

Identifying adults with serious illness in Singapore's surgical population and its impact on postoperative healthcare utilisation and costs

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ABSTRACT

Introduction: Serious illness (SI) refers to life-limiting conditions that adversely affect quality of life. It is increasingly prevalent among ageing populations and has potential downstream repercussions for healthcare systems. Up to 40% of adults with SI undergo surgery, yet the burden of SI among adults undergoing surgery in Singapore remains poorly understood. In this study, the authors adapted a consensus-based definition of SI for the Singapore context and examined its association with postoperative healthcare utilisation and costs.

Methods: The authors used data from the registry of Singapore's largest healthcare cluster and included adults who underwent inpatient surgery between April 2019 and March 2023. First, they identified SI by mapping its consensus definition to locally adopted International Classification of Diseases, 10th Revision codes. Subsequently, they built multivariable regression models to test associations between SI and postoperative health-care utilisation and gross inpatient bill size.

Results: Among 228,687 adults who underwent inpatient surgery, 41,011 (17.9%) met the adapted SI definition. Compared with adults without SI, adults with SI had a longer length of stay (incidence rate ratio 1.81; 95% confidence interval [CI] 1.80–1.83), higher odds of 30-day hospital readmission (odds ratio [OR] 1.58; 95% CI 1.52–1.64), 1-year hospital readmission (OR 2.60; 95% CI 2.53–2.67), 30-day emergency department (ED) visits (OR 1.57; 95% CI 1.51–1.64), 1-year ED visits (OR 2.08; 95% CI 2.03–2.14), and higher relative bill size (relative ratio 1.64; 95% CI 1.62–1.67).

Conclusion: SI was associated with greater postoperative healthcare utilisation and higher gross inpatient bill size. The findings highlight the burden of SI in Singapore and the need for targeted interventions in this vulnerable population to decrease downstream adverse effects on Singapore's healthcare system.

Keywords: costs, healthcare utilisation, serious illness, Singapore, surgery

CLINICAL IMPACT

What is New

- In a large cohort study, the prevalence of serious illness (SI) was 17.9% among adults undergoing inpatient surgery.
- SI was independently associated with higher healthcare utilisation and costs following surgery.

Clinical Implications

- Routinely collected electronic health record data can identify seriously ill adults with high healthcare needs.
- Findings highlight the burden of SI on the healthcare system and the need for targeted perioperative supportive care interventions for this vulnerable cohort.

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INTRODUCTION

In developed and ageing populations globally, healthcare utilisation and expenditure are concentrated among a small proportion of individuals with complex healthcare needs.¹ These “super-utilisers” comprise only approximately 5% of the population but account for a disproportionate share of healthcare utilisation and an estimated 40–60% of total healthcare spending.^{2,3} Many of these individuals live with serious illness (SI), characterised by high mortality risk, substantial symptom burden, impaired quality of life and function, and significant caregiver strain.⁴ Adults with SI commonly include those with advanced cancer, dementia, end-stage renal, or heart or pulmonary disease, and other life-limiting conditions.^{5,6} As populations age globally, the rising burden of SI has emerged as a major driver of healthcare utilisation, hospital admissions, and healthcare expenditure across multiple healthcare systems.

In response to escalating healthcare costs, healthcare systems internationally have increasingly focused on the prospective identification of populations with SI to enable earlier delivery of supportive and palliative care interventions. In the US, where healthcare expenditure exceeded 18% of gross domestic product in 2024, substantial efforts have been made to operationalise SI definitions using administrative data to identify high-need, high-cost populations.⁷ Early identification of seriously ill adults enables the timely delivery of palliative care interventions, which have been shown to improve quality of life, support caregivers, and reduce healthcare utilisation and costs.⁸

Adults with SI account for an important proportion of the inpatient surgical population and may experience substantial postoperative healthcare burden.^{9,10} Among adults with SI, those with unmet palliative care needs were more likely to experience increased hospital days, emergency readmissions, and emergency department (ED) visits within 1 year after surgery.¹¹ Healthcare costs after surgery have also been shown to double among seriously ill adults with unmet palliative care needs. These findings underscore the importance of identifying supportive-care needs and prospectively evaluating targeted interventions in surgical populations.

