

Factors associated with persistent high healthcare service utilisers in Singapore: A population health analysis

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ABSTRACT

Introduction: Albeit comprising a small portion of the hospital population, persistent high utilisers (PHUs) contribute disproportionately to healthcare expenditures. Amid rising healthcare costs and an ageing population, this study examines factors associated with PHUs among residents in eastern Singapore.

Method: This is a retrospective study of eligible patients at Changi General Hospital in Singapore between 1 January 2020 and 31 December 2022. The study included Singapore citizens who utilised any services offered by CGH. Patients were classified as PHUs if their annual healthcare expenditure exceeded SGD3700 for 3 consecutive years. Demographics, healthcare utilisation patterns and clinical profiles were compared, and multivariable analyses were conducted to identify factors associated with PHUs.

Results: There were 267,838 eligible patients identified, with 5316 (2%) classified as PHUs. PHUs accounted for 18.4% of the total healthcare expenditure, with the highest costs attributed to inpatient services, followed by outpatient services. PHUs were more likely to be older, male, non-Chinese and of lower socioeconomic status. Conditions with the strongest association with PHUs were mental health disorders, chronic obstructive pulmonary disease, osteoporosis, asthma and renal diseases. Inpatient discharges from renal medicine, psychological medicine and general/geriatric medicine wards had the strongest association with PHUs. Utilisation of allied health services had the highest odds of being a PHU in outpatient care.

Conclusion: This study identified key factors associated with PHUs, providing invaluable insights into the planning of population health services within the hospital's geographical region. Targeted service development and process improvements of medical care can help mitigate persistent high utilisation.

Keywords: epidemiology, healthcare cost, healthcare utilisation, population health, public health

CLINICAL IMPACT

What is New

- This is the first study in Singapore to identify persistent high healthcare service utilisers from the lens of national-level healthcare utilisation.
- The findings identified key factors associated with persistent high healthcare utilisation.

Clinical Implications

- This study further underscored the importance of advancing integrated care between hospitals, community and primary care in the management of patients with complex care to manage persistent high utilisation of healthcare services for conditions beyond diabetes, hypertension and dyslipidaemia.

INTRODUCTION

Singapore's healthcare system comprises private and public sector providers,¹ financed through a

combination of government subvention and subsidies, personal medical savings and funds, health insurance and a government endowment fund.² Public sector primary care, intermediate and long-term care (ILTC) facilities, and hospitals are grouped and managed by 3 healthcare clusters that receive annual subvention and subsidies from the government for the provision of medical services. In 2023, Singapore's Ministry of Health (MOH) launched the multi-year Healthier SG (a national initiative to focus on preventive healthcare) strategy,³ with 1 key feature to support the 3 healthcare clusters in managing primary care, ILTC and hospitals to care for the residents within their catchment areas. Supported by capitation funding based on the residential population, the strategy focuses on right-siting, service efficiency and preventive care.³ Patients may seek care from private or public providers island-wide, where transfer payments will be made between clusters.³ To optimise the use of capitation funds,⁴ the healthcare clusters would need to identify and implement targeted interventions for high utilisers (HU), reduce healthcare costs and allow resource reallocation. Addressing HUs minimises cost

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variability and stabilises resource allocation under the capitation funding model.

Patients with complex needs are often HUs of healthcare services,^{5,6} with various definitions used to identify them.⁷ Studies showed that most HUs reduce their utilisation over time,^{8,9} but a subgroup of them termed persistent HUs (PHUs),^{10–12} continue high utilisation for more than 2 years.^{10,13} Although PHUs represent a small proportion of the population, they incur disproportionate healthcare expenditures.^{10,11,14,15,24,25} Early identification of PHUs through various definitions aims to reduce future utilisation.^{16,17} However, heterogeneity in definitions, study populations and healthcare financing models makes direct comparisons and application to the Singapore context difficult.

Although some studies in Singapore have characterised PHUs, they focused on either inpatient settings¹⁸ or specific conditions,¹⁹ defining high utilisation based on expenditures, a minimum length of stay or a minimum number of emergency department (ED) visits. While effective for capturing PHUs with high inpatient costs, these approaches may miss other healthcare utilisation patterns such as high outpatient clinic visits or medication costs without inpatient admissions. Moreover, with residents given the flexibility to seek care across multiple institutions nationwide, such a method may not adequately identify PHUs with dispersed utilisation patterns.

With these in mind, this study aimed to examine factors associated with PHUs among residents in eastern Singapore by adopting a different approach to identify PHUs from the lens of national-level healthcare utilisation. Findings from this study could offer potential insights on possible early identification of PHUs, targeted interventions for PHUs and strategic healthcare resource reallocation to reduce their healthcare utilisation. Overall, this study comprised 2 main components. First, it identified PHUs residing within the catchment area of Changi General Hospital (CGH)—a public tertiary hospital in eastern Singapore—from 2017 to 2019, from the national registry. Thereafter, the annual gross bill threshold incurred by these PHUs in CGH was derived and applied to identify PHUs who had visited CGH in 2020–2022.

METHOD

Study design, settings and participants

This retrospective cohort study included all CGH patients who utilised the hospital's services (i.e. ED, inpatient, day surgery, specialist outpatient clinics and community health services—referred to as outpatient services) between 1 January 2020 and 31

December 2022, excluding non-Singapore citizens and those deceased before 1 January 2023.

