Geriatric Nursing 46 (2022) 1–11

Contents lists available at ScienceDirect

Geriatric Nursing

journal homepage: www.gnjournal.com

The impact of community nursing program on healthcare utilization: A program evaluation

Yi Xu[a], Xuan Han Koh[b], Yi Tian Stella Chua[a,*], Cheng Gaik Irene Tan[a], Fazila Abu Bakar Aloweni[c], Bee Eng Joanne Yap[d], Poh Choo Tan[d], Xueli Chua[e], Yee Kee Shannon Lim[e], Hong Choon Oh[b], Swee Hong Stephanie Teo[f], Su Fee Lim[a]

[a] PHICO-Community Nursing, Population Health and Integrated Care Office, Singapore General Hospital, 10 Hospital Boulevard, SingHealth Tower, Singapore, 168582
[b] Health Services Research, Changi General Hospital, 2 Simei Street 3, Singapore, 529889
[c] Nursing Division (Nursing Research), Singapore General Hospital, 10 Hospital Boulevard, SingHealth Tower, Singapore, 168582
[d] Community Nursing, Changi General Hospital, 2 Simei Street 3, Singapore, 529889
[e] SingHealth Office of Regional Health, 167 Jalan Bukit Merah, #22-10, Singapore, 150167
[f] Department of Nursing, SingHealth Polyclinics, 167 Jalan Bukit Merah Connection One (Tower 5), Singapore, 150167

ARTICLE INFO

Article history:
Received 16 January 2022
Received in revised form 21 April 2022
Accepted 21 April 2022
Available online xxx

Keywords:
Healthcare utilization
Community nursing
Older adults
Readmission
Program evaluation

ABSTRACT

Background: The role of nurses has evolved to meet the dynamic needs of an aging population. Community nursing has been established in Singapore with the aim to anchor population health and provide sustainable healthcare services beyond the hospital to the community. Community nurses provide health services to residents at the Community Nurse Posts (CNP) situated within the heartland residential estates.
Objective: To investigate the effect on healthcare utilization six months pre and post first community nurse visit in older adults, and if the effect is modified by the presence of two or more community nurse visits or absence of a polyclinic chronic disease diagnosis.
Design: A single-group pretest-posttest study
Setting(s): Fifty-one SingHealth CNPs at the southeast and east regions of Singapore
Participants: Community-dwelling older adults aged ≥ 60 years, seen at any of the SingHealth CNPs between 1 April and 30 November 2019.
Methods: The number of emergency department (ED) visits, unplanned inpatient admissions, length of inpatient stay, specialist outpatient clinic (SOC) and polyclinic visits at SingHealth institutions six months from the first community nurse visit were compared to six months prior. Negative binomial generalized estimating equations were used to model healthcare utilization events, adjusting for baseline age, gender, and race.
Results: 1,600 community-dwelling participants were included, of whom 1,561 (median age of 71 years) survived the post-test period. There was a population-average 23% lower rate of ED visits (incidence rate ratio 0.77, 95% confidence interval 0.68 to 0.87, $p<0.001$) and 15% lower rate of unplanned inpatient admissions (0.85, 0.75 to 0.96, $p=0.011$). A trend towards a lower rate of inpatient length of stay and a higher rate of SOC and polyclinic visits was also observed. The reduction in acute care utilization may have been greater among adults with two or more community nurse visits. Participants with no recent polyclinic chronic disease diagnosis had a greater increase in SOC visits.
Conclusions: Community nursing services are associated with reduced acute care utilization, especially for older adults with two or more community nurse visits. The trend of a higher rate of SOC visits could be attributed to the community nurses' referrals for undiagnosed/ new conditions and/or treatment of suboptimal health issues. There is a potential role for community nursing towards a sustainable healthcare system.

Background

The role and scope of nursing practice have evolved in response to the dynamic needs of individuals, communities, and healthcare services.[1] Community nursing has been widely recognized in health promotion, disease prevention and disease management across a broad

*Corresponding author.
E-mail address: stella.chua.y.t@sgh.com.sg (Y.T.S. Chua).

https://doi.org/10.1016/j.gerinurse.2022.04.024
0197-4572/$ – see front matter © 2022 Elsevier Inc. All rights reserved.

range of settings. The philosophy of community nursing services in Singapore is characterized by person-centeredness, client and family empowerment, and continuity of care.[2] These services bear similarities to community health nursing internationally, where its intervention focuses on aspects of community care, i.e., health education and counselling, community mobilization, health risk assessment and screening, care coordination, case management, monitoring and rehabilitation.[3] Community nurses support the regional and national health policies planning, implementation and education, and can potentially contribute significantly to ensure individuals and communities' access to quality healthcare.[3]

The aging population and growing burden of chronic diseases have profound implications on healthcare systems globally. In past decades, the decline in birth rates along with increased life expectancies contributed to an increased proportion of the aged population worldwide, rising to 1.6 billion by 2050 and tripled for people aged 80 and above.[4] Multimorbidity, the co-occurrence of two or more diseases, often complicates treatment planning and leads to high healthcare utilization.[5] Frail older adults with multifactorial health and social care needs experienced increased hospital admissions, unplanned readmissions and longer hospitalization.[6] Health care agencies worldwide are trying to find ways to improve health care delivery and provide more cost-effective and value-added care.[7]

In Singapore, the progression of aging population within land space limitations brings on a unique set of challenges. The nation's health and care needs are being managed through reformed government policies.[8] As of June 2020, the proportion of citizens aged 65 and above has increased from 10.1% in 2010 to 16.8% in 2020. This number is projected to increase to 23.7% in 2030. The number of citizens aged 80 and above has also almost doubled over the last decade.[9] Forty percent of Singaporeans aged 60 years and above have three or more chronic conditions.[10] Older adults aged 65 and above formed up to 21% to 40% of Emergency Department (ED) users[11] and accounted for 19% readmission rates between 2011 to 2013.[12] These factors place greater demands on health resources utilization and prompted a need for change in care model and community service delivery.

In 2017, the Singapore Ministry of Health identified three key priorities for a more sustainable healthcare system beyond 2020, i.e., beyond hospital to community, beyond quality to value and beyond health care to health.[13] Health services are directed to maintain individuals in their communities and keeping them out of the hospitals where possible. To address these key priorities, the Regional Health System (RHS)-led community nursing pilot programs were established across three Singapore integrated healthcare clusters in October 2017.[2] Community Nurse Posts (CNPs) have been progressively set up and co-located at Senior Activity Centers, community centers, places of worship and medical clinics in the neighborhood. The team is expected to respond to a portfolio of population, and provide services including i) early interventions for pre-frail older adults, ii) chronic disease management for patients whose conditions are not well controlled, iii) care for frail patients in their immediate post-discharge period, and iv) generalist palliative care for patients with life-limiting diseases.[14] The geographically organized team-based community nurses provide services aligned to different levels of health risks and needs. Essentially, these services are tailored to CNP clients with goals which include empowering and motivating them to adopt lifestyle behavioral modifications, enhancing their chronic disease management literacy, improving their compliance to medication and referral visits to other appropriate healthcare resources. Overall, the program aims to anchor population health with improved health outcomes and healthcare utilization.

An extensive literature review was conducted and is presented in the following sections. The emerging themes are based on i) impact of chronic diseases on healthcare utilization, ii) factors affecting the access to healthcare, iii) impact of models of care with community nurses' interventions across settings on the healthcare utilizations, iv) community-based Nurse-led Programs, and v) Impact of COVID-19.

Literature review

Impact of chronic diseases on healthcare utilization

With increasing prevalence and rising costs, chronic disease management is one of the most challenging and urgent healthcare endeavors. In 2014, it was found that 42% of adults in the US had more than one chronic condition.[15] Chronic conditions were most prevalent in high utilization of hospital admissions and ED and outpatient visits.[16] In Singapore, conditions that accounted for frequent ED visits were asthma, chronic obstructive pulmonary disease (COPD), upper respiratory tract infection and headache. Older adults aged 76 to 85 accounted for the most non-self-referred visits.[17]

Among people with chronic diseases, those with mental health disorders are associated with substantial higher healthcare utilization.[18-21] The causes were multifactorial, including poor access to coordinated care.[19] Early triaging and improving access to community care make a huge difference in these acute care utilizations.