Singapore faces similar pressures from an ageing population, rising multimorbidity, and increasing healthcare expenditure.¹² In 2025, recognising the growing burden of adults with complex healthcare needs, the Ministry of Health (MOH), Singapore established the Appropriate and Value-Based Care initiative aimed at improving healthcare value and optimising healthcare spending.¹³ However, despite increasing policy emphasis on value-based care, there remains no operationalised or validated definition of SI in Singapore. This limits the ability to systematically

identify high-need, high-cost populations; implement targeted health services interventions; and measure quality outcomes across healthcare systems.¹⁴

This study therefore applied an adapted International Classification of Diseases, 10th Revision (ICD-10) diagnosis code-based definition of SI within Singapore’s healthcare context and examined its association with short- and long-term healthcare utilisation and costs following inpatient surgery in Singapore’s largest healthcare cluster. By relying primarily on routinely recorded ICD-10 diagnostic codes, this approach is readily reproducible and potentially automatable within electronic health record systems in Singapore. By anchoring the analyses to a surgical admission, the authors sought to characterise the perioperative burden of SI and its relationship with subsequent healthcare utilisation and expenditure. This work provides a foundation for validation in Singapore and future prospective identification of surgical patients who may benefit from targeted supportive and palliative care interventions, while informing broader efforts to operationalise SI identification across Singapore’s healthcare system.

METHODS

Study design and data source

The authors conducted a retrospective cohort study using the SingHealth Electronic Health Intelligence System (eHints), a population-based database comprising routinely collected healthcare data of Singapore’s largest public healthcare cluster and covering approximately 35% of the national population.¹⁵ The eHints registry houses demographics, disease, treatment, and out-come information. This study was reported in accordance with the Strengthening the Reporting of Cohort, Cross-sectional and Case-control Studies in Surgery guidelines and the REporting of studies Conducted using Observational Routinely-collected health Data extension of the Strengthening the Reporting of Observational Studies in Epidemiology statement.^{16,38}

Study population

The authors included adults aged 21 years and older who underwent inpatient surgery and were discharged between April 2019 and March 2023. Surgical procedures and procedure types were identified using the Table of Surgical Procedures (TOSP) codes designated by MOH, Singapore.¹⁷ For patients with more than 1 qualifying surgical admission during the study period, a single index admission was retained to avoid double-counting and ensure independence of observations. The admission associated with the highest TOSP code was selected as the index admission, with TOSP codes used as a pragmatic proxy for procedural complexity to identify the highest-

complexity perioperative episode during the study period. Where multiple admissions had the same highest TOSP code, the earliest admission was selected based on admission date and case number. Day-surgery and other non-inpatient cases were excluded. A sensitivity analysis was conducted using the first eligible surgical admission for each patient as the index admission.

Operationalising the SI definition in Singapore

The authors operationalised an ICD-10 diagnosis-only definition of SI derived from the US consensus-based definition of SI in surgery; this definition has been validated in several population-based studies.^{18,19} Adults with any of the following diagnoses were considered to have SI: (1) advanced cancer (i.e. stage III or IV solid organ cancers), (2) advanced pulmonary disease, (3) heart failure, (4) cirrhosis, (5) end-stage renal disease on dialysis or eligible for dialysis, and (6) dementia.^{5,6,20} ICD-10 codes used to identify these conditions in US Medicare claims were individually mapped to corresponding ICD-10 diagnostic codes used in Singapore. The mapping was reviewed and refined by the SingHealth study team against local ICD-10 descriptors to account for differences in coding terminology and classification. As an adaptation for use with routinely collected diagnostic data, the operational definition did not incorporate non-diagnostic criteria included in the original definition, such as healthcare utilisation or care-need triggers, frailty, nursing-home residence, or functional impairment, as these variables were not consistently available within the study dataset. The resulting ICD-10-based definition has not been validated against medical record review or a clinically adjudicated reference standard and should therefore be interpreted as an adapted operational definition of SI in Singapore's healthcare context. The mapped SI definitions and corresponding ICD-10 codes are provided in Supplementary Tables S1 and S2.

Outcomes: Healthcare utilisation and gross inpatient bill size

Healthcare utilisation outcomes were measured using the length of stay (LOS) for the index surgical admission, 30-day and 1-year hospital readmissions, and 30-day and 1-year ED visits following discharge from the index surgical admission. The financial outcome was the pre-subsidy gross inpatient bill size for the index surgical admission, derived from hospital billing records. It represents a hospital billing amount rather than an economic cost of care, payer expenditure, or patient out-of-pocket payment.²¹ Gross inpatient bill sizes were adjusted for inflation (2020 Singapore Dollars [SGD]) based on the consumer price index.²²

Study covariates

Patient characteristics, such as age, sex, and ethnicity, were included. Data on the qualifying SI condition, number of qualifying SI conditions, surgical procedure type, surgery nature (minor versus major), admission type, and financial year were also collected. Surgical procedure type was classified using MOH-defined TOSP codes, which organise surgical procedures into body system-based categories.¹⁷ Additionally, surgery nature was classified as minor or major using the same TOSP coding system, which ranks surgical procedures from Table 1A to 7C, with higher numbers indicating greater procedural complexity.^{17,23} Procedures coded as Table 4 and above were defined as major surgery, while those below Table 4 were considered minor surgery.²³

Statistical analysis

The annual prevalence of SI among patients undergoing inpatient surgery was summarised descriptively. Patient characteristics were compared between adults with and without SI using standardised mean differences, given the sensitivity of conventional significance testing to small differences in large samples. Univariable and multivariable regression analyses were performed to evaluate the association between SI and postoperative healthcare utilisation and index-admission gross inpatient bill amounts. Negative binomial regression was used to model LOS to account for overdispersion in count data. Gamma regression with a log link was used for gross inpatient bill sizes because of their positive, right-skewed distribution, while logistic regression was used for binary outcomes, including hospital readmissions and ED visits.

Multivariable models were adjusted for age, sex, ethnicity, surgical procedure type, surgery nature, admission type, and financial year. Individual SI conditions and the number of qualifying SI conditions were not included in the primary models because they formed part of the operational definition of the primary exposure (SI status). For all multivariable models, 95% confidence intervals (CIs) were calculated using heteroskedasticity-consistent type 1. Adjusted marginal mean gross inpatient bill sizes were estimated from the multivariable models by averaging predicted values across the observed covariate distribution. Effect modification by surgery nature (major vs minor surgery) was evaluated by including an interaction term between SI status and surgery nature. Finally, as a sensitivity analysis, primary analyses were repeated using the first eligible surgical admission as the index admission, rather than the admission with the highest TOSP code. All statistical analyses were performed using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Study participants

A total of 813,211 surgical cases were identified during the study period. After excluding patients aged <21 years and non-inpatient surgical cases, 315,171 inpatient surgical cases were identified. For patients with multiple surgical admissions during the study period, a single index admission corresponding to the highest TOSP-coded surgery was retained, resulting in a final study cohort of 228,687 unique patients. Fig. 1 depicts the study cohort flow.

In total, 41,011 (17.9%) met the operational definition of SI. Among patients with SI, advanced cancer was the most common qualifying condition (n=26,451; 64.5%), followed by end-stage renal disease (n=6669; 16.3%), heart failure (n=4856; 11.8%), dementia (n=2723; 6.6%), advanced pulmonary disease (n=2051; 5.0%), and cirrhosis (n=921; 2.2%). Most patients with SI had a single qualifying condition (n=38,480; 93.8%), while 2403 (5.9%) had 2 and 128

(0.3%) had 3 or more qualifying conditions. Study cohort characteristics are presented in Table 1.

Trend in the prevalence of SI among surgical patients

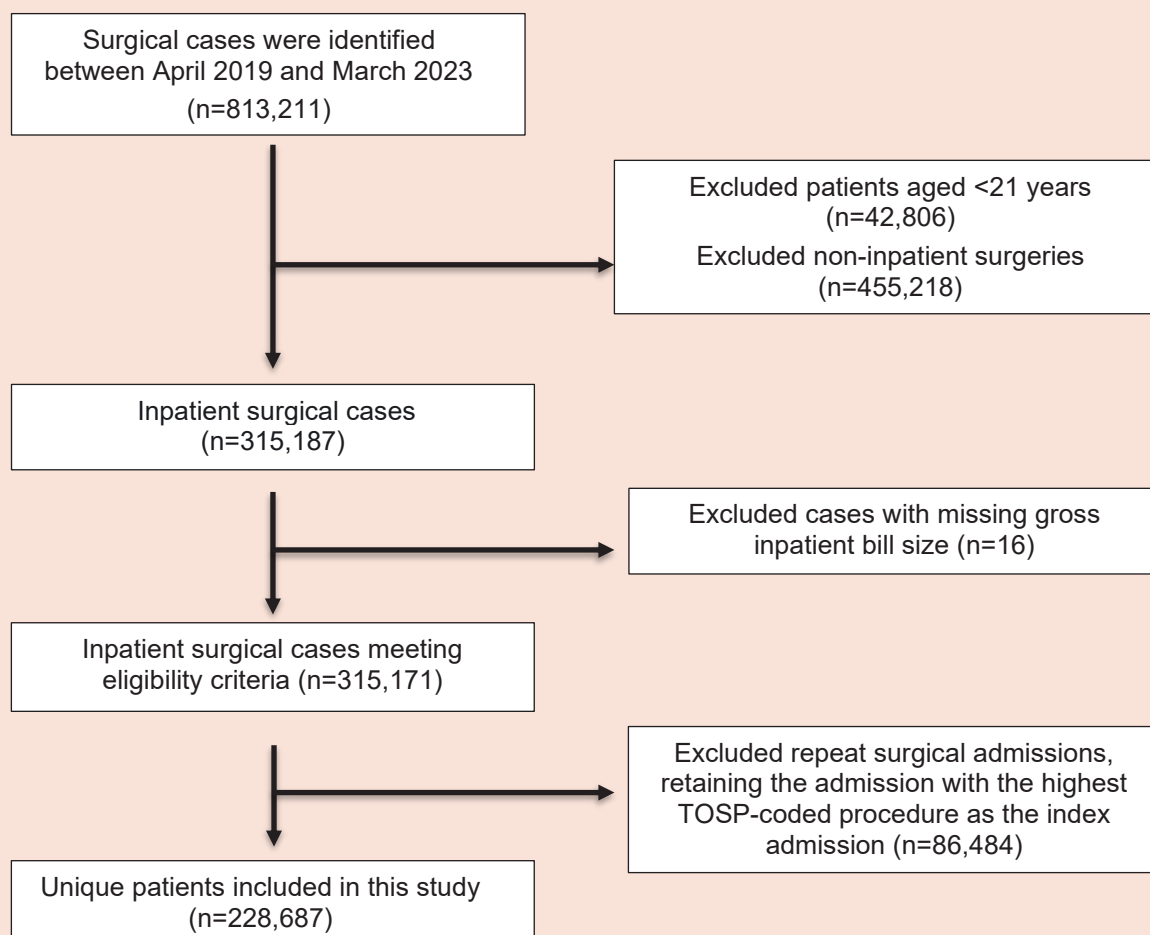
The proportion of adults undergoing inpatient surgery who met criteria for SI remained relatively stable across the 4-year study period, ranging from 17.1% to 18.3%. The annual prevalence was 17.6% in April 2019–March 2020, 17.1% in April 2020–March 2021, 18.3% in April 2021–March 2022, and 18.1% in April 2022–March 2023.

Healthcare utilisation

Table 2 presents the adjusted associations between SI and postoperative healthcare utilisation, including hospital LOS, hospital readmissions, and ED visits. Unadjusted analyses are presented in Supplementary Table S3.

The mean hospital LOS for the overall cohort was 6.3 days (standard deviation [SD] 12.0). Mean LOS was 11.8 days (SD 17.6) among adults with SI and 5.1

Fig. 1. Flow diagram for study cohort.



TOSP: Table of Surgical Procedures

Table 1. Baseline characteristics of adults with and without SI undergoing surgery (April 2019–March 2023, n=228,687).

Patient characteristics	Adults without SI (n=187,676)	Adults with SI (n=41,011)	Absolute SMD
Age in years, mean (SD)	52.1 (17.9)	66.2 (13.5)	0.89
Female sex, no. (%)	115,723 (61.7)	18,831 (45.9)	0.32
Qualifying serious illness,^a no. (%)			-
Advanced cancer	-	26,451 (64.5)	
End-stage renal disease	-	6669 (16.3)	
Heart failure	-	4856 (11.8)	
Dementia	-	2723 (6.6)	
Advanced pulmonary disease	-	2051 (5.0)	
Cirrhosis	-	921 (2.2)	
No. of qualifying conditions, mean (SD)	-	1.065 (0.259)	
One condition, no. (%)	-	38,480 (93.8)	
Two conditions, no. (%)	-	2403 (5.9)	
At least 3 conditions, no. (%)	-	128 (0.3)	
Surgical procedure type, no. (%)			
Breast and soft tissue	14,418 (7.7)	3663 (8.9)	0.045
Cardiothoracic and vascular	23,860 (12.7)	9218 (22.5)	0.259
Central nervous system ^b	3165 (1.7)	778 (1.9)	0.016
Ear, nose, and throat	5536 (2.9)	686 (1.7)	0.085
Endocrine ^c	1495 (0.8)	882 (2.2)	0.113
Eye	1004 (0.5)	134 (0.3)	0.032
Gastrointestinal	32,911 (17.5)	12,527 (30.5)	0.308
Genito-urinary ^d	6280 (3.3)	3363 (8.2)	0.209
Gynaecological	63,264 (33.7)	2949 (7.2)	0.696
Musculoskeletal	32,757 (17.5)	2815 (6.9)	0.328
Respiratory	2108 (1.1)	3478 (8.5)	0.349
Others ^e	878 (0.5)	518 (1.3)	0.086
Surgery nature, no. (%)			
Major	92,864 (49.5)	25,026 (61.0)	0.234
Minor	94,812 (50.5)	15,985 (39.0)	0.234
Length of stay, days, mean (SD)	5.11 (9.93)	11.77 (17.56)	0.467
Length of stay, days, median (IQR)	3 (2–5)	6 (3–14)	-
30-day hospital readmission, any, no. (%)	13,491 (7.2)	3902 (9.5)	0.084
1-year hospital readmission, any, no. (%)	35,578 (19.0)	17,351 (42.3)	0.524
30-day ED visit, any, no. (%)	16,442 (8.8)	5981 (14.6)	0.182
1-year ED visit, any, no. (%)	43,091 (23.0)	19,264 (47.0)	0.520

ED: emergency department; IQR: interquartile range; SD: standard deviation; SI: serious illness; SMD: standard mean difference

^a Does not sum up to 100% as a patient can have >1 serious illness condition

^b Neurosurgery, spine

^c Thyroid, adrenal

^d This excludes female genital; female genital is under gynaecological procedure

^e Lymphatics, spleen

Table 2. SI and healthcare utilisation and cost outcomes among adults undergoing surgery.

SI status	Length of stay (IRR, ^a 95% CI)	30-day hospital readmission, any (OR, ^a 95% CI)	1-year hospital readmission, any (OR, ^a 95% CI)	30-day ED visits, any (OR, ^a 95% CI)	1-year ED visits, any (OR, ^a 95% CI)	Gross inpatient bill size (relative ratio, ^a 95% CI)
SI vs non-SI	1.81 (1.79–1.83)	1.58 (1.52–1.64)	2.60 (2.53–2.67)	1.57 (1.51–1.64)	2.08 (2.03–2.138)	1.64 (1.61–1.67)

CI: confidence interval; ED: emergency department; IRR: incidence rate ratio; OR: odds ratio; SI: serious illness

^a Models are adjusted for age, sex, ethnicity, TOSP, surgery nature, admission type, and financial year.

days (SD 9.9) among adults without SI. SI was independently associated with longer LOS following inpatient surgery (adjusted incidence rate ratio [IRR] 1.81, 95% CI 1.80–1.83).

The 30-day hospital readmission rate was 9.5% among adults with SI and 7.2% among adults without SI, while the corresponding 1-year readmission rates were 42.3% and 19.0%, respectively. SI was independently associated with higher odds of hospital readmission at both 30 days (adjusted OR 1.58, 95% CI 1.52–1.64) and 1 year (adjusted OR 2.60, 95% CI 2.53–2.67) following inpatient surgery.

Similarly, 30-day ED visit rates were 14.6% and 8.8%, while 1-year ED visit rates were 47.0% and 23.0% among adults with and without SI, respectively. SI was also independently associated with higher odds of ED visits at 30 days (adjusted OR 1.57, 95% CI 1.51–1.64) and 1 year (adjusted OR 2.08, 95% CI 2.03–2.14).

Fig. 2 presents the associations between SI and healthcare utilisation outcomes, stratified by surgery nature. The association between SI and LOS differed by surgery nature, with a stronger association among adults undergoing minor surgery (adjusted IRR 2.00, 95% CI 1.97–2.03) than among those undergoing major surgery (adjusted IRR 1.70, 95% CI 1.68–1.72; *P* for interaction <0.001). In contrast, there was no evidence of effect modification by surgery nature for 1-year hospital readmission (adjusted OR 2.63 for major surgery vs 2.55 for minor surgery; *P* for interaction=0.193) or 1-year ED visits (adjusted OR 2.12 for major surgery vs 2.04 for minor surgery; *P* for interaction=0.109).

Gross inpatient bill size

The adjusted mean gross inpatient bill size was SGD25,648.08 (standard error [SE] 154.22; 95% CI 25,345.81–25,950.35) among adults with SI and SGD15,615.66 (SE 48.50; 95% CI 15,520.60–15,710.72) among those without SI. SI was independently associated with a 1.64-fold higher gross inpatient bill size following inpatient surgery (adjusted relative ratio 1.64, 95% CI 1.62–1.67).

When stratified by surgery nature, the adjusted marginal mean gross inpatient bill size following major surgery was SGD34,586.24 (SE 206.97) among adults with SI and SGD21,217.42 (SE 65.11) among adults without SI. Following minor surgery, the adjusted marginal mean gross inpatient bill sizes were SGD15,338.97 (SE 175.22) and SGD9630.46 (SE 50.82) among adults with and without SI, respectively. There was no evidence of effect modification by surgery nature, with similar associations between SI and gross inpatient bill size following major surgery (adjusted relative ratio 1.65, 95% CI 1.62–1.67) and minor surgery (adjusted relative ratio 1.64, 95% CI 1.59–1.69; *P* for interaction=0.682).

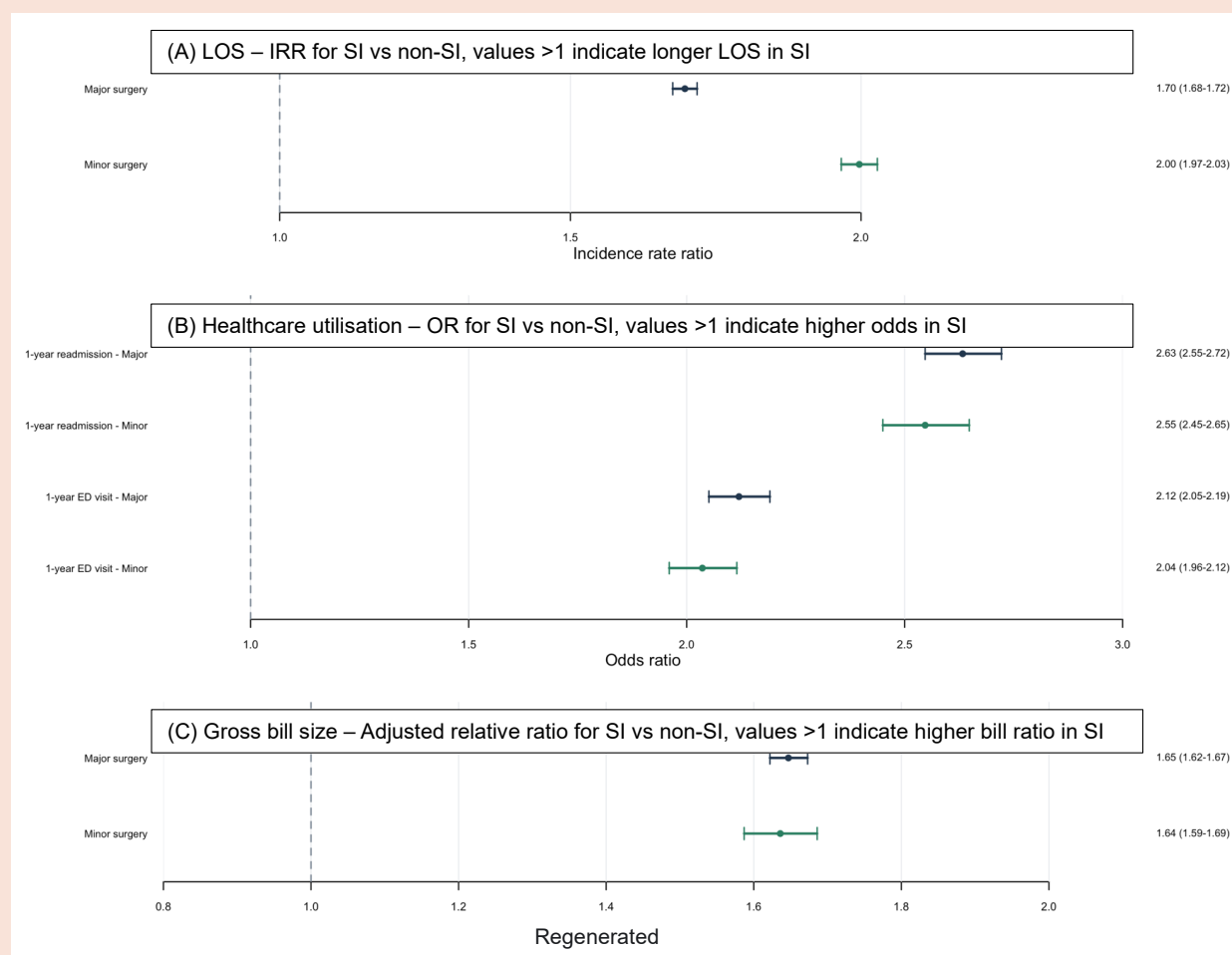
Sensitivity analysis using the first eligible surgical admission as the index admission yielded findings consistent with the primary analysis for all healthcare utilisation outcomes and gross inpatient bill sizes (Supplementary Table S4).

DISCUSSION

In this population-based study of adults undergoing inpatient surgery in Singapore, nearly 1 in 5 patients (17.9%) met the adapted ICD-10-based definition of SI, with advanced cancer being the qualifying condition in almost two-thirds of adults with SI. The proportion of surgical patients with SI remained relatively stable over the 4-year study period. Compared with adults without SI, those with SI experienced substantially greater postoperative healthcare utilisation, including longer hospital stays and higher rates of hospital readmissions and ED visits, with differences persisting up to 1 year after surgery. SI was also associated with substantially higher gross inpatient bill sizes. Collectively, these findings demonstrate the considerable and sustained healthcare burden associated with SI among adults undergoing inpatient surgery.

This study represents one of the first efforts to operationalise and evaluate an SI definition among adults undergoing surgery outside the US healthcare system. Although consensus-based SI definitions have been developed and evaluated in the US, their

Fig. 2. Differences in outcomes: (A) length of stay, (B) 1-year hospital readmission and 1-year emergency department visits, and (C) inpatient healthcare costs in adults with and without serious illness by surgery nature (minor vs major).



CI: confidence interval; ED: emergency department; IRR: incidence rate ratio; LOS: length of stay; OR: odds ratio; SI: serious illness
 Note: Points represent relative estimates for adults with SI versus adults without SI within each surgery nature group (minor vs major); horizontal lines represent 95% CIs

application in other healthcare systems remains limited despite the growing global burden of ageing, multimorbidity, and healthcare utilisation.²⁴⁻²⁶ The authors adapted a US-based definition of SI in surgery definition into an ICD-10-only approach using routinely collected diagnostic data available within Singapore's largest public healthcare cluster. The ability of this pragmatic definition to identify a sizeable surgical population with substantially greater subsequent healthcare needs supports its potential utility as a scalable approach for identifying SI within routinely collected health data.

This study highlights the substantial short- and longer-term healthcare utilisation associated with SI among adults undergoing surgery. Adults with SI were more likely to visit the ED or experience hospital readmission at 30 days and 1 year after surgery. This increased healthcare utilisation was accompanied by substantially higher inpatient costs, with adjusted

gross inpatient bill sizes approximately 64% higher among adults with SI. The findings align well with prior US-based studies, which demonstrated similar trends in healthcare utilisation.^{11,27-29} In a cohort of seriously ill older adults undergoing major elective surgery, those with unmet palliative care needs, such as pain, functional dependence, depression, or care-partner needs, had the highest risk of increased healthcare utilisation and costs at 1 year after surgery.¹¹

Notably, the relative increase in LOS associated with SI was greater among adults undergoing minor surgery than among those undergoing major surgery. One possible explanation is that the expected LOS following minor surgery is relatively short, such that additional perioperative complexity associated with SI may result in a proportionally larger increase in hospital stay.^{30,31} In contrast, major surgery is inherently associated with longer postoperative recovery and hospitalisation, which may attenuate the relative

difference in LOS attributable to SI.³² Despite this difference in LOS, the associations between SI and longer-term hospital readmissions and ED visits were similar following major and minor surgeries. This suggests that while procedural complexity may influence the immediate perioperative impact of SI, longer-term healthcare utilisation may be driven to a greater extent by patients' underlying SI and associated healthcare needs. Given the observational nature of this study and the absence of detailed perioperative clinical variables, these findings remain hypothesis-generating and warrant further investigation.

This study specifically focused on adults undergoing surgery because perioperative care represents a clinically intensive episode frequently associated with substantial healthcare utilisation, care transitions, and postoperative morbidity among patients with SI.³³⁻³⁵ Although surgery may not represent the primary treatment modality for all SI conditions included in this study, such as dementia or advanced cancer, these individuals nevertheless commonly undