 14 (8.48)   |
| Employed part-time                  | 13 (7.88)   |
| Unemployed                          | 7 (4.24)    |
| Retired                             | 127 (76.97) |
| Others                              | 4 (2.42)    |
| Chronic disease status <sup>a</sup> |             |
| Weighted CCI <sup>b</sup>           | 4.82        |

CCI: Charlson Comorbidity Index; EC: executive condominium; HDB: Housing and Development Board; HUDC: Housing and Urban Development Company

<sup>a</sup> Chronic disease list: hypertension, high blood cholesterol, arthritis, eyesight problems, back pain, diabetes, hearing problems, incontinence, frequent falls, dementia, heart conditions, stroke, chronic lung disease, osteoporosis, depression, anxiety, neurological diseases, others.

<sup>b</sup> The weighted CCI was used as the summary measure for adjusting for comorbidities in our multivariable linear regression model. The CCI was based on the number of chronic conditions that are each assigned an integer weight from 1 to 6, with a weight of 6 representing the most severe morbidity. The summation of the weighted comorbidity scores resulted in a summary score. In this study, the International Classification of Diseases 10th Revision (ICD-10) codes of study participants were based on a national healthcare administrative database and the PCMH clinic administrative database. Subsequently, we compute the weighted CCIs based on ICD-10 codes.

## Cost to society

Table 6 presents the 3-month cumulative cost per study participant per-quarter from a societal perspective. Compared to the 3-month period prior to enrolment, mean total cost increased by SGD559.50 (17.8%) in the first 3-month period post-enrolment and by SGD365.20 (11.6%) in the second 3-month period post-enrolment, with the former being statistically significant and the latter being non-significant based on the multivariable regression models. The mean cost of informal caregiving by family members remained stable.

## DISCUSSION

This study evaluated the cost of implementing a PCMH care model with integrated clinic and home-care management services designed for adults with complex needs. Our study contributes to the literature by investigating how implementing a PCMH care model affects cost components for different stakeholders in an Asian context.<sup>12</sup>

Table 4. Cost from the patient perspective: 3-month cumulative cost per study participant

| Outcome                                                                                                                                                                                                | T <sub>-3months_enrolment</sub> |             |  | T <sub>enrolment_3months</sub> |             |  | T <sub>3months_6months</sub>    |             |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------|--|--------------------------------|-------------|--|---------------------------------|-------------|--|
|                                                                                                                                                                                                        | Mean (SD), SGD                  | Median, SGD |  | Mean (SD), SGD                 | Median, SGD |  | Mean (SD), SGD                  | Median, SGD |  |
| Total cost                                                                                                                                                                                             | 889.50<br>(1941.00)             | 56.40       |  | 1012.60<br>(1827.00)           | 87.30       |  | 1069.70<br>(2207.50)            | 91.10       |  |
| PCMH services                                                                                                                                                                                          | NA                              | NA          |  | 34.90<br>(71.70)               | 6.60        |  | 22.70 <sup>a,c</sup><br>(49.60) | 2.60        |  |
| Non-PCMH health services                                                                                                                                                                               |                                 |             |  |                                |             |  |                                 |             |  |
| Non-PCMH primary care:<br>Government primary care and private general practice                                                                                                                         | 22.70<br>(45.60)                | 13.20       |  | 13.30 <sup>b</sup><br>(24.30)  | 0           |  | 19.10 <sup>a</sup><br>(59.70)   | 0           |  |
| Outpatient services:<br>Accident and emergency (A&E), specialist outpatient clinic (SOC), outpatient allied health, and day surgery                                                                    | 45.90<br>(82.30)                | 0           |  | 42.20<br>(82.40)               | 0           |  | 46.10<br>(75.70)                | 0           |  |
| Inpatient admission                                                                                                                                                                                    | 108.60<br>(476.70)              | 0           |  | 65.40<br>(299.70)              | 0           |  | 61.80<br>(218.90)               | 0           |  |
| Non-PCMH community care:<br>Social day care, day rehabilitation, dementia day care, home medical care, hospice care, escort services, and community development council/family service centre services | 89.60<br>(310.90)               | 0           |  | 116.80<br>(409.90)             | 0           |  | 123.30<br>(385.00)              | 0           |  |
| Caregiving by domestic helpers                                                                                                                                                                         | 566.90<br>(1582.20)             | 0           |  | 641.50<br>(1453.40)            | 0           |  | 682.70<br>(1456.90)             | 0           |  |
| Work productivity loss                                                                                                                                                                                 | 55.80<br>(625.20)               | 0           |  | 98.60<br>(917.30)              | 0           |  | 114.00<br>(1192.00)             | 0           |  |

A&E: accident and emergency; PCMH: Patient-Centred Medical Home; SOC: specialist outpatient clinic

T<sub>-3months\_enrolment</sub>: 3-month period immediately before enrolment

T<sub>enrolment\_3months</sub>: 3-month period from enrolment to 3 months post-enrolment

T<sub>3months\_6months</sub>: 3-month period from 3 months post-enrolment to 6 months post-enrolment

<sup>a</sup> *P* value <0.05; <sup>b</sup> *P* value <0.001

Compared to mean cost at T<sub>-3months\_enrolment</sub> the change in mean cost using multivariable linear regression modelling that adjusted for age at enrolment, sex, weighted Charlson Comorbidity Index at baseline, having received any formal education (yes/no), housing types in Singapore (1-2- and 3-room Housing and Development Board [HDB] apartments; 4-room or larger HDB apartments and Housing and Urban Development Company [HUDC] apartments and executive condominiums) and baseline 13-item Patient Activation Measure score.

<sup>c</sup> Reference group was mean cost at T<sub>enrolment\_3months</sub>

Table 5. Cost from the healthcare provider perspective: 3-month cumulative cost per study participant

| Outcome                                                                                                                                                                                                            | T <sub>-3months_enrolment</sub> |             |                                        | T <sub>enrolment_3months</sub> |                                        |                      | T <sub>3months_6months</sub> |  |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------|----------------------------------------|--------------------------------|----------------------------------------|----------------------|------------------------------|--|--|
|                                                                                                                                                                                                                    | Mean (SD), SGD                  | Median, SGD | Mean (SD), SGD                         | Mean (SD), SGD                 | Median, SGD                            | Mean (SD), SGD       | Median, SGD                  |  |  |
| <b>Total cost</b>                                                                                                                                                                                                  | 2183.30 (7528.30)               | 272.40      | <b>2597.80<sup>a</sup></b> (6486.20)   | 1110.30                        | 2378.00 (5831.10)                      | 695.10<br>SA: 847.00 |                              |  |  |
|                                                                                                                                                                                                                    | SA : 2500.50 7598.10)           | SA544.80    | SA:2880.80 (6597.10)                   | 1328.70                        | SA: 2677.50 (6026.00)                  |                      |                              |  |  |
| PCMH services (total)                                                                                                                                                                                              | NA                              | NA          | 834.80 (357.50)                        | 801.30                         | <b>407.50<sup>b,c</sup></b> (308.90)   | 324.00               |                              |  |  |
| Breakdown of manpower costs                                                                                                                                                                                        |                                 |             |                                        |                                |                                        |                      |                              |  |  |
| Doctor and nurse                                                                                                                                                                                                   | NA                              | NA          | 698.70 (314.90)                        | 723.80                         | 330.90 (272.50)                        | 288.30               |                              |  |  |
| Care manager                                                                                                                                                                                                       | NA                              | NA          | 136.20 (251.90)                        | 0                              | 76.60 (155.10)                         | 0                    |                              |  |  |
| Non-PCMH health services                                                                                                                                                                                           |                                 |             |                                        |                                |                                        |                      |                              |  |  |
| Non-PCMH primary care:<br>Government primary care and private<br>general practice                                                                                                                                  | 130.70 (211.60)                 | 130.70      | <b>80.00<sup>b</sup></b><br>(130.30)   | 0                              | <b>101.40<sup>a</sup></b><br>(264.60)  | 0                    |                              |  |  |
|                                                                                                                                                                                                                    | SA: 261.30 (423.10)             | SA: 261.30  | SA: <b>160.00<sup>b</sup></b> (260.64) | SA: 0                          | SA: <b>202.70<sup>b</sup></b> (529.20) | SA: 0                |                              |  |  |
| Outpatient services:<br>Accident and emergency (A&E),<br>specialist outpatient clinic (SOC),<br>outpatient allied health, and day surgery                                                                          | 205.40 (328.90)                 | 0           | 212.80 (433.00)                        | 0                              | 209.50 (339.60)                        | 0                    |                              |  |  |
|                                                                                                                                                                                                                    | SA: 392.00 (613.90)             | SA: 0       | SA: 415.90 (851.10)                    | SA: 0                          | SA: 407.60 (670.20)                    | SA: 0                |                              |  |  |
| Inpatient admission                                                                                                                                                                                                | 1667.80 (7441.20)               | 0           | 1257.60 (6413.70)                      | 0                              | 1419.00<br>(5550.30)                   | 0                    |                              |  |  |
| Non-PCMH community care:<br>Social day care, day rehabilitation,<br>dementia day care, home medical<br>care, hospice care, escort services, and<br>community development council/family<br>service centre services | 179.40 (611.00)                 | 0           | 212.60 (677.10)                        | 0                              | 240.70 (645.50)                        | 0                    |                              |  |  |