Definitions of PHUs

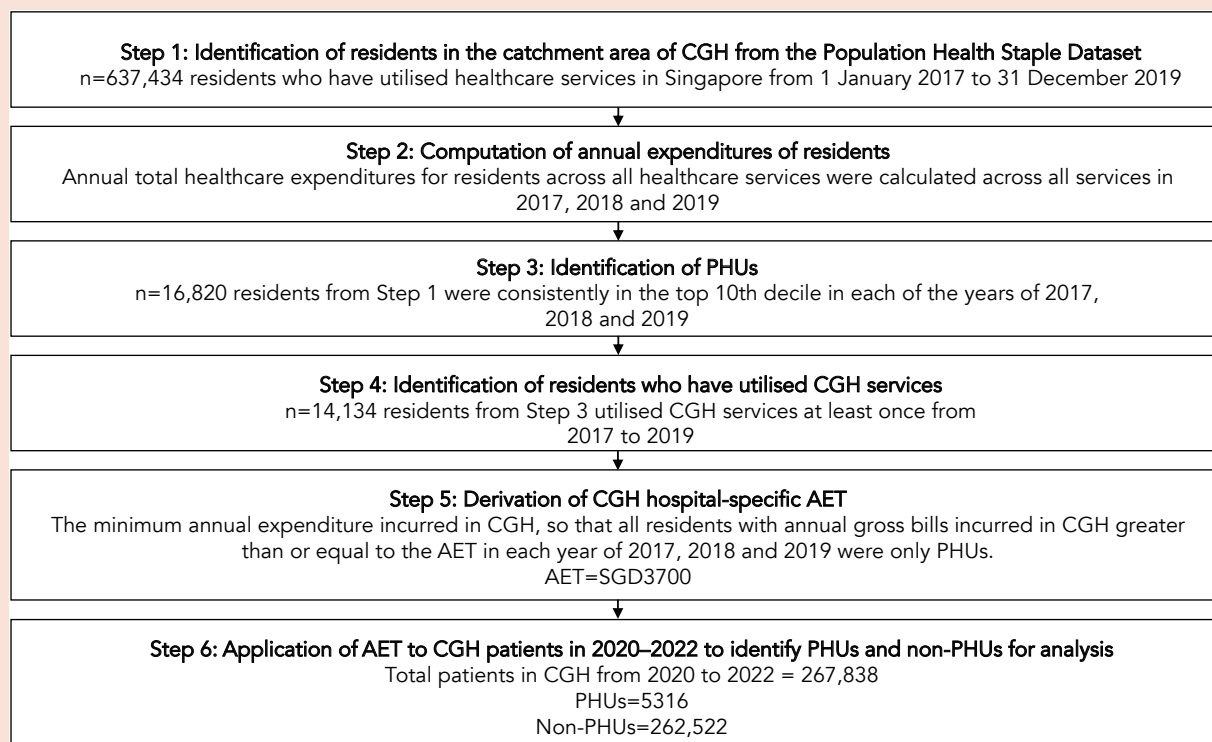
Although utilisation and cost are both common approaches, used either in combination or separately in defining PHUs,²⁰ an expenditure-based approach (surrogate for cost) was employed instead of a utilisation-based approach, basing the expenditure on a patient's gross healthcare bills, for a few reasons. First, a utilisation-based approach may not accurately capture instances of costly healthcare use, such as short inpatient stays that result in disproportionately high bills. Second, in the absence of cost data reflecting the actual expenses incurred by the healthcare system in delivering services, expenditure serves as the most appropriate proxy for assessing patients' healthcare utilisation.²¹

This study classified Singapore citizens as HUs in a year if their annual gross healthcare bills were within the 10th decile of the Singapore population in the same year. These gross healthcare bills referred to gross bills (inclusive of any government subsidies or third-party payments) captured in MOH's Population Health Staple Dataset (PHSD), which recorded all healthcare services utilised by residents at all public healthcare institutions and care settings in Singapore, subsidised primary care and step-down care services (offered by ILTC facilities), inpatient, day surgery and selected outpatient services in private hospitals.

First, PHSD was used to identify PHUs who resided within the catchment area of CGH from 2017 to 2019. Then, the threshold of annual gross bills—which were incurred by these PHUs in CGH—was estimated at SGD3700; this was used to identify PHUs among patients who had visited CGH in 2020–2022. Details of how the threshold was derived from PHSD are described in Supplementary Appendix S2 and Fig. S1. Therefore, a patient was classified as an HU that year if he/she had an annual expenditure of at least SGD3700 in CGH. PHUs were then defined as patients who were HUs for 3 consecutive years from 2020 to 2022 and non-PHUs otherwise. A flowchart of this methodology is summarised in Fig. 1.

In this study, CGH data (instead of the national registry) were used for a few reasons. First, institutional data can be timely accessed with minimal delays and administrative barriers. Second, internal data autonomy enables further qualitative exploration, such as case note reviews, to identify care gaps and understand PHU profiles. Last, institutional data offered higher granularity, capturing details like inpatient discharge specialities, outpatient visit characters and a detailed breakdown of bills by

Fig. 1. Flowchart for PHU determination.



AET: annual expenditure threshold; CGH: Changi General Hospital; PHUs: persistent high utilisers

service type. This allowed deeper insights often missed in the national registry.

Data sources and variables

All datasets were obtained from CGH's administrative databases. Visit-level data were extracted for inpatient admissions, ED visits, outpatient specialist visits and day surgery admissions. Bills data were extracted by service types (e.g. gross bill for specific ward types during inpatient admissions). Patient-level variables were aggregated annually (2020–2022) for variables such as (1) demographics, (2) healthcare service utilisation (i.e. total gross bills, number of visits/admissions and visit/admission details by service type) and (3) disease conditions.

Patients' age, sex, ethnicity, resident status and housing type (based on the housing type with the largest proportion in the block via patients' postal code data²²) were studied. To estimate the density of PHU in each geographic location, a population-related census by geographical location was obtained from the website by a government agency in Singapore and referenced to the 2020 data.²² All healthcare expenditures were adjusted to 2022 Singapore dollars.²³

Dates of expenditures for emergency and outpatient services were based on attendance dates, while those for inpatient services were based on

admission dates. Annual healthcare expenditure (gross bills and number of visits/admissions) was estimated by summing gross bills, including subsidies and third-party payments, by year. Patients' disease conditions were identified based on inpatient discharge diagnosis codes (International Classification of Diseases, Tenth Revision), broadly categorised as detailed in Supplementary Table S3. Inpatient discharge specialities and outpatient specialities were collated to assess associations with PHU status.

Statistical methods

Categorical variables were summarised as frequencies and percentages, while continuous variables as mean and standard deviation (SD). Comparisons between PHUs and non-PHUs were tested with chi-square tests and two-sample t-test for categorical and continuous variables, respectively. For healthcare utilisation-related data, the mean with SD and median with interquartile range of the total healthcare expenditures (2020–2022) were presented, and differences were tested with the Mann-Whitney U-test. Multi-variable logistic regressions were conducted to study the association between PHU status with different disease conditions, healthcare utilisation patterns and demographic characteristics. Statistical significance was set at 5% and analyses were performed using R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient population

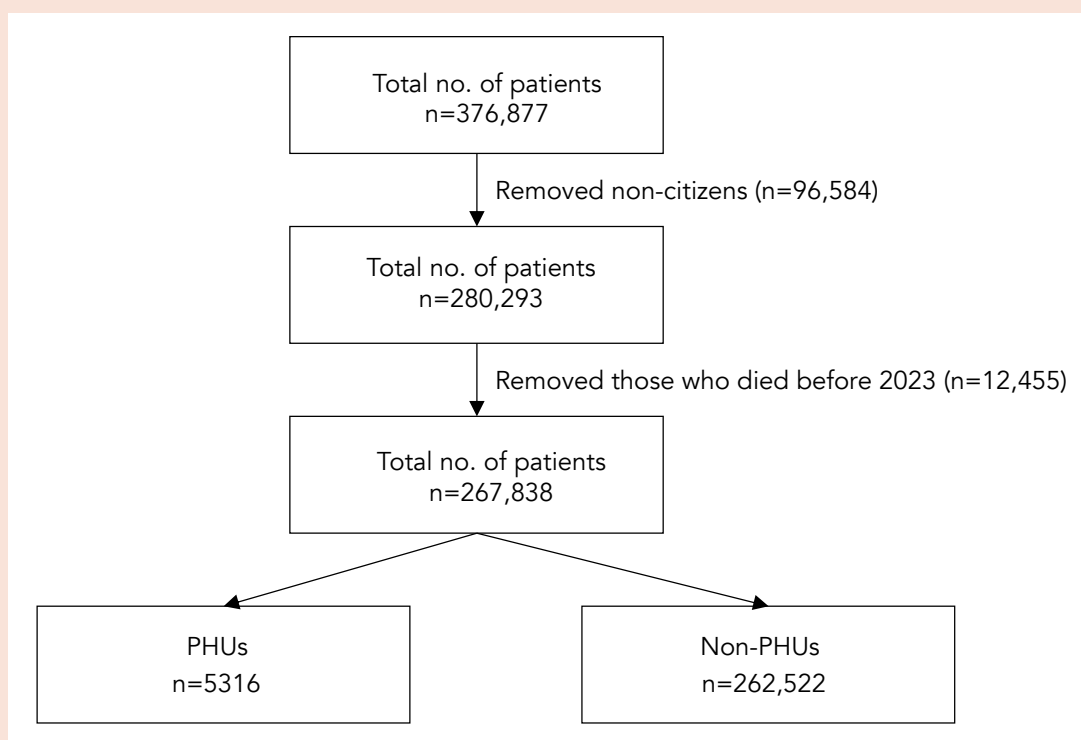
From 1 January 2020 to 31 December 2022, 376,877 patients visited CGH. After excluding non-Singapore citizens (25.6%) and those who passed away before 1 January 2023 (3.3%), 267,838 patients remained in the study cohort. Of these, 5316 were identified as PHUs (1.98%) and 262,522 as non-PHUs (98.0%) (Fig. 2). Fig. 3 illustrates expenditure differences over 3 years for PHUs and non-PHUs, and their distribution across service types. Across the 3 years, despite

comprising only 1.98% of the study cohort, PHUs incurred disproportionately higher total healthcare expenditure at SGD298.8 million (18.4% of CGH's total expenditure), compared to the 99.1% of non-PHUs at SGD1329.5 million. The mean total expenditure for PHUs was SGD56,200 per patient, 11 times that of non-PHUs, at SGD5064.

Patient population characteristics

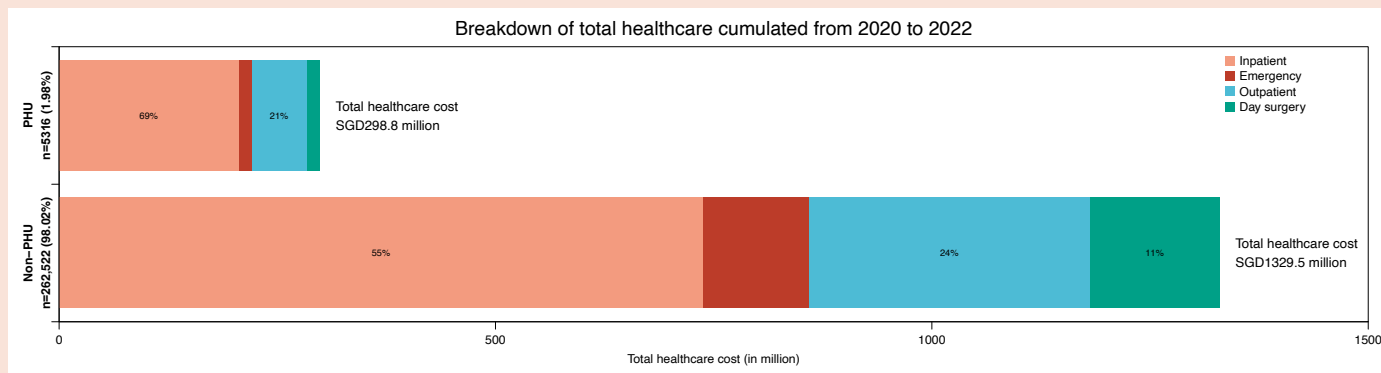
Table 1 compares the demographic profiles of PHUs and non-PHUs. The mean age of PHUs was statistically higher than non-PHUs at 66.3 (SD=14.6) and 48.9

Fig. 2. Flowchart of patients included in the study cohort.



PHUs: persistent high utilisers

Fig. 3. Breakdown of total bill cumulated from 2020 to 2022 for services utilised by PHUs versus non-PHUs.



PHUs: persistent high utilisers

(SD=19.7), respectively ($P<0.001$). The proportion of males was higher in PHUs (58%) compared to non-PHUs (56%). The ethnic distribution of patients was different between PHUs and non-PHUs ($P<0.001$) with more non-Chinese (Indian, Malay and other ethnic groups) in the PHU group (39%) as compared to the non-PHU group (33%). The distribution of housing types was statistically different ($P<0.01$); PHUs (34%)

lived in 1- to 3-room flats (a proxy for lower socioeconomic status [SES]), which was statistically higher compared to non-PHUs (23%).

Table 2 summarises differences in healthcare service utilisation between PHUs and non-PHUs. Among the cohort, 27% had inpatient admissions (89% of PHUs and 26% non-PHUs). PHUs had 3.5 times more admissions and a mean inpatient expenditure of 4.6 times

Table 1. Demographic comparison of PHUs and non-PHUs.

Categories	Overall (n=267,838)	PHUs (n=5316)	Non-PHUs (n=262,522)	P value ^a
Age in 2020, no. (%)				
Mean (SD)	49.3 (19.7)	66.3 (14.6)	48.9 (19.7)	<0.001
40 and below	95,284 (36)	297 (6)	94,987 (36)	<0.001
41–50	35,916 (13)	370 (7)	35,546 (14)	
51–60	48,163 (18)	1001 (19)	47,162 (18)	
61–70	48,521 (18)	1419 (27)	47,102 (18)	
71–80	26,560 (10)	1354 (25)	25,206 (10)	
Above 80	13,394 (5)	875 (16)	12,519 (5)	
Sex, no. (%)				
Female	118,509 (44)	2256 (42)	116,253 (44)	0.008
Male	149,329 (56)	3060 (58)	146,269 (56)	
Ethnicity, no. (%)				
Chinese	177,427 (66)	3232 (61)	174,195 (66)	<0.001
Indian	21,795 (8)	482 (9)	21,313 (8)	
Malay	48,533 (18)	1055 (20)	47,478 (18)	
Others	20,083 (7)	547 (10)	19,536 (7)	
Resident status, no. (%)				
Citizens	18,276 (7)	111 (2)	18,165 (7)	<0.001
Permanent residents	249,562 (93)	5205 (98)	244,357 (93)	
Housing type, no. (%)				
1–2 rooms	15,081 (6)	581 (11)	14,500 (6)	<0.001
3 rooms	45,799 (17)	1244 (23)	44,555 (17)	
4 rooms	79,342 (30)	1536 (29)	77,806 (30)	
5 rooms or executive	63,502 (24)	1100 (21)	62,402 (24)	
Private	53,720 (20)	691 (13)	53,029 (20)	
Missing	10,394 (3.9)	164 (3.1)	10,230 (3.9)	

PHUs: persistent high utilisers; SD: standard deviation

^aP value estimated from Chi-square test.

higher than non-PHUs. The proportion of urgent admissions was similar between groups despite statistical significance. Still, PHUs had an average length of stay 4.0 times longer than non-PHUs, with higher usage across all ward types. Regarding ED utilisation, 60% of the study cohort visited the ED (90% of PHUs and 59% of non-PHUs). PHUs had 4.0 times higher mean ED expenditures and 3.76 times more visits than non-PHUs. Self-referred ED visits were higher among PHUs (73.9%) than non-PHUs (64.9%), but the difference was not statistically significant. For outpatient services, 80% of the cohort utilised them, including all PHUs and 80% of

non-PHUs. PHUs had 7.5 times higher mean outpatient expenditures and 6.2 times more visits than non-PHUs. The mean number of no-show visits was 3.1 times higher in PHUs than in non-PHUs. Last, 21% of the study cohort underwent day surgery (58% of PHUs and 21% of non-PHUs). PHUs had 1.8 times higher mean day surgery expenditure and 1.7 times more day surgery than non-PHUs.

Among those with inpatient admission, all diseases were significantly associated with being a PHU, except dyslipidaemia and myocardial infarction (MI) (Table 3 [item A]). Specifically, mental health disorders (presence of either schizophrenia, major depressive

Table 2. Service utilisation and bill size comparison of PHU and non-PHUs.

	Overall (n=267,838)	PHUs (n=5316)	Non-PHUs (n=262,522)	P value
Total gross bill from 2020 to 2022				
Mean (SD)	6140 (15,800)	56,200 (54,500)	5120 (11900)	<0.001
Median [Q1, Q3]	1430 [440, 5250]	41,100 [25,900, 68,200]	1360 [430, 4820]	
Inpatient admissions, no. (%)	71,931 (27)	4737 (89)	67,194 (26 %)	<0.001
Total inpatient gross bill from 2020 to 2022				
Mean (SD)	14,300 (24,900)	43,800 (54,800)	12,000 (19,200)	<0.001
Median [Q1, Q3]	6720 [2850, 16,400]	29,600 [13,700, 56,100]	6100 [2710, 14,600]	
Total no. of inpatient admissions from 2020 to 2022				
Mean (SD)	1.78 (2.02)	5.34 (5.12)	1.53 (1.25)	<0.001
Median [Q1, Q3]	1.00 [1.00, 2.00]	4.00 [2.00, 7.00]	1.00 [1.00, 2.00]	
Urgent admissions from 2020 to 2022				
Mean (SD) of total no.	1.40 (1.71)	4.28 (4.29)	1.19 (1.09)	<0.001
Mean (SD) of proportion	79.4 (37.4)	80.3 (29.8)	79.4 (37.9)	<0.001
Total no. of inpatient admissions with surgery encounter from 2020 to 2022				
Mean (SD)	0.491 (0.822)	1.36 (1.86)	0.429 (0.650)	<0.001
Total no. of inpatient LOS from 2020 to 2022				
Mean (SD)	10.3 (20.1)	34.3 (39.8)	8.49 (16.4)	<0.001
Median [Q1, Q3]	4.00 [2.00, 10.0]	21.0 [9.00, 45.0]	4.00 [2.00, 8.00]	
Patients who stayed in A ward ¹ , no. (%)	495 (0)	67 (1)	428 (0)	<0.001
Total no. of inpatient LOS in class A from 2020 to 2022				
Mean (SD)	2.74 (3.20)	4.18 (4.94)	2.51 (2.77)	0.0121
Median [Q1, Q3]	1.00 [1.00, 3.00]	2.00 [1.00, 4.50]	1.00 [1.00, 3.00]	
Patients who stayed in B ward ² , no. (%)	7348 (3)	945 (18)	6403 (2 %)	<0.001

Table 2. Service utilisation and bill size comparison of PHU and non-PHUs. (Cont'd)

	Overall (n=267,838)	PHUs (n=5316)	Non-PHUs (n=262,522)	P value
Total no. of inpatient LOS in class B from 2020 to 2022				
Mean (SD)	3.60 (6.87)	7.00 (12.6)	3.09 (5.37)	<0.001
Median [Q1, Q3]	1.00 [1.00, 3.00]	3.00 [1.00, 7.00]	1.00 [1.00, 3.00]	
Patients who stayed in C ward ³ , no. (%)	57,752 (22)	4430 (83)	53,322 (20)	<0.001
Total no. of inpatient LOS in class C from 2020 to 2022				
Mean (SD)	10.6 (20.1)	32.5 (38.0)	8.77 (16.5)	<0.001
Median [Q1, Q3]	4.00 [2.00, 10.0]	20.0 [8.00, 43.0]	4.00 [2.00, 9.00]	
Patients who stayed in ICU ⁴ or HD ⁵ ward, no. (%)	3308 (1)	466 (9)	2842 (1)	<0.001
Total no. of inpatient LOS in ICU or HD from 2020 to 2022				
Mean (SD)	12.2 (19.1)	17.4 (25.0)	11.3 (17.8)	<0.001
Median [Q1, Q3]	6.00 [3.00, 12.0]	9.00 [5.00, 18.8]	5.00 [3.00, 11.0]	
ED visits, no. (%)	159,736 (60)	4782 (90)	154,954 (59)	<0.001
Total ED gross bill from 2020 to 2022				
Mean (SD)	855 (1320)	3170 (4590)	784 (990)	<0.001
Median [Q1, Q3]	533 [354, 922]	2180 [1140, 3830]	524 [350, 875]	
Total no. of ED visits from 2020 to 2022				
Mean (SD)	1.79 (2.83)	6.20 (12.3)	1.65 (1.74)	<0.001
Median [Q1, Q3]	1.00 [1.00, 2.00]	4.00 [2.00, 7.00]	1.00 [1.00, 2.00]	
Total no. of self-referred visits from 2020 to 2022				
Mean (SD)	1.22 (2.68)	4.82 (11.9)	1.11 (1.62)	<0.001
Median [Q1, Q3]	1.00 [0, 1.00]	3.00 [1.00, 6.00]	1.00 [0, 1.00]	
Percentage of self-referred visits from 2020 to 2022				
Mean (SD)	65.2 (44.3)	73.9 (31.4)	64.9 (44.6)	0.689
Outpatient visits, no. (%)	214,142 (80)	5295 (100)	208,847 (80)	<0.001
Total outpatient gross bill from 2020 to 2022				
Mean (SD)	1840 (3050)	11,900 (8850)	1580 (2200)	<0.001
Median [Q1, Q3]	801 [261, 2100]	10,800 [6040, 15,400]	761 [253, 1940]	
Total outpatient from 2020 to 2022				
Mean (SD)	10.9 (16.1)	60.3 (42.9)	9.65 (12.4)	<0.001
Median [Q1, Q3]	5.00 [2.00, 13.0]	51.0 [32.0, 77.0]	5.00 [2.00, 12.0]	
Specialist outpatient clinics, no. (%)	214,142 (80)	5295 (100)	208,847 (80)	<0.001

Table 2. Service utilisation and bill size comparison of PHU and non-PHUs. (Cont'd)

	Overall (n=267,838)	PHUs (n=5316)	Non-PHUs (n=262,522)	P value
Actualised visits				
Mean (SD) of total no.	8.40 (11.5)	40.1 (32.2)	7.57 (9.07)	<0.001
Mean (SD) of percentage	84.7 (19.7)	67.7 (16.6)	85.1 (19.6)	<0.001
Walk-in visits				
Mean (SD) of total no.	5.24 (7.67)	20.1 (17.7)	4.52 (5.94)	<0.001
Mean (SD) of percentage	36.3 (25.5)	33.4 (16.7)	36.4 (25.8)	0.0026
No-show visits (denominator: actualised + no show)				
Mean (SD) of total no.	2.95 (3.62)	8.37 (9.39)	2.73 (2.97)	<0.001
Day surgery, no. (%)	56,923 (21)	3062 (58)	53,861 (21)	<0.001
Total day surgery gross bill from 2020 to 2022				
Mean (SD)	3070 (3250)	5300 (4910)	2950 (3080)	<0.001
Median [Q1, Q3]	2130 [935, 3770]	3770 [1860, 7480]	2080 [915, 3690]	
No. of day surgery				
Mean (SD)	1.61 (1.11)	2.58 (1.96)	1.55 (1.01)	<0.001
Median [Q1, Q3]	1.00 [1.00, 2.00]	2.00 [1.00, 3.00]	1.00 [1.00, 2.00]	

HD: high dependency; ICU: intensive care unit; LOS: length of stay; SD: standard deviation; PHUs: persistent high utilities

^aA ward: most expensive option—private room with no government subsidy.

^bB ward: moderately priced—shared room (4–6 beds) with partial subsidy.

^cC ward: most affordable—basic shared room (8–10 beds) without air-conditioning and with the highest subsidy.

^dICU ward: specialised unit providing close monitoring and life support for critically ill patients, with the highest level of care and staffing.

^eHD ward: provides a higher level of care than general wards for patients who are stable but still require close monitoring and medical support.

disorder, anxiety disorder or bipolar disorder) showed the strongest association (odds ratio [OR]=3.48; 95% confidence interval [CI]=[2.97, 4.08]), followed by chronic obstructive pulmonary disease (COPD) (OR=2.69; 95% CI=[2.29, 3.17]) and osteoporosis (OR=2.64; 95% CI=[2.36, 2.94]). Table 3 (item B) shows that renal medicine or nephrology department (OR=14.1; 95% CI=[12.2, 16.2]) had the strongest association with being a PHU, followed by the psychological medicine (OR=11; 95% CI=[7.86, 15.3]), general medicine or geriatric medicine (OR=4.9; 95% CI=[4.55, 5.28]). Table 3 (item C) highlights that visits to allied health services had the highest odds of being a PHU (OR=23.2; 95% CI=[20, 27]). Across the 3 logistic regression models, older age, male sex, non-Chinese and lower socioeconomic status had significantly higher odds of being a PHU.

Table 4 details the mean bills for each service type and services within the service types by PHUs and non-PHUs, while Supplementary Fig. S2 details the proportion of services spent for each service type by groups. For inpatient admission, ward services and

investigations constitute the largest portion of bills, with PHUs spending 4.13 and 3.69 times more, respectively, compared to non-PHUs. In the ED, attendance fees and investigation dominated costs, with PHUs spending 4.77 and 3.75 times, respectively than non-PHUs. In outpatient care, PHUs primarily spent on medications, investigations and consultations, whereas non-PHUs spent most on investigations. PHU medication bills were 14.8 times higher than non-PHUs. For day surgery, facility fees accounted for the largest share, with PHUs spending 1.7 times more than non-PHUs. The heat map in Supplementary Fig. S3 shows the density of PHUs per 1000 residents in subzones with over 3000 residents. Bedok North (7.83), Tampines East (7.16) and Kembangan (7.12) had the highest PHU densities.

DISCUSSION

Key results

This study identified factors significantly associated with being a PHU, including older age, male sex,

Table 3. Distribution of (A) disease profile, (B) inpatient discharge specialties, (C) outpatient specialties by groups and adjusted OR from respective logistic regression models with 95% CI for diseases associated with being a PHU.

	Overall	PHUs	Non-PHUs	P value ^a	Adjusted OR ^b [95% CI] ^c
(A) Disease profile^{c, d}					
No. of patients	71,817	4735	67,082	-	-
No. of conditions					
Mean (SD)	1.44 (1.81)	3.17 (2.30)	1.32 (1.71)	<0.001	
Median [Q1, Q3]	1.00 [0, 3.00]	3.00 [1.00, 5.00]	0 [0, 3.00]		
Conditions, no. (%)					
Diabetes	18,868 (26)	2338 (49)	16,530 (25)	<0.001	1.47 [1.33–1.62] ^e
Hypertension	24,373 (34)	3005 (63)	21,368 (32)	<0.001	1.28 [1.17–1.41] ^e
Dyslipidaemia	19,076 (27)	2271 (48)	16,805 (25)	<0.001	0.939 [0.85–1.04]
Stroke	3544 (5)	381 (8)	3163 (5)	<0.001	1.1 [0.973–1.24]
Atrial fibrillation	3429 (5)	689 (15)	2740 (4)	<0.001	1.88 [1.7–2.09] ^e
Asthma	1223 (2)	193 (4)	1030 (2)	<0.001	2.41 [2.02–2.88] ^e
Chronic obstructive pulmonary disease	1165 (2)	238 (5)	927 (1)	<0.001	2.69 [2.29–3.17] ^e
Myocardial infarction	3596 (5)	530 (11)	3066 (5)	<0.001	0.986 [0.879–1.11]
Ischaemic heart disease	8744 (12)	1496 (32)	7248 (11)	<0.001	1.81 [1.67–1.97] ^e
Heart failure	2988 (4)	688 (15)	2300 (3)	<0.001	1.67 [1.5–1.86] ^e
Renal	8767 (12)	1730 (37)	7037 (10)	<0.001	2.4 [2.22–2.6] ^e
Osteoporosis	2996 (4)	547 (12)	2449 (4)	<0.001	2.64 [2.36–2.94] ^e
Dementia	2701 (4)	479 (10)	2222 (3)	<0.001	1.89 [1.67–2.13] ^e
Mental health disorders ^e	1334 (2)	259 (5)	1075 (2)	<0.001	3.48 [2.97–4.08] ^e
(B) Inpatient discharge specialty^c					
No. of patients	71,817	4735	67,082		
Patients who had admissions to, no. (%)					
Cardiovascular medicine/cardiology	10,079 (14)	1235 (26)	8844 (13)	<0.001	4.45 [4.08–4.84] ^e
Dermatology	141 (0)	19 (0)	122 (0)	0.00177	4.17 [2.31–7.53] ^e
Endocrinology	872 (1)	116 (2)	756 (1)	<0.001	3.25 [2.53–4.17] ^e
Otolaryngology	1717 (2)	138 (3)	1579 (2)	0.0168	3.59 [2.87–4.49] ^e

Table 3. Distribution of (A) disease profile, (B) inpatient discharge specialties by groups and adjusted OR from respective logistic regression models with 95% CI for diseases associated with being a PHU. (Cont'd)

	Overall	PHUs	Non-PHUs	P value ^a	Adjusted OR ^b [95% CI] ^c
Ophthalmology	436 (1)	47 (1)	389 (1)	<0.001	3.77 [2.57–5.52] ^g
Gastroenterology	4000 (6)	588 (12)	3412 (5)	<0.001	3.92 [3.49–4.41] ^g
General/geriatric medicine	28,349 (39)	3073 (65)	25,276 (38)	<0.001	4.9 [4.55–5.28] ^g
Infectious disease	2454 (3)	317 (7)	2137 (3)	<0.001	2.93 [2.5–3.43] ^g
Neurology	2325 (3)	205 (4)	2120 (3)	<0.001	2.81 [2.35–3.35] ^g
Neurosurgery	590 (1)	41 (1)	549 (1)	0.79	2.03 [1.4–2.95] ^g
Oral and maxillofacial surgery	141 (0)	4 (0)	137 (0)	0.103	2.62 [0.821–8.38]
Orthopaedic surgery	10,521 (15)	873 (18)	9648 (14)	<0.001	3.31 [3.01–3.63] ^g
Psychological medicine	345 (0)	67 (1)	278 (0)	<0.001	11 [7.86–15.3] ^g
Renal medicine/nephrology	1381 (2)	558 (12)	823 (1)	<0.001	14.1 [12.2–16.2] ^g
Respiratory medicine	3663 (5)	564 (12)	3099 (5)	<0.001	4.1 [3.64–4.63] ^g
Rehabilitation medicine	2706 (4)	379 (8)	2327 (3)	<0.001	3.07 [2.66–3.53] ^g
Sleep medicine surgery science	1586 (2)	127 (3)	1459 (2)	0.0248	3.24 [2.58–4.07] ^g
General surgery	12,924 (18)	1562 (33)	11,362 (17)	<0.001	4.61 [4.26–5] ^g
Urology	2349 (3)	258 (5)	2091 (3)	<0.001	3.58 [3.04–4.23] ^g
(C) Outpatient specialty^f					
No. of patients	226,895	5308	221,587	-	
Patients who ever visited, no. (%)					
Allied health services	18,138 (8)	1313 (25)	16,825 (8)	<0.001	23.2 [20–27] ^g
Medical discipline services	113,458 (50)	5119 (96)	108,339 (49)	<0.001	4.34 [4.07–4.62] ^g
Nursing related clinic services	2786 (1)	368 (7)	2418 (1)	<0.001	5.55 [4.92–6.26] ^g
Surgical discipline services	153,258 (68)	4999 (94)	148,259 (67)	<0.001	2.3 [2.14–2.47] ^g
Other services	74,236 (33)	3737 (70)	70,499 (32)	<0.001	1.82 [1.6–2.07] ^g

CI: confidence interval; OR: odds ratio; PHUs: persistent high utilisers; SD: standard deviation

^aP value estimated from Chi-square test.^bAdjusted OR from a logistic regression with adjustments for age, sex, ethnicity and housing type where all the reference groups presented are “No” or absence of the mentioned items.^cA total of 63,430 patients were considered for the analysis after excluding 2681 (4.1%) of patients with missing housing type data.^dLimited to patients who were admitted to inpatient at least once during the study period.^eMental health disorders represented patients diagnosed with either schizophrenia, major depression, anxiety or bipolar disorder.^fA total of 218,090 patients were considered for the analysis after excluding 8805 (3.8%) of patients with missing housing type data.^gRepresents statistical significance at 5% level.

Table 4. Mean bills breakdown by service types and different services (in SGD).

Service type	Services	PHU (SGD)	Non-PHU (SGD)	Ratio ^a
Inpatient	Emergency visit attendance fees	485.38	146.08	3.32
	Consumables	3378.37	932.97	3.62
	Dialysis	1208.07	54.19	22.29
	Facility fees	2922.6	1019.33	2.87
	Implants	1430.94	592.24	2.42
	Investigations	8817.26	2386.4	3.69
	Medications	3202.07	481.35	6.65
	Others	8.98	2.67	3.36
	Procedures	4485.15	1005.32	4.46
	Professional fees	2197.71	713.04	3.08
	Rehabilitation services	1113.54	280.52	3.97
	Ward services	15167.08	3673.49	4.13
Emergency department	Attendance fees	1599.76	426.98	3.75
	Investigations	1292.79	270.89	4.77
	Medications	52.56	17.71	2.97
	Others	5.35	1.77	3.02
	Procedures	55.18	18.49	2.98
	Professional fees	0.06	0.03	2
Outpatient	Consultation	1795.29	381.76	4.7
	Consumables	0.01	0.01	1
	Investigations	3904.91	696.86	5.6
	Medications	4973.36	335.7	14.81
	Miscellaneous	136.88	27.06	5.06
	Miscellaneous treatment	0.17	0.02	8.5
	Other procedures	0.11	0.65	0.17
	Others	223.01	11.91	18.72
	Procedures	642.14	65.53	9.8
	Rehabilitation services	349.98	49.34	7.09
	Services	19.73	1.04	18.97
Day surgery	Consultation	42.61	34.54	1.23
	Consumables	869.86	371.48	2.34
	Facility fees	2131.85	1256.36	1.7
	Implants	84.56	50.96	1.66
	Investigations	594.47	334.64	1.78
	Medications	108.56	52.74	2.06
	Others	136.75	78.71	1.74
	Procedures	124.55	59.09	2.11
	Professional fees	978.97	559.8	1.75

PHUs: persistent high utilisers; SGD: Singapore dollars

^aRepresents the ratio of the mean value from PHUs and the mean value from non-PHUs.

non-Chinese and lower SES. Despite only comprising 2% of the study cohort, they accounted for nearly 20% of the total healthcare expenditure. PHUs spent 4.6, 4.0, 7.5 and 1.8 times more on inpatient, ED, outpatient and day surgery services respectively, compared to non-PHUs. Mental health disorders had the strongest association with being a PHU, followed by COPD and osteoporosis. Renal medicine was the inpatient specialty most strongly associated with PHUs, while utilisation of allied health services in outpatient settings had the strongest association.

Interpretation

This study's analysis reflected the high prevalence of cardiovascular and other chronic medical conditions in PHUs, which was commonly observed across studies.^{5,10,11,18} While diseases such as diabetes, hypertension and dyslipidaemia are more prevalent in this study's population settings, the analysis saw specifically that mental health issues, COPD and osteoporosis had the highest odds of being a PHU, highlighting that prioritisation of the needs of these conditions to address high utilisation would be useful. While the prevalence of mental health disorders (5.0%) among PHUs was lower than other chronic medical conditions, its strong association (OR 3.48) was observed, in line with many studies in US Medicaid and total population studies.^{7,24}

Renal conditions were the most prevalent among the diseases with the highest odds of association with being a PHU. This was aligned with the findings of other studies given that patients often had worsening symptoms with progression of chronic kidney disease, with other possible complications such as acute kidney injury, heart failure, MI, stroke and anaemia requiring outpatient, ED visits and inpatient admissions.²⁵⁻²⁷ Utilisation of allied health services in outpatient settings was strongly associated with PHU status, which was unsurprising given that PHUs usually have functional impairments or psychosocial challenges, requiring intervention by allied health professionals. This study further underscored the importance of advancing integrated care between hospitals, community and primary care, e.g. via patient-centred care models^{12,30-33} in the management of patients with complex care. Integrated care models through community sited services can reduce reliance on hospital-based allied health intervention and address persistent high utilisation more effectively. Future studies could benefit from cross-jurisdictional comparisons to understand how differences in healthcare systems, social practices and cultural structures influence healthcare utilisation.

Similar to other studies, PHUs in this study were older, lived in smaller flat sizes and have a higher prevalence of chronic diseases as well as mental health

disorders. While the OR for being a PHU was higher in those above the age of 41, the OR was lower for those above 80 years compared to those aged between 41 and 80 years. While a previous study in the US²⁸ attributed similar findings to mortality effects, this explanation was not applicable to this study as patients who were deceased prior to 2023 were excluded. The mechanism underlying this observation warrants further investigation by future studies. The study's findings also align with a previous study in Singapore²⁹, which identified total length of stay in the last 12 months and days following the last non-elective admission as key predictors of frequent hospital use. This reinforces the value of historical inpatient utilisation in identifying high-needs patients. Last, useful insights on the distribution of PHUs across the catchment area of CGH were provided to aid regional health management. The identification of the subzones with a higher density of PHUs would facilitate the assessment and development of service needs in these areas with stakeholders in medical care as well as social services.

Strength

Defining PHU in this study presented methodological challenge due to substantial heterogeneity in existing literature on study population selection criteria, PHU definitions and healthcare expenditure metrics.³ To the authors' knowledge, only 1 other study from Singapore conducted analysis on PHUs in a 1000-bed academic medical centre,¹⁸ using the annual threshold of the top 10% of inpatient expenditure (SGD8150) to define a PHU (if they were HUs for 3 consecutive years). A novel threshold-setting approach, which considered the residents' total healthcare expenditure and those who had significant hospital service utilisations, was undertaken. In this study, the threshold for an HU in the hospital was established at SGD3700, taking reference from the healthcare expenditure of the resident population across all healthcare services in hospitals and the community. While the derived threshold was lower, this reflects a larger denominator with further lower-cost users. Additionally, policy shifts between the 2 periods (2005–2013 and 2020–2022) such as the expansion of Community Health Assist Scheme³⁰ in 2019, a Singapore government programme that provides subsidies for Singapore citizens at participating clinics, may have expanded subsidies and shifted care towards the community, reducing hospital-centric expenditures and lowering top-decile thresholds in this analysis. Further, this study considered all healthcare services within CGH apart from just inpatient admission, although inpatient admissions were the main contributor to the healthcare expenditures. This approach revealed that high outpatient service

utilisation contributed substantially to total expenditure, with some patients classified as PHU based on outpatient service utilisation alone. This approach, which expanded the study population beyond a focus on specific chronic conditions,¹⁹ captured patient groups who might otherwise slip through the gaps in care, particularly those with high healthcare needs that do not fit neatly into specific disease categories. Last, the analysis of visit-level and billing-item-level data provided granular insights into utilisation patterns that may not be discernible in national-level datasets.

This study identified key factors associated with PHUs. These factors can inform clinical interventions and system-level strategies to address PHUs. Once these interventions and strategies are identified, relevant resources can be scoped and set aside so that the interventions and strategies can be implemented efficiently to address PHUs. These resources may include (1) manpower and information technology (IT) infrastructure needed for the development of predictive tools for early identification of at-risk PHU patients using predictive tools; (2) manpower, workflow and IT integration to enhance coordination between hospital, community and primary care, particularly in managing mental health, renal care and rehabilitation, so that the fragmentation of care can be reduced and unnecessary utilisation can be prevented. Additionally, the geospatial insights on PHU concentration across subzones offer a basis for prioritising service development and outreach efforts within the catchment area in Singapore. Admittedly, the findings may not be generalisable to other countries due to underlying differences in healthcare practices and policies. Nevertheless, the reported methodology offers a systematic framework for studying PHUs, and this framework can be readily employed by other researchers in other countries who also aim to develop clinical interventions and system-level strategies that address PHUs.

Limitations

This study is not without its limitations. First, the analysis was restricted to PHUs who utilised CGH's services, excluding those residing in CGH's catchment area but sought care elsewhere. Second, while many CGH patients were discharged to community hospitals for continued care, expenditure data from these facilities were unavailable for a comprehensive analysis. Third, healthcare utilisation patterns would usually fluctuate with patient, policy and environmental factors, which should be considered when the results from the analysis is generalised. Also, the cross-sectional design of this study using calendar year cut-offs may have resulted in patients who were ill and consumed a series of sequential services spanning the

year-end to fall below the HU threshold, compared to a patient with similar care journey beginning earlier in the year.

Additionally, the derivation of the annual expenditure threshold did not account for expenditures incurred in private services due to data limitations. This could partly explain the association of low SES with PHU as higher SES residents may tend to seek care in private institutions. The macro-costing approach used, although suitable for estimating overall healthcare utilisation, unfortunately does not allow attribution of expenditure to specific conditions. As such, observed associations with individual chronic diseases, may reflect the cumulative cost burden of multimorbidity rather than isolated disease effects. The study period was also affected by the COVID-19 pandemic, which may have influenced healthcare utilisation patterns. However, the recency of the data for this study context (requiring 3 years of data) ensures relevance despite this limitation. Additionally, findings from these patients identified during the pandemic are likely to offer more valuable and relevant insights, as they are more likely to be clinically complex (given that many avoided healthcare services during the pandemic).

CONCLUSION

This study highlighted PHUs as a small but distinct patient group with disproportionately high healthcare utilisation across all service types. Their profile (i.e. older age, male sex, lower socioeconomic status, chronic disease burden and strong associations with mental health disorders, renal conditions and allied health services used) highlighted the complexity of their needs. These findings can inform clinical interventions and system-level strategies to address PHUs. Early identification of at-risk patients using predictive tools can support timely care planning. Enhanced coordination between hospital, community and primary care, particularly in managing mental health, renal care and rehabilitation, may reduce the fragmentation of care and prevent unnecessary utilisation.

Supplementary materials

Appendix S1. Population Health Staple Dataset (PHSD): The Singapore National Healthcare Expenditure Registry dataset.

Appendix S2. Threshold estimation.

Fig. S1. Breakdown of eligible residents from the study cohort in DS1.

Fig. S2. Bills breakdown by PHUs and non-PHUs for the different services for (A) inpatient admission, (B) emergency department, (C) outpatient and (D) day surgery.

Fig. S3. Heat map for the no. of resident PHUs per 1000 residential population in the respective subzones.

Table S1. Comparison of catchment area demographics with study population demographics.

Table S2. Determination of AET in DS1.

Table S3. ICD-10 codes for broad disease conditions.

Table S4. Fully adjusted logistic regression models with 95% CI for (A) diseases, (B) inpatient discharge specialty and (C) outpatient specialty.

Table S5. Subgroup analysis: PHUs versus non-PHUs by sex (female and male), age group (above 60 and 60 and below) and ethnicity (Chinese, Malay, Indian and Others).

Ethics statement

This study was approved by the SingHealth Centralised Institutional Review Board (2023/2314) and deemed it not to require ethical deliberation, as this is a service evaluation project using deidentified data.

Declaration

The authors declare there are no affiliations with or involvement in any organisation or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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