Factors affecting healthcare access

Access to healthcare is defined as the opportunity to identify healthcare needs, seek healthcare services, reach, attain or utilize health care resources, and be offered services appropriate to the care needs.[22] Socioeconomic inequalities affecting access to specialist and primary care services are evident in many countries.[23] Low-income individuals were more likely to suffer from chronic disease and disproportionately burdened by healthcare costs and associated social and economic consequences.[16] In Singapore, older adults with poor health status and living in public rental housing have lower participation in health screening, higher hospital utilization and under-utilization of primary care.[17] High cost-sharing, limitations in health literacy, perception of non-urgency of symptoms and diseases, imperfect communication strategies, and low quality of care contributed to poor healthcare access.[17,23]

Ensuring equity in resource allocation and healthcare access are important when designing a community health program. Access to healthcare should not be solely based on affordability, geographical, and organizational availabilities. It should encompass the individual's capability to select and be fully engaged in acceptable services.[22] The current model of community healthcare programs should provide accessible and affordable services with individualized interventions. Ultimately, these interventions would promote health-seeking behaviors and empower effective self-care among older adults, especially those with low socioeconomic status.

Impact of integrated and transitional care models on healthcare utilization

Maintaining health is a holistic and multifaceted process. Population health takes an integrated approach towards coordinating health and social care services to maximize disease prevention, promote individual and family responsibility, and reduce inefficiencies.[24] Integrated and transitional care models have been widely explored and implemented in various healthcare systems to meet the increasing demands of aging population and effectively utilize resources across sectors to improve health outcomes.

In Singapore, healthcare delivery services are integrated as part of a wider ecosystem of providing public health, primary care, acute care, rehabilitation, and long-term and palliative care integration.[24] Integrated and transitional care models with nursing involvement

had positive outcomes on health care utilization. The Aged Care Transition (ACTION) program led by registered nurses (RNs) and medical social workers significantly reduced unplanned readmission and ED visits among older Singaporean with complex needs at six months post-discharge.[25]

Multi-disciplinary transitional home care program reported similar significant outcomes i.e. reduction in hospital readmission, ED visits and hospital LOS.[26,27] The sustainable effectiveness is evident among cognitively impaired patients,[28] adults aged ≥ 50[29] and frail older adults with advanced non-malignant diseases.[30]

The integrated care and transitional care studies provided fundamental grounding for community nursing care models. The high-intensity interventions contributed to positive outcomes on healthcare utilization. They comprise of i) early home visits, ii) comprehensive assessment, iii) nurse care coordination, iv) telephone outreach, v) health coaching with an emphasis on medication management, vi) active communication with primary and community care providers, and vii) the use of shared electronic records and patient education tools.[6,25,27,29]

Community-based nurse-led programs

The role and scope of nursing practice have evolved in response to the dynamic needs of individuals, communities, and healthcare services. Nurses are in the prime position to empower residents in the community with the necessary knowledge and autonomy to manage their health optimally, which in the long term could have an impact on healthcare utilization.

Community nurse/Advanced Practice Nurse (APN) -led program provide nursing consultation, health coaching (using motivation and empowerment approaches to promote self-management), care coordination, and case management. These interventions improved care continuity across hospitals, transitional care facilities, primary and long - term care,[31] and decreased healthcare utilization, i.e. readmission rates, ED visits, and hospitalization.[32,33]

The growth of community-based nurse-led clinics has been targeted to increase care access and provide cost-effective and high quality streamlined services. Interventions that combine counselling, regular assessment of individual risk factors and health status effectively enabled people with chronic diseases to age well in the community.[34] Nurse-led clinics in western countries were found to have a positive impact on patient satisfaction and access to care[1], reduced ED attendance, and increased community health referrals[35] However, there are limited studies in Asia on healthcare outcomes from nurse-led clinics.

Impact of COVID-19

During the COVID-19 pandemic, healthcare utilization at ED, inpatient or outpatient settings decreased about one third in the overall services due to the lockdown and stay-at-home orders.[36] This situation aggravated the social vulnerability of the elderly, particularly those who were frail. During the pandemic, alternatives to hospital treatment were scaled up through virtual consultations, access to intermediate care at home, and community care facilities.[29]

Drawing on the experience of the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003, staying vigilant at the community level through public education and risk communication was one of the important lessons learnt in health crisis management.[37] In the US, the SARS Community Outreach Team conducted community visits/teleconferences and provided culturally tailored intervention to promote public health education, strengthening community resiliency and capacity to mitigate fear, stigmatization, and discrimination; and encouraging appropriate health-seeking behaviors among the affected population.[38]

Community nurses play an important role in public health as trusted healthcare professionals. They explain and reinforce broad prevention messages. They also help to ensure that the vulnerable residents are still being cared about, and cared for, even while being 'shielded'.[39] In Singapore, a nationwide partial lockdown ('circuit breaker') was implemented on 07 April 2020 due to the COVID-19 pandemic. Teleconsultations, essential home visits for people with needs, and virtual health talks have shown to be effective in engaging older adults during the COVID-19 pandemic.[40]

In summary this literature provided an overview of the impact of chronic diseases on health care utilization, factors affecting access to healthcare and the impact of various models of care including community nurses' interventions across settings on healthcare utilizations.

Many of the outcomes in the discussion took reference from Western countries. There are limited studies in Asia evaluating the effectiveness of community nurse-led programs with multifaceted interventions on acute and primary care utilization. Community nursing is new in Singapore. It was established with the aim to anchor population health and provide sustainable healthcare services beyond the hospital to the community. Community nurses provide health services to residents at the Community Nurse Posts (CNP) situated within the residential estates.

Aim and objectives

The study aims to investigate if six months post first community nurse visit is associated with a change in healthcare utilization in a multiethnic older adults' cohort with multiple chronic conditions in East and Southeast regions of Singapore. Specifically, we would like to determine:

1) if six months post first community nurse visit is associated with a change in ED visits, unplanned inpatient admissions, inpatient length of stay, specialist outpatient clinic (SOC) visits, and/or SingHealth Polyclinic visits relative to six months pre first community nurse visit; and

2) if the effect of six months post first community nurse visit on healthcare utilization is modified by whether an older adult had a) at least two community nurse visits or b) no chronic disease diagnosis at a SingHealth Polyclinic in the two-year period before his/her first community nurse visit.

Study hypotheses

1) We hypothesized that six months post first community nurse visit (includes interventions such as health assessment, health coaching, chronic disease monitoring, medication management, and care coordination) is associated with a decrease in emergency visits, unplanned inpatient admissions, and inpatient length of stay, and an increase in outpatient visits to specialist clinics and SingHealth polyclinics (government-enabled primary care center).

2) The decrease in the rate of ED visits, unplanned inpatient admissions, and inpatient length of stay was hypothesized to be greater among older adults who had at least two community nurse visits.

3) The increase in the rate of specialist clinic visits was hypothesized to be greater among older adults who had no chronic disease diagnosis by polyclinics in the two-year period before the first community nurse visit.

Method

Study design and population

This was a single-group pretest-posttest study investigating if six months post first community nurse visit is associated with a change in healthcare utilization in an older adult cohort with multiple chronic health conditions in Singapore. The pre and post 6 months period were identified after the first community nurse visit of each participant. Data were extracted from the SingHealth-IHiS Electronic Health Intelligence System (eHints). The study period was determined based on the data availability after the participants' recruitment into the study.

Older adults belonging to the 51 CNPs of two hospitals between 1 April 2019 and 30 November 2019 were recruited into the study. Singapore General Hospital and Changi General Hospital are the two acute care hospitals in the SingHealth cluster spearheading the community nursing pilot for supporting the population health of the southeast and east regions of Singapore. Each community nursing team is led by an advanced practice nurse. Each group comprises a nurse clinician and four to eight registered nurses equipped with acute and community care experiences.

The inclusion criteria were older adults who i) were Singapore citizens or permanent residents, ii) were aged $\geq$ 60 years old, iii) had multiple chronic health conditions including but not limited to hypertension, hyperlipidemia, diabetes mellitus, chronic kidney disease, and heart failure and iv) required assistance in managing their chronic conditions. We excluded older adults with a previous SingHealth community nurse visit to avoid the potential residual effect of a previous visit on healthcare utilization during the pretest period.

Intervention

Community nurses carried out the interventions according to individual needs at CNP or participant's home that comprised of

i) Health and geriatric assessment, that covers physical, nutrition, elimination, functional, fall risk and home safety, cognitive, and psychosocial aspects,

ii) Health coaching for disease prevention,

iii) Chronic diseases monitoring,

iv) Education on self-care, medication and chronic disease management,

v) Medication management,

vi) Advanced Care Planning (ACP) facilitation, and

vii) Care coordination with healthcare institutions, community health and social care agencies

Definitions of Variables

The healthcare utilization data were available from 1 October 2018 (six months before the earliest first community nurse visit date) to 31 May 2020 (six months after the latest first community nurse visit date).

i) An ED visit was defined as a visit to the ED of the two participating hospitals.

ii) An unplanned inpatient admission was defined as an unplanned hospitalization at any of the two participating acute care hospitals.

iii) Inpatient length of stay was defined as the number of inpatient days from planned and/or unplanned inpatient admissions at any of the two participating hospitals.

iv) A specialist outpatient visit was defined as a visit to specialist clinics within the SingHealth cluster.

Statistical analyses

All statistical analyses were conducted using Stata 15.0 (College Station, TX: StataCorp, LLC). The dependent variables were the rate of emergency visits, unplanned inpatient admissions, inpatient length of stay, specialist clinic visits, and polyclinic visits, i.e., the number of events or days over a six-month (180 days) period. Other study variables included the community nurse visit, participants' age, gender, ethnic group, marital status, living arrangement and housing type. All data were obtained from the SingHealth-*IHiS* (Integrated Health Information Systems) Electronic Health Intelligence System (eHints).

A generalized estimating equation (GEE) based negative binomial model was used to model count data for each healthcare utilization measure. This model was chosen because i) there was a within-subjects correlation and ii) we were interested in the population average effect (as opposed to individual-specific effect) of the six-month post first community nurse visit period. Huber-White sandwich standard errors were calculated for parameter estimates as they are robust to correlation structure misspecification. The panel variable was the participant and the time variable was posttest/pretest. We wanted to determine if there was a change in the odds of participants having higher healthcare utilization. Thus, we also evaluated healthcare utilization as a binary variable, i.e., one or more vs no healthcare utilization event. For binary outcomes, a logistic mixed-effects model was used. The conservative likelihood ratio test was used to assess if the random effects in the generalized linear mixed models were non-zero.

Incidence rate ratios (IRR) and odds ratios (OR) were reported with corresponding 95% confidence intervals. All tests were two-tailed, and p values less than 0.05 were considered statistically significant.

Sensitivity analyses

To account for the pandemic as a potential positive confounder, we restricted the analysis to participants with a six-month follow-up period before the COVID-19 pandemic in Singapore. Hence, we restricted the analysis to participants with a six-month follow-up period before 1 February 2020 and before 1 April 2020. A $\geq$10% difference in IRR/OR towards the null in the restriction analysis would suggest that COVID-19 was a positive confounder.

Ethical considerations

A waiver of IRB from the SingHealth Centralized Institutional Review Board was obtained and approved (CIRB Ref 2020/2222). Access to participants' medical records was sought and approved by all the relevant institutional data protection officers and the chief medical board.

Results

Association of six months post first community nurse visit with healthcare utilization

Baseline characteristics of 1,600 participants with a first SingHealth community nurse visit between 1 April and 30 November 2020 were described in Table 1. The median age of the participants was 71 years old, and 24.7% were aged 80 and above. 27.3% of all

Table 1
Baseline characteristics of 1,600 SingHealth CNP participants with a first CNP visit between 01 April and 30 November 2020, by whether they survived/died during the posttest period.

Variable	Metric	All participants (n=1,600)	Participants who survived posttest period (n=1,561)	Participants who died during posttest period (n=39)	Missing n (%)
Age in years	Mean ± sd	71.4 ± 10.6	71.2 ± 10.6	77.1 ± 7.1	1 (0.0)
	Median (IQR)	71 (64-79)	71 (64-79)	79 (72-82)	
≤59	n (%)	196 (12.3)	195 (12.5)	1 (2.6)	
60-69	n (%)	480 (30.0)	478 (30.6)	2 (5.1)	
70-79	n (%)	528 (33.0)	507 (32.5)	21 (53.9)	
80-89	n (%)	344 (21.5)	331 (21.2)	13 (33.3)	
≥90	n (%)	51 (3.2)	49 (3.1)	2 (5.1)	
Gender					1 (0.0)
Male	n (%)	661 (41.3)	640 (41.0)	21 (53.9)	
Female	n (%)	938 (58.7)	920 (59.0)	18 (46.2)	
Race					0 (0.0)
Chinese	n (%)	1,165 (72.8)	1,135 (72.1)	30 (76.9)	
Malay	n (%)	108 (6.8)	105 (6.7)	3 (7.7)	
Indian	n (%)	290 (18.1)	284 (18.2)	6 (15.4)	
Others	n (%)	37 (2.3)	37 (2.4)	0 (0.0)	
Marital status					98 (6.1)
Single	n (%)	266 (17.7)	263 (17.9)	3 (8.8)	
Married	n (%)	802 (53.4)	783 (53.3)	19 (55.9)	
Widowed	n (%)	330 (22.0)	319 (21.7)	11 (32.4)	
Separated	n (%)	13 (0.9)	13 (0.9)	0 (0.0)	
Divorced	n (%)	91 (6.1)	90 (6.1)	1 (2.9)	
Living arrangement					316 (19.8)
Lives with spouse	n (%)	486 (37.9)	472 (37.6)	14 (46.7)	
Lives with children	n (%)	213 (16.6)	207 (16.5)	6 (20.0)	
Lives with other family member	n (%)	93 (7.2)	92 (7.4)	1 (3.3)	
Lives with non-family member	n (%)	142 (8.9)	139 (8.9)	3 (7.7)	
Lives alone	n (%)	350 (27.3)	344 (27.4)	6 (20.0)	
Housing type					167 (10.4)
HDB flat (rental)	n (%)	577 (40.3)	562 (40.3)	15 (40.5)	
HDB flat (purchased)	n (%)	805 (56.2)	784 (56.2)	21 (56.8)	
Private	n (%)	35 (2.4)	35 (2.5)	0 (0.0)	
Others	n (%)	16 (1.1)	15 (1.1)	1 (2.7)	
Employment					501 (31.3)
Employed	n (%)	114 (10.4)	113 (10.5)	1 (3.7)	
Retired	n (%)	437 (39.8)	426 (39.7)	11 (40.7)	
Unemployed	n (%)	548 (50.0)	533 (49.7)	15 (55.6)	
Smoking					288 (18.0)
Non-smoker	n (%)	991 (75.5)	971 (76.1)	20 (55.6)	
Current-smoker	n (%)	203 (15.5)	189 (14.8)	14 (38.9)	
Ex-smoker	n (%)	118 (9.0)	116 (9.1)	2 (5.6)	
Alcohol consumption					376 (23.5)
Non-drinker	n (%)	1,048 (85.6)	1,022 (85.7)	26 (81.3)	
Current drinker	n (%)	85 (6.9)	83 (7.0)	2 (6.3)	
Ex-drinker	n (%)	91 (7.4)	87 (7.3)	4 (12.5)	
Problems associated with chronic disease					0 (0.0)
Hypertension	n (%)	774 (48.4)	754 (48.3)	20 (51.3)	
Hyperlipidemia	n (%)	465 (29.1)	452 (29.0)	13 (33.3)	
Diabetes mellitus	n (%)	431 (26.9)	419 (26.8)	12 (30.8)	
Chronic kidney disease	n (%)	66 (4.1)	62 (4.0)	4 (10.3)	
Heart failure	n (%)	64 (4.0)	56 (3.6)	8 (20.5)	
Chronic obstructive pulmonary disease/asthma	n (%)	60 (3.8)	57 (3.7)	3 (7.7)	
Stroke	n (%)	54 (3.4)	53 (3.4)	1 (2.6)	
Dementia	n (%)	29 (1.8)	27 (1.7)	2 (5.1)	
Clinical Frailty Scale					0 (0.0)
≥5: Frail	n (%)	254 (15.9)	238 (15.2)	16 (41.0)	
1: Very fit	n (%)	45 (2.8)	45 (2.9)	0 (0.0)	
2: Well	n (%)	206 (12.9)	206 (13.2)	0 (0.0)	
3: Managing well	n (%)	614 (38.4)	608 (39.0)	6 (15.4)	
4: Vulnerable	n (%)	481 (30.1)	464 (29.7)	17 (43.6)	
5: Mildly frail	n (%)	152 (9.5)	146 (9.4)	6 (15.4)	
6: Moderately frail	n (%)	80 (5.0)	75 (4.8)	5 (12.8)	
7: Severely frail	n (%)	22 (1.4)	17 (1.1)	5 (12.8)	
8: Very severely frail	n (%)	0 (0.0)	0 (0.0)	0 (0.0)	
9: Terminally frail	n (%)	0 (0.0)	0 (0.0)	0 (0.0)	

participants lived alone and 40.3% lived in rental flats. 24.5% were smokers or ex-smokers and 14.3 % were drinkers or ex-drinkers. Hypertension, hyperlipidemia, and diabetes mellitus were the top three chronic diseases that the participants had problems in self-managing. Nearly half of the participants presented with Clinical Frailty Score (CFS) of 4 and above, i.e. "vulnerable" with symptoms limiting activities and "mild to severe frailty" with dependence in daily activities.[41]

In the primary analysis, 39 participants who died during the post-test period (six months from their first community nurse visit) were excluded. Of the 1,561 participants who survived the post-test period, one had missing age and gender data.

In 1,560 participants who survived the post-test period, the GEE based negative binomial model showed that six months post first Community Nurse visit was associated with a population-average of 23% lower rate of emergency visits (IRR 0.77, 95% CI 0.68 to 0.87, p<0.001) and 15% lower rate of unplanned inpatient admissions (IRR 0.85, 95% CI 0.75 to 0.96, p=0.011). There was a trend towards a lower rate of inpatient length of stay (IRR 0.94, 95% CI 0.76 to 1.15, p=0.531), and a higher rate of SOC visits (IRR 1.06, 95% CI 0.98 to 1.14, p=0.127) and SingHealth Polyclinics visits (IRR 1.04, 9% CI 0.96 to 1.12, p=0.347).

The GEE based logistic regression model showed that six months post first community nurse visit was associated with a population-average of 20% (OR 0.80, 95% CI 0.70 to 0.91, p=0.001) and 24% (OR 0.76, 95% CI 0.66 to 0.87, p<0.001) lower odds of having one or more emergency visit and inpatient admission respectively. Six months post first community nurse visit was also associated with a population-average of 16% (OR 1.16, 95% CI 1.05 to 1.28, p=0.004) and 25% (OR 1.25, 95% CI 1.14 to 1.37, p<0.001) higher odds of having one or more SOC and SingHealth Polyclinics visits respectively (Table 2).

In the secondary analysis of the same 1,560 participants, the Negative Binomial Mixed Models (NBMM) and the logistic mixed-effects models with random intercepts for community nurse posts and participants showed largely similar results. Using the NBMM instead of the GEE based negative binomial model, six months post first community nurse visit was associated with a subject-specific of 33% lower rate of inpatient length of stay (IRR 0.67, 95% 0.51 to 0.88, p=0.004) and a 10% higher rate of SOC visits (IRR 1.10, 95% CI 1.03 to 1.19, p=0.006). In all Generalized Linear Mixed Models (GLMM), the likelihood ratio test showed that the random effects were non-zero (p<0.001) (Supplementary Table 1).

Effect modification by at least two community nurse visits

We assessed if there was evidence of effect modification on the additive and multiplicative scales by examining if the effect of six months post first community nurse visit on the rate of ED visits, unplanned inpatient admissions, or inpatient length of stay was modified by whether a participant had a two or more community nurse visits, in the 1,560 participants who survived the post-test period. GEE based negative binomial models showed that there was a non-significant 0.54 lower rate of ED visits on the additive scale (RERI -0.54, 95% CI -1.37 to 0.28, p=0.199), and a non-significant population-average of 17% lower rate of ED visits on the multiplicative scale (ratio of IRRs 0.83, 95% CI 0.57 to 1.21, p=0.328) for participants with two or more community nurse visits.

Participants with two or more community nurse visits visit had a non-significant 0.64 lower rate of unplanned inpatient admissions on the additive scale (RERI -0.64, 95% CI -1.51 to 0.23, p=0.152) and a population-average of 29% lower rate of unplanned inpatient admissions on the multiplicative scale (IRR 0.71, 95% CI 0.49 to 1.03, p=0.074). Participants with ≥1 community nurse visit also had a non-significant 0.91 lower rate of inpatient length of stay on the additive scale (RERI -0.91, 95% CI -2.70 to 0.88, p=0.319), and a non-significant population-average of 42% lower rate of inpatient length of stay on the multiplicative scale (IRR 0.58, 95% CI 0.33 to 1.03, p=0.062).

We also assessed if there was evidence of modification of the effect of six months post first community nurse visit on the rate of outpatient visits, by whether a participant was 'previously unknown to the system'. Older adults who were 'previously unknown to system' had a 0.17 higher rate of outpatient visits on the additive scale (RERI 0.17, 95% CI 0.05 to 0.28, p=0.005) and a population-average of 29% higher rate of outpatient visits on the multiplicative scale (IRR 1.29, 95% CI 1.11 to 1.50, p=0.001) (Table 5). In the secondary analysis of the same 1,560 participants, the NBMMs with random intercepts for community nurse posts and older adults showed similar results (Supplementary Table 2).

Table 2
Main analysis of six months post first CNP visit and healthcare utilization in 1,560 participants who survived the posttest period. All GEE-based models were adjusted for baseline age, gender, and race. CNP=Community nurse post. ED=Emergency department. IRR=Incidence rate ratio. LOS=Length of stay. OR=Odds ratio. SHP=SingHealth Polyclinic. SOC=Specialist Outpatient Clinic.

Variable	ED visits			≥1 ED visit		
	n	IRR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	776	1.00 (ref)	-	381 (24.4)	1.00 (ref)	-
6 months post first CNP visit	602	0.77 (0.68 to 0.87)	<0.001	321 (20.6)	0.80 (0.70 to 0.91)	0.001
Variable	Unplanned inpatient admissions			≥1 Unplanned inpatient admission		
	n	IRR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	635	1.00 (ref)	-	375 (24.0)	1.00 (ref)	-
6 months post first CNP visit	545	0.85 (0.75 to 0.96)	0.011	304 (19.5)	0.76 (0.66 to 0.87)	<0.001
Variable	Inpatient LOS in days					
	n	IRR (95% CI)	P value			
6 months pre first CNP visit	3,349	1.00 (ref)	-			
6 months post first CNP visit	3,168	0.94 (0.76 to 1.15)	0.531			
Variable	SOC visits			≥1 SOC visit		
	n	IRR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	5,651	1.00 (ref)	-	913 (58.5)	1.00 (ref)	-
6 months post first CNP visit	5,961	1.06 (0.98 to 1.14)	0.127	965 (61.8)	1.16 (1.05 to 1.28)	0.004
Variable	SHP visits			≥1 SHP visit		
	n	IRR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	3,808	1.00 (ref)	-	870 (55.7)	1.00 (ref)	-
6 months post first CNP visit	3,938	1.04 (0.96 to 1.12)	0.347	953 (61.1)	1.25 (1.14 to 1.37)	<0.001

Sensitivity analyses

To account for the COVID-19 pandemic as a potential positive confounder, the analysis was restricted to older adults with a six-month follow-up period before the COVID-19 pandemic in Singapore. In 1,093 participants before 'circuit breaker', GEE based models showed no evidence that COVID-19 positively confounded the relationship between six months post first Community Nurse visit and the population-average rate of emergency visits (IRR 0.73, 95% CI 0.63 to 0.85, p<0.001), odds of one or more emergency visit (OR 0.76, 95% CI 0.63 to 0.88, p<0.001), rate of unplanned inpatient admissions (IRR 0.84, 95% CI 0.72 to 0.97, p<0.001), odds of one or more unplanned inpatient admissions (IRR 0.74, 95% CI 0.63 to 0.88, p<0.001), or odds of one or more outpatient visit (OR 1.19, 95% CI 1.05 to 1.34, p=0.006). When the analyses were restricted to 634 older adults before DORSCON Orange, i.e. 1 February 2020, similar results were obtained (Table 3).

To account for potential bias towards the alternative hypothesis by excluding 39 older adults who died during the post-test period, a worst-case-scenario analysis of 1,599 participants was performed whereby all 39 older adults were included and assumed to have one or more healthcare utilization in the post-test period. The GEE based negative binomial model showed that six months post first community nurse visit was associated with a population-average of 14% (OR 0.86, 95% CI 0.75 to 0.97, p=0.019) and 19% (OR 0.81, 95% CI 0.71 to 0.93, p=0.002) lower odds of having one or more emergency visit and unplanned inpatient admission respectively in the worst-case scenario (Table 4).

Discussion

Our study showed that a nurse-led community program might contribute to the reduction of healthcare utilization for community-dwelling older adults with chronic diseases in the six months after the first CNP visit. The older adults had significant reductions in unplanned inpatient admissions, ED attendance, and hospital length of stay. A significant increase in SOC (in those previously undiagnosed by SingHealth Polyclinics) and SingHealth Polyclinic visits were also

Table 3
Sensitivity analysis of six months post first CNP visit and healthcare utilization in 1,094 participants before 'circuit breaker' and in 634 participants before DORSCON Orange. All GEE-based models were adjusted for age, gender, and race. CNP=Community nurse post. ED=Emergency department. IRR=Incidence rate ratio. LOS=Length of stay. OR=Odds ratio. SHP=SingHealth Polyclinic. SOC=Specialist Outpatient Clinic.

Variable	Outcome: ED visits								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value
6 months pre first CNP visit	776	1.00 (ref)	-	573	1.00 (ref)	-	340	1.00 (ref)	-
6 months post first CNP visit	602	0.77 (0.68 to 0.87)	<0.001	423	0.73 (0.63 to 0.85)	<0.001	218	0.65 (0.52 to 0.79)	<0.001
Variable	Outcome: ≥1 ED visit								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	381 (24.4)	1.00 (ref)	-	291 (26.6)	1.00 (ref)	-	173 (27.3)	1.00 (ref)	-
6 months post first CNP visit	321 (20.6)	0.80 (0.70 to 0.91)	0.001	235 (21.5)	0.76 (0.63 to 0.88)	<0.001	123 (19.4)	0.63 (0.51 to 0.78)	<0.001
Variable	Outcome: Unplanned inpatient admissions								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value
6 months pre first CNP visit	635	1.00 (ref)	-	483	1.00 (ref)	-	278	1.00 (ref)	-
6 months post first CNP visit	545	0.85 (0.75 to 0.96)	0.011	410	0.84 (0.72 to 0.97)	0.018	200	0.71 (0.58 to 0.88)	0.001
Variable	Outcome: ≥1 unplanned inpatient admission								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	375 (24.0)	1.00 (ref)	-	285 (26.1)	1.00 (ref)	-	174 (27.4)	1.00 (ref)	-
6 months post first CNP visit	304 (19.5)	0.76 (0.66 to 0.87)	<0.001	230 (21.0)	0.74 (0.63 to 0.88)	<0.001	120 (18.9)	0.60 (0.48 to 0.75)	<0.001
Variable	Outcome: Inpatient LOS in days								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value
6 months pre first CNP visit	3,349	1.00 (ref)	-	2,616	1.00 (ref)	-	1,466	1.00 (ref)	-
6 months post first CNP visit	3,168	0.94 (0.76 to 1.15)	0.531	2,250	0.82 (0.63 to 1.05)	0.119	991	0.66 (0.48 to 0.92)	0.015
Variable	Outcome: SOC visits								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value
6 months pre first CNP visit	5,651	1.00 (ref)	-	4,012	1.00 (ref)	-	2,321	1.00 (ref)	-
6 months post first CNP visit	5,961	1.06 (0.98 to 1.14)	0.127	4,299	1.08 (0.99 to 1.17)	0.088	2,567	1.12 (1.01 to 1.25)	0.039
Variable	Outcome: ≥1 SOC visit								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	913 (58.5)	1.00 (ref)	-	660 (60.3)	1.00 (ref)	-	390 (61.5)	1.00 (ref)	-
6 months post first CNP visit	965 (61.8)	1.16 (1.05 to 1.28)	0.004	702 (64.2)	1.19 (1.05 to 1.34)	0.006	410 (64.7)	1.15 (0.98 to 1.36)	0.093
Variable	Outcome: SHP visits								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value	n	IRR (95% CI)	P value
6 months pre first CNP visit	3,808	1.00 (ref)	-	2,667	1.00 (ref)	-	1,499	1.00 (ref)	-
6 months post first CNP visit	3,938	1.04 (0.96 to 1.12)	0.347	2,878	1.08 (0.98 to 1.19)	0.106	1,633	1.10 (0.98 to 1.24)	0.101
Variable	Outcome: ≥1 SHP visit								
	Main analysis (n=1,560)			Before 'circuit breaker' (n=1,093)			Before DORSCON Orange (n=634)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	870 (55.7)	1.00 (ref)	-	619 (56.6)	1.00 (ref)	-	355 (56.0)	1.00 (ref)	-
6 months post first CNP visit	953 (61.1)	1.25 (1.14 to 1.37)	<0.001	685 (62.6)	1.29 (1.15 to 1.44)	<0.001	396 (62.5)	1.31 (1.13 to 1.52)	<0.001

Table 4
Worst-case scenario analysis of six months post first CNP visit and healthcare utilization in all 1,599 participants. All GEE-based models were adjusted for age, gender, and race. CNP=Community nurse post. ED=Emergency department.

Variable	≥1 ED visit					
	Main analysis (n=1,560)			Worst-case analysis (n=1,599)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	381 (24.4)	1.00 (ref)	-	404 (25.3)	1.00 (ref)	-
6 months post first CNP visit	321 (20.6)	0.80 (0.70 to 0.91)	0.001	360 (22.5)	0.86 (0.75 to 0.97)	0.019
Variable	≥1 unplanned inpatient admission					
	Main analysis (n=1,560)			Worst-case analysis (n=1,599)		
	n (%)	OR (95% CI)	P value	n (%)	OR (95% CI)	P value
6 months pre first CNP visit	375 (24.0)	1.00 (ref)	-	400 (25.0)	1.00 (ref)	-
6 months post first CNP visit	304 (19.5)	0.76 (0.66 to 0.87)	<0.001	343 (21.4)	0.81 (0.71 to 0.93)	0.002

observed. The results supported our two out of three hypotheses. The older adults with ≥ one visit had a lesser hospital length of stay, but not significant. The COVID-19 pandemic and the data of those demised were not confounded to the relationship between the CNP visit and healthcare utilization.

The participants are relatively older and required assistance in daily activities. They are socioeconomically disadvantaged and might lack caregiver support. They faced challenges in chronic diseases self-management. Those with chronic diseases that were undiagnosed by primary care physicians were likely to have lived with the symptoms for some time and were only seeking health care services when their conditions deteriorated. All these older adults' characteristics implied that they could benefit from comprehensive assessment, chronic diseases monitoring, health coaching, care coordination and referral at the accessible community nurse posts.

Our study reported a significant reduction of ED attendance and unplanned readmissions at six months post first CNP visit. These results were consistent with other nurse-led Community-Based Health Home program where significant reductions in ED utilization among the vulnerable older adults with multi-morbidity was also observed.[42] Interventions such as home visits, nursing surveillance, education, interdisciplinary care coordination with acute and primary care providers, medication management, greater advocacy and addressing the social determinants of health (e.g., meals, home safety) contributed to the improved healthcare utilization and socioemotional health.

Medication management which includes medication reconsolidation, medication packing, and education were routinely performed during the community nurse visits in our study as medication non-adherence potentially led to hospitalization. Studies in UK and Singapore have also shown the association between medication issues and unplanned hospital admissions.[43,44] Medication adherence interventions decreased the odds for hospital readmission.[45] Predictors of medication non-adherence include perceived complicated medication regimes, feeling dissatisfied with medication regimes, experiencing side effects, and not knowing the purpose of medications.[43] Limited English health literacy among the older Singaporeans was also associated with medication non-adherence, with difficulty in understanding medication labels identified as a significant mediator.[46] Community nurses can serve as a safety net to the complex medication management process by working with the individual and other professionals on the barriers relating to non-adherence. Community nursing interventions, such as i) individualized coaching in a common instructional language, ii) assisted medication packing, iii) liaising with physicians for medication regime adjustment, and iv) monitoring for adverse effects potentially improve older adults' medication adherence and reduce their healthcare utilization.

In addition to medication education, our community nurses provide health coaching on preventive health and chronic disease self-management. Community-based nurse-led interventions supporting self-management were found to be effective in HbA1c reduction and blood pressure control.[47] Our study has demonstrated that interventions promoting self-management greatly impacted healthcare utilization on a large scale besides clinical outcomes. As the primary care systems worldwide are facing the challenges of an ageing population and an increase of patients with chronic diseases, the focus has shifted to support patients in self-management, with improved self-efficacy and health-related behaviors. Nurse-led services that support self-management should be included as part of the standard primary care activities to reduce health-utilizations such as readmissions, unplanned SOC and ED visits.

Within the study population, we have another group of frail older adults with advanced chronic diseases. They lived alone and faced difficulties in managing their health conditions. Our community nurses advocated and facilitated ACP discussion and documentation. It is important to ensure that the care the older adults received is aligned with their values and preferences in anticipation of possible future decline and mental incapacity. Patients enrolled under an ACP program showed lower mean of acute admission and shorter LOS in the last three months of life compared with the non-ACP group.[48] Similar to our program, ACP conversations with patients with chronic diseases, including those with mild cognitive impairment reduced the risk of hospitalizations and ED visits within 1 year.[49] It is believed that community-based ACP discussion is effective given the less rushed settings at home /community and rapport-building after several visits.

Multi-disciplinary transitional home care program, with nurse case managers as part of the team, had significantly lower acute hospital utilization of patients at 6-months post enrolment.[26] Our community nursing program focuses on providing long term comprehensive care coordination as community-dwelling older adults' health and psychoemotional conditions fluctuate, especially when they become progressively frail as they age. Receiving services in a familiar environment close to their homes enable them to live well and age well in place. Similar community nursing models through the care coordination of nurses and APNs reported significant decrease in emergency visits[35,50] and readmissions.[50] The community nurses supported the older adults in managing their medical conditions, physical functioning, medication management, and health and social services.

Our results showed a non-significant reduction in the inpatient LOS. The top three reasons for prolonged hospitalization in a Singapore acute care hospital were attributed to multiple factors such as patient demographics, acuity of illness, discharge planning process and availability of community resources.[51] Integration of care involving nurse navigators and multi-disciplinary transitional hospital to home services are pivotal in facilitating care coordination, discharge planning, and care transition from hospital to community. As transitional care is time-limited, handover to long-term healthcare providers, such as community nurses, will help achieve sustainable outcomes.

Table 5
Effect modification analysis in 1,560 participants who survived the posttest period. Modification of the effect of six months post first CNP visit on the rate of a) ED visits, b) unplanned inpatient admissions, and c) inpatient LOS, by whether a participant had a follow-up visit, and d) the effect of six months post first CNP visit on the rate of SOC visits, by whether a participant was 'previously unknown to system', i.e. no SingHealth Polyclinic chronic disease diagnosis in the two-year period prior to the first CNP visit. CNP=Community nurse post. ED=Emergency department. IRR: Incidence rate ratio. LOS: Length of stay. RERI=Relative excess risk due to interaction. SOC=Specialist Outpatient Clinic.

Effect modifier stratum	Six months pre first CNP visit			Six months post first CNP visit				
	n ED visits	IRR (95% CI)	P value	n ED visits	IRR (95% CI)	P value	IRR (95% CI) for posttest within strata of 0/≥1 follow-up CNP visit	P value
0 follow-up CNP visit	98	1.00 (ref)	-	88	0.90 (0.64 to 1.29)	0.575	0.90 (0.64 to 1.29)	0.575
≥1 follow-up CNP visit	678	2.54 (1.83 to 3.54)	<0.001	514	1.91 (1.35 to 2.68)	<0.001	0.75 (0.66 to 0.85)	<0.001
Measure of effect modification on additive scale: RERI (95% CI) = -0.54 (-1.37 to 0.28); P=0.199.								
Measure of effect modification on multiplicative scale: ratio of IRRs (95% CI) = 0.83 (0.57 to 1.21); P=0.328.								
IRRs were adjusted for age, gender, and race.								
Effect modifier stratum	Six months pre first CNP visit			Six months post first CNP visit				
	n unpl. inpt. adm.	IRR (95% CI)	P value	n unpl. inpt. adm.	IRR (95% CI)	P value	IRR (95% CI) for posttest within strata of 0/≥1 follow-up CNP visit	P value
0 follow-up CNP visit	79	1.00 (ref)	-	89	1.14 (0.80 to 1.63)	0.465	1.14 (0.80 to 1.63)	0.465
≥1 follow-up CNP visit	556	2.58 (1.89 to 3.51)	<0.001	456	2.08 (1.51 to 2.87)	<0.001	0.81 (0.71 to 0.92)	0.002
Measure of effect modification on additive scale: RERI (95% CI) = -0.64 (-1.51 to 0.23); P=0.152.								
Measure of effect modification on multiplicative scale: ratio of IRRs (95% CI) = 0.71 (0.49 to 1.03); P=0.074.								
IRRs were adjusted for age, gender, and race.								
Effect modifier stratum	Six months pre first CNP visit			Six months post first CNP visit				
	Inpt. LOS in days	IRR (95% CI)	P value	Inpt. LOS in days	IRR (95% CI)	P value	IRR (95% CI) for posttest within strata of 0/≥1 follow-up CNP visit	P value
0 follow-up CNP visit	342	1.00 (ref)	-	498	1.50 (0.89 to 2.51)	0.127	1.50 (0.89 to 2.51)	0.127
≥1 follow-up CNP visit	3,007	3.31 (2.14 to 5.12)	<0.001	2,670	2.89 (1.82 to 4.60)	<0.001	0.88 (0.70 to 1.10)	0.246
Measure of effect modification on additive scale: RERI (95% CI) = -0.91 (-2.70 to 0.88); P=0.319.								
Measure of effect modification on multiplicative scale: ratio of IRRs (95% CI) = 0.58 (0.33 to 1.03); P=0.062.								
IRRs were adjusted for age, gender, and race.								
Effect modifier stratum	Six months pre first CNP visit			Six months post first CNP visit				
	n SOC visits	IRR (95% CI)	P value	n SOC visits	IRR (95% CI)	P value	IRR (95% CI) for posttest within strata of whether a participant was 'previously unknown to system'	P value
'Previously known to system'	4,238	1.00 (ref)	-	4,173	0.99 (0.90 to 1.08)	0.754	0.99 (0.90 to 1.08)	0.754
'Previously unknown to system'	1,413	0.56 (0.46 to 0.69)	<0.001	1,788	0.72 (0.59 to 0.86)	<0.001	1.28 (1.12 to 1.46)	<0.001
Measure of effect modification on additive scale: RERI (95% CI) = 0.17 (0.05 to 0.28); P=0.005.								
Measure of effect modification on multiplicative scale: ratio of IRRs (95% CI) = 1.29 (1.11 to 1.50); P=0.001.								
IRRs were adjusted for age, gender, and race.								

The higher rate of SOC visits was not a surprise and this could be due to the new medical conditions requiring early interventions, as identified by the community nurses. The increased number of SOC visits was also reported in another transitional care pilot study in Singapore.[26] The study attributed two reasons; unresolved clinical issues that require specialist input and transition of patients with complex needs beyond the capabilities of primary care providers. The increased polyclinic visits in our study were likely due to the new referrals and care escalation by the community nurses.

The COVID-19 pandemic did not have an impact on the outcomes of our interventions. Community nurses transit from face-to-face consults to teleconsultations and keep their services accessible during the pandemic. For older persons with stable health conditions, community nurses provided teleconsultation to assess their general wellbeing, health and self-monitoring measures, for example, for blood pressure. The ongoing monitoring was essential for targeted interventions and care escalation when the medical conditions were not well controlled and/or when the patient had a recent medication change.[40]

To the researchers' best knowledge, this is the first study in evaluating healthcare utilization among older adults who were followed up by community nurses from acute care hospitals in Singapore. The findings will aid in refining the community nursing services to ensure program sustainability and future service expansion.

Limitations

There are several limitations to this study. Firstly, the data from electronic medical records were restricted to SingHealth institutions only and hence researchers were unable to track data from other institutions. However, these numbers are likely to be small as most of the older adults accessed the acute and primary healthcare services near their premises. Secondly, this study used a small sample size from two hospitals over a period of 12 months. Future research should embark on a longer period of evaluation to ensure the sustainability of the program. Thirdly, the COVID-19 pandemic took place during the six-month follow-up period. We have performed sensitivity analysis by restricting to older adults with a six-month follow-up period before the COVID-19 pandemic. The results showed no evidence that the COVID-19 positively confounded with the reduced non-outpatient healthcare utilization. Lastly, the nature of pre-and post-test design without control groups is unable to determine the outcome causality, thus limiting the generalizability of the findings. The purposeful sampling allowed the assessment of the specific population, but not the population as a whole.

Despite these limitations, this study makes a conscious effort to evaluate the healthcare utilization of the geographically organized team-based community nursing program. These findings add new perspectives to the limited literature on community nursing services worldwide.

Conclusions

The community nursing program has evolved to meet the aging population's demand and chronic disease burden. Enrollment with at least one CNP visit was associated with a significant reduction of unplanned readmission and ED visits. The trend of a higher rate of SOC visits could be attributed to the community nurses' referrals for new diagnosis and/or treatment of suboptimal health issues. The geographically team-based community nursing model, comprehensive scope of practice across acute and community settings may have contributed to the effectiveness of this program. Keeping the community nursing service accessible during the pandemic was essential for vulnerable older persons through timely interventions. The promising results from this retrospective study have supported the expansion of community nursing services in the regional health system.

Funding sources

The RHS Community Nursing Program is funded by the Ministry of Health Singapore.

Conflict of interest

None declared.

CRediT authorship contribution statement

Yi Xu: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Project administration. **Xuan Han Koh:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Yi Tian Stella Chua:** Methodology, Investigation, Writing – original draft, Project administration. **Cheng Gaik Irene Tan:** Methodology, Investigation, Writing – original draft, Project administration. **Fazila Abu Bakar Aloweni:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Visualization. **Bee Eng Joanne Yap:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Poh Choo Tan:** Conceptualization, Methodology, Writing – review & editing, Visualization. **Xueli Chua:** Conceptualization, Methodology, Writing – review & editing. **Yee Kee Shannon Lim:** Conceptualization, Methodology, Writing – review & editing. **Hong Choon Oh:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Visualization. **Swee Hong Stephanie Teo:** Conceptualization, Methodology, Writing – review & editing, Visualization. **Su Fee Lim:** Conceptualization, Methodology, Writing – review & editing, Visualization.

Acknowledgments

The authors would like to thank the community nurses of Singapore General Hospital and Changi General Hospital who contributed to the data collection and the SingHealth Office of Regional Office for providing the administrative support.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.gerinurse.2022.04.024.

References

1. Randall S, Crawford T, Currie J, River J, Betihavas V. Impact of community based nurse-led clinics on patient outcomes, patient satisfaction, patient access and cost effectiveness: A systematic review. *Int J Nurs Stud*. 2017;73:24–33.
2. *Ministry of Health Singapore. Community nursing competency framework*. National Nursing Academy; 2021. Available from: https://www.nna.gov.sg/resources-tools/nursing-competency-framework/community-nursing-competency-framework.
3. *Enhancing the role of community health nursing for universal health coverage*. World Health Organization; 2017. Available from: https://www.who.int/publications/i/item/9789241511896.
4. He W, Goodkind D, Kowal PR. *An aging world: 2015*. Washington, DC: United States Census Bureau; 2016.
5. Mitsutake S, Ishizaki T, Teramoto C, Shimizu S, Ito H. Peer Reviewed: Patterns of Co-Occurrence of Chronic Disease Among Older Adults in Tokyo, Japan. *Preventing Chronic Disease*. 2019:16.
6. Lowthian J. How do we optimise care transition of frail older people? *Age Ageing*. 2017;46(1):2–4.
7. Pruchno R. International aging: Spotlighting the spotlights. *Gerontologist*. 2017;57(3):392–395.
8. Rogerson A, Stacey S. Successful ageing in Singapore. *Geriatrics*. 2018;3(4):81.
9. *Prime Minister's Office, Singapore Department of Statistics, Ministry of Home Affairs, Immigration & Checkpoints Authority, Manpower Mo*. National Population and Talent Division SG; 2020. Population in brief 2020. Available from: https://www.

google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjX7b-De35L3AhXBW3wKHQ_HAIcQFnoECAcQAQ&url=https%3A%2F%2Fwww.strategygroup.gov.sg%2Ffiles%2Fmedia-centre%2Fpublications%2Fpopulation-in-brief-2020.pdf&usg=AOvVaw0AMTRMb_DDK_jq9fKkqTtT.
10. Chan CQH, Lee KH, Low LL. A systematic review of health status, health seeking behaviour and healthcare utilisation of low socioeconomic status populations in urban Singapore. *International journal for equity in health*. 2018;17(1):1–21.
11. Gan E. *At emergency departments, more patience for elderly patients Today*. 2018. [Available from: https://www.todayonline.com/singapore/emergency-departments-more-patience-elderly-patients.
12. Low S, Rao KA, Tang T, Wee S-L. Factors associated with hospital readmission and emergency visits among older adults−5-year experience in a busy acute hospital. *Journal of Clinical Gerontology & Geriatrics*. 2018;9(4):126–136.
13. *Building a Sustainable Healthcare System for the Future*. Ministry of Health; 2018. Available from: https://www.moh.gov.sg/news-highlights/details/speech-by-mr-Gan-kim-yong-minister-for-health-at-the-ministry-of-health-committee-of-supply-debate-2018.
14. Xu Y, Lim S. The development of geographically-based SGH community nursing in SingHealth (Southeast) regional health system. *College Mirror*. 2019;45(1):12–13.
15. Buttorff C, Ruder T, Bauman M. *Multiple chronic conditions in the United States*. Monica, CA: Rand Santa; 2017.
16. Hayes, Gillian, eds. *Chronic disease in the United States: A worsening health and economic crisis*. American Action Forum; 2020.
17. Chan JS-E, Tin AS, Chow WL, Tiah L, Tiru M, Lee CE. Frequent attenders at the emergency department: an analysis of characteristics and utilisation trends. In: *Proceedings of Singapore Healthcare*. 27, 201812–19.
18. Hutter N, Schnurr A, Baumeister H. Healthcare costs in patients with diabetes mellitus and comorbid mental disorders—a systematic review. *Diabetologia*. 2010;53(12):2470–2479.
19. Sporinova B, Manns B, Tonelli M, Hemmelgarn B, MacMaster F, Mitchell N, et al. Association of mental health disorders with health care utilization and costs among adults with chronic disease. *JAMA network open*. 2019;2:(8) e199910.
20. Subramaniam M, Abdin E, Vaingankar JA, Picco L, Seow E, Chua BY, et al. Comorbid Diabetes and Depression among Older Adults—Prevalence, Correlates, Disability and Healthcare Utilisation. *Ann Acad Med Singapore*. 2017;46(3):91–101.
21. Xu W, Collet J-P, Shapiro S, Lin Y, Yang T, Platt RW, et al. Independent effect of depression and anxiety on chronic obstructive pulmonary disease exacerbations and hospitalizations. *Am J Respir Crit Care Med*. 2008;178(9):913–920.
22. Levesque J-F, Harris MF, Russell G. Patient-centred access to health care: conceptualising access at the interface of health systems and populations. *International journal for equity in health*. 2013;12(1):1–9.
23. *United Kingdom: Country Health Profile 2019*. OECD; 2019.
24. *Singapore's Long-Term Care System: Adapting to Population Aging*. Asian Development Bank; 2020. Available from: https://www.adb.org/publications/singapore-care-system-population-aging.
25. Wee SL, Loke CK, Liang C, Ganesan G, Wong LM, Cheah J. Effectiveness of a national transitional care program in reducing acute care use. *J Am Geriatr Soc*. 2014;62(4):747–753.
26. Low LL, Vasanwala FF, Ng LB, Chen C, Lee KH, Tan SY. Effectiveness of a transitional home care program in reducing acute hospital utilization: a quasi-experimental study. *BMC Health Services Research*. 2015;15(1):1–8.
27. Low LL, Tan SY, Ng MJM, Tay WY, Ng LB, Balasubramaniam K, et al. Applying the integrated practice unit concept to a modified virtual ward model of care for patients at highest risk of readmission: a randomized controlled trial. *PLoS One*. 2017;12:(1) e0168757.
28. Naylor MD, Hirschman KB, Hanlon AL, Bowles KH, Bradway C, McCauley KM, et al. Comparison of evidence-based interventions on outcomes of hospitalized, cognitively impaired older adults. *Journal of comparative effectiveness research*. 2014;3(3):245–257.
29. Sezgin D, O'Caoimh R, Liew A, O'Donovan MR, Illario M, Salem MA, et al. The effectiveness of intermediate care including transitional care interventions on function, healthcare utilisation and costs: a scoping review. *European geriatric medicine*. 2020;11(6):961–974.
30. Sezgin D, Hendry A, Liew A, O'Donovan M, Salem M, Carriazo AM, et al. Transitional palliative care interventions for older adults with advanced non-malignant diseases and frailty: a systematic review. *Journal of Integrated Care*. 2020.
31. Chow SKY, Wong FKY. A randomized controlled trial of a nurse-led case management programme for hospital-discharged older adults with co-morbidities. *J Adv Nurs*. 2014;70(10):2257–2271.
32. Han E, Quek RYC, Tan SM, Singh SR, Shiraz F, Gea-Sanchez M, et al. The role of community-based nursing interventions in improving outcomes for individuals with cardiovascular disease: A systematic review. *Int J Nurs Stud*. 2019;100:103415.
33. Rice H, Say R, Betihavas V. The effect of nurse-led education on hospitalisation, readmission, quality of life and cost in adults with heart failure. A systematic review. *Patient Educ Couns*. 2018;101(3):363–374.
34. Wilson A, Whitaker N, Whitford D. Rising to the challenge of health care reform with entrepreneurial and intrapreneurial nursing initiatives. *Online J Issues Nurs*. 2012;17(2):5.
35. Mallitt K-A, McNab J, Hughes R, Fernyhough J, Paterson J, O'Halloran D. Reducing emergency department presentations among chronically ill patients in Western Sydney: a key role for coordinated primary care. *Australian Journal of Primary Health*. 2017;23(2):140–146.
36. Moynihan R, Sanders S, Michaleff ZA, Scott AM, Clark J, To EJ, et al. Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review. *BMJ open*. 2021;11:(3) e045343.
37. Lai AY-H, Tan SL. *Impact of disasters and disaster risk management in Singapore: A case study of Singapore's experience in fighting the SARS epidemic*. Resilience and Recovery in Asian Disasters: Springer; 2015:309–336.
38. Person B, Sy F, Holton K, Govert B, Liang A. Fear and stigma: the epidemic within the SARS outbreak. *Emerg Infect Dis*. 2004;10(2):358.
39. Sher J. *Community Nursing and the COVID-19 Pandemic*. 2020. Available from: https://www.qnis.org.uk/community-nursing-and-the-covid-19-pandemic/.
40. Xu Y, Jamil N, Tan I, Lim S. Community nursing services during the COVID-19 pandemic: The Singapore experience. *Br J Community Nurs*. 2020;25(8):390–395.
41. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ*. 2005;173(5):489–495.
42. Sadarangani T, Missaelides L, Eilertsen E, Jaganathan H, Wu B. A mixed-methods evaluation of a nurse-led community-based health home for ethnically diverse older adults with multimorbidity in the adult day health setting. *Policy, Politics, & Nursing Practice*. 2019;20(3):131–144.
43. Chew SM, Lee JH, Lim SF, Liew MJ, Xu Y, Towle RM. Prevalence and predictors of medication non-adherence among older community-dwelling people with chronic disease in Singapore. *J Adv Nurs*. 2021;77(10):4069–4080.
44. Frontiers Economics. *Exploring the costs of unsafe care in the NHS*. London: Frontiers Economics Ltd.; 2014. Available from: https://www.frontier-economics.com/media/2459/exploring-the-costs-of-unsafe-care-in-the-nhs-frontier-report-2-2-2-2.pdf.
45. Ruppar TM, Cooper PS, Mehr DR, Delgado JM, Dunbar-Jacob JM. Medication adherence interventions improve heart failure mortality and readmission rates: systematic review and meta-analysis of controlled trials. *J Am Heart Assoc*. 2016;5:(6) e002606.
46. Suppiah S, Tan YW, Cheng GH, Tang WE, Malhotra R. Mediators of the association of limited English health literacy with medication non-adherence among Singaporean elderly. *Proceedings of Singapore Healthcare*. 2020;29(1):25–32.
47. Massimi A, De Vito C, Brufola I, Corsaro A, Marzuillo C, Migliara G, et al. Are community-based nurse-led self-management support interventions effective in chronic patients? Results of a systematic review and meta-analysis. *PLoS One*. 2017;12:(3) e0173617.
48. Chan KY, Chiu HY, Yap DY, Li CW, Yip T, Tsang KW, et al. Impact of structured advance care planning program on patients' wish items and healthcare utilization. *Annals of palliative medicine*. 2020.
49. Litzelman DK, Inui TS, Griffin WJ, Perkins A, Cottingham AH, Wendholt KM, et al. Impact of community health workers on elderly patients' advance care planning and health care utilization: moving the dial. *Med Care*. 2017;55(4):319.
50. Popejoy LL, Stetzer F, Hicks L, Rantz MJ, Galambos C, Popescu M, et al. Comparing aging in place to home health care: impact of nurse care coordination on utilization and costs. *Nursing economic$*. 2015;33(6):306.
51. Towle RM, Mohammed Hussain ZB, Chew SM. A descriptive study on reasons for prolonged hospital stay in a tertiary hospital in Singapore. *J Nurs Manag*. 2021;29(7):2307–2313.