A&E: accident and emergency; PCMH: Patient-Centred Medical Home; SA: sensitivity analysis; SD: standard deviation; SOC: specialist outpatient clinic

Superscript numbers: Refer to REFERENCES

This study assigned durations of visit for patients that were representative of our study population from consultations with local experts—A&E: 15 min; SOC: 15 min; outpatient allied health visit: 25 mins; non-PCMH primary care visit: 15 min. We conducted sensitivity analyses using a longer duration of 30 mins for A&E, SOC and non-PCMH primary care visits (see Table 3).

T<sub>-3months\_enrolment</sub>: 3-month period immediately before enrolment

T<sub>enrolment\_3months</sub>: 3-month period from enrolment to 3 months post-enrolment

T<sub>3months\_6months</sub>: 3-month period from 3 months post-enrolment to 6 months post-enrolment

<sup>a</sup> P value <0.05; <sup>b</sup> P value <0.001

Compared to mean cost at T<sub>-3months\_enrolment</sub><sup>b</sup>

at baseline, having received any formal education (yes/no), housing types in Singapore (1- 2- and 3-room Housing and Development Board [HDB] apartments; 4-room or larger HDB apartments and Housing and Urban Development Company [HUDC] apartments and executive condominiums) and baseline 13-item Patient Activation Measure score.

<sup>c</sup> Reference group was mean cost at T<sub>enrolment\_3months</sub>

Table 6. Cost from the societal perspective: 3-month cumulative cost per study participant

| Outcome                                                                                                                                                                                                 | T <sub>-3months_enrolment</sub> |             |  | T <sub>enrolment_3months</sub>          |             |  | T <sub>3months_6months</sub>          |             |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------|--|-----------------------------------------|-------------|--|---------------------------------------|-------------|--|
|                                                                                                                                                                                                         | Mean (SD), SGD                  | Median, SGD |  | Mean (SD), SGD                          | Median, SGD |  | Mean (SD), SGD                        | Median, SGD |  |
| Total cost                                                                                                                                                                                              | 3135.20<br>(8281.20)            | 392.00      |  | <b>3694.70<sup>a</sup></b><br>(6882.40) | 1250.00     |  | 3500.40<br>(7036.30)                  | 855.90      |  |
| PCMH services                                                                                                                                                                                           | NA                              | NA          |  | 834.80<br>(357.50)                      | 801.30      |  | <b>407.50<sup>b,c</sup></b> (308.90)  | 324.00      |  |
| Non-PCMH services                                                                                                                                                                                       |                                 |             |  |                                         |             |  |                                       |             |  |
| Non-PCMH primary care:<br>Government primary care and private general practice                                                                                                                          | 130.70<br>(211.60)              | 130.70      |  | <b>80.00<sup>b</sup></b><br>(130.30)    | 0           |  | <b>101.40<sup>a</sup></b><br>(264.60) | 0           |  |
| Outpatient services:<br>Accident and emergency (A&E), specialist outpatient clinic (SOC), outpatient allied health, and day surgery                                                                     | 205.40<br>(328.90)              | 0           |  | 212.80<br>(433.00)                      | 0           |  | 209.50<br>(339.60)                    | 0           |  |
| Inpatient admission                                                                                                                                                                                     | 1667.80<br>(7441.20)            | 0           |  | 1257.60<br>(6413.70)                    | 0           |  | 1419.00<br>(5550.30)                  | 0           |  |
| Non-PCMH community care:<br>Social day care, day rehabilitation, dementia day care, home medical care, hospice care, escort services, and community development council/family service centre services. | 179.40<br>(611.00)              | 0           |  | 212.60<br>(677.10)                      | 0           |  | 240.70<br>(645.50)                    | 0           |  |
| Caregiving by domestic helpers                                                                                                                                                                          | 566.90<br>(1582.20)             | 0           |  | 641.50<br>(1453.40)                     | 0           |  | 682.70<br>(1456.90)                   | 0           |  |
| Work productivity loss by study participants                                                                                                                                                            | 55.80<br>(625.20)               | 0           |  | 98.60<br>(917.30)                       | 0           |  | 114.00<br>(1192.00)                   | 0           |  |
| Caregiving by family members                                                                                                                                                                            | 329.00<br>(1871.80)             | 0           |  | 356.90<br>(1299.50)                     | 0           |  | 325.60<br>(1275.10)                   | 0           |  |

A&E: accident and emergency; PCMH: Patient-Centred Medical Home; SA: sensitivity analysis; SD: standard deviation; SOC: specialist outpatient clinic

T<sub>-3months\_enrolment</sub>: 3-month period immediately before enrolment

T<sub>enrolment\_3months</sub>: 3-month period from enrolment to 3 months post-enrolment

T<sub>3months\_6months</sub>: 3-month period from 3 months post-enrolment to 6 months post-enrolment

<sup>a</sup> P value <0.05; <sup>b</sup> P value <0.001

Compared to mean cost at T<sub>3months\_enrolment</sub>, the change in mean cost using multivariable linear regression modelling that adjusted for age at enrolment, sex, weighted Charlson Comorbidity Index at baseline, having received any formal education (yes/no), housing types in Singapore (1-2- and 3-room HDB and Development Board [HDB] apartments; 4-room or larger HDB apartments and Housing and Urban Development Company [HUDC] apartments and executive condominiums) and baseline 13-item Patient Activation Measure score.

<sup>c</sup> Reference group was mean cost at T<sub>enrolment\_3months</sub>

Reference: Abidin E, Subramaniam M, Achilla E, et al. The Societal Cost of Dementia in Singapore: Results from the WiSE Study. J Alzheimers Dis 2016; 51:439-49.

Although the PCMH has the added benefits of both clinic and home-based care management relative to existing primary care, this study found no evidence that implementing the PCMH model resulted in increased costs from the healthcare system perspective. An initial non-significant increase in mean total per-participant healthcare resource cost was recorded in the first quarter after enrolment, which may be primarily attributed to the higher frequency and longer duration of visits for PCMH providers to conduct initial comprehensive geriatric assessments. It was not unexpected for resource costs to be high during the initial implementation stages of PCMH.<sup>8,9</sup> Importantly, we found that mean total per-participant resource costs subsequently dropped by approximately half in the subsequent quarter, consistent with a fall in resource cost to deliver PCMH services cost per-participant in the second quarter after enrolment.

The estimated mean resource costs associated with non-PCMH primary care consultations (government primary care, private general practice) fell from the first post-enrolment quarter. Given that the estimation only included consultation fees, it was plausible that unmeasured savings were even larger. There were no other significant changes in resource costs associated with other outpatient services (A&E, SOC, outpatient allied health, day surgery), inpatient admissions or community care. This suggested that at the health system level, change was driven primarily by patients' substitution from usual primary care (government primary care/polyclinics, private GP) to community-based primary care by the PCMH. The PCMH model shifted OOPE of patients from non-PCMH primary care towards primary care in the community (i.e. PCMH). Other studies also suggested that implementing PCMH may not increase overall costs to patients and health systems.<sup>8,23</sup>

In the existing literature, findings on costs have been mixed and challenging to interpret due to the different contexts and target populations for PCMH.<sup>8,9,24</sup> Our findings suggest potential for cost savings for patients and their families from longer-term reductions in other formal and informal care. Over our study period, we found no significant changes in the mean cost to patients for other outpatient services and inpatient admissions. At the same time, costs to patients and society associated with formal and informal caregiving remained stable with non-significant changes. From the societal perspective, therefore, the total mean cost per-participant initially rises due to the initial increase in resource use, but it subsequently decreased. We furthermore expect these to reduce with a longer follow-up, as PCMH

management further reduces utilisation of services like A&E and hospitalisations.<sup>8,9,24</sup>

Given the evidence of better QoL and patient activation from our previous publication,<sup>6</sup> our findings show that the PCMH model dominates the current standard of care, namely, intervention was both more effective and not more costly. As such, the results are presented in the form of a detailed cost analysis rather than a cost-effectiveness analysis.

A strength of PCMH is its ability to meet the multidimensional needs of patients, such as aspects of comprehensive assessments in the clinic and the home setting, a multidisciplinary care team, individualised care plans, shared decision-making, and empanelment (assignment of patients to primary care providers and care teams, taking into account patient and family preferences). We previously reported improved QoL and patient activation, and this study found no increase in societal cost, and a decrease in cost for usual primary care. We had low loss to follow-up and examined cost analysis holistically from the perspectives of patients, healthcare providers and society. When interpreted together, these findings suggest positive overall system-level outcomes for PCMH.

However, this study had a few limitations. We recognised that the participants recruited were older persons even though persons aged  $\geq 40$  years were eligible, which would affect the generalisability of our study. However, most PCMH care models have also focused on older populations.<sup>25</sup> Next, unit prices of PCMH services were based on PCMH administrative data that consisted of fees for consultation, procedures and medications, whereas prices of non-PCMH services included consultation fees. The omitted category of procedures and medications was approximately 30–40% of the total bill. Our results likely understated costs of non-PCMH services to patients. This made PCMH appear relatively expensive by understating cost savings from reducing non-PCMH services. Calculation of resource cost to providers for non-PCMH health services used manpower cost of only doctors due to the lack of data availability, whereas the cost of PCMH included manpower cost of doctors, nurses and care managers. Hence, our findings likely underestimated the resource costs of PCMH services and resource cost-savings from reducing non-PCMH services. Utilisation counts and durations of caregiving were self-reported, but the CSRI survey has been validated and used in Singapore.<sup>18,26</sup> Importantly, we included relevant cost components with unit costs based on the literature. Utility bills, indirect costs (e.g. transportation) and other overhead costs were omitted due to lack of data.

Our study has important implications for practice and policy. Our analysis shows that the PCMH model effectively resulted in an increase in utilisation of community-based primary care services and suggested potential reductions in hospital-based care, consistent with Singapore's national healthcare policy directives to move beyond acute to preventive care, and from hospital to community settings. The model supports multiple mechanisms by which this may occur including more access to higher-quality care. This results in better care outcomes or increased care coordination at the community level, enabling stronger care networks and management of care in the lived environment. These remain to be investigated further. Second, our study recognises that the implementation of a PCMH care model may require a significant amount of initial investment but suggests that offsetting cost savings to the system and patients may be realised in a relatively short period. This makes the PCMH model a potentially more sustainable paradigm for patients with complex care needs. Finally, analysing estimates from different payers' and stakeholders' perspectives shows that the PCMH model is consistently aligned in economic impact and incentives to change. This is especially important in a multipayer health system to support decision-making on benefits and risks, so as to enable a comprehensive practice transformation towards effective team-based PCMH care.<sup>27</sup>

## CONCLUSION

Evidence suggested that the PCMH care model shifted the OPOE of patients and resource costs of providers from usual primary care and outpatient services, towards community-based primary care with the added benefits of comprehensive and individualised care for community-dwelling older adults. PCMH reduced costs to the health system and patients for usual primary care and did not increase informal caregiving costs. There may be potential for sustainability and scalability of PCMH.

### Ethics approval and consent to participate

This study was registered with ClinicalTrials.gov (Protocol ID: 2017/00352) and was approved by the National Healthcare Group Domain Specific Review Board (NHG DSRB) Singapore (Reference: DSRB 2017/00352). Informed consent was taken from all participants or their proxies. All methods were performed in accordance with the relevant guidelines and regulations.

### Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to strict government confidentiality. The corresponding author can be contacted on this matter.

### Disclosure

Wong CH is currently affiliated to Tsao Foundation, which was involved in implementing this PCMH demonstration. However, Wong CH was not affiliated to Tsao Foundation at the time of the study conceptualisation and development, analysis and manuscript writing. All other authors had no competing interests.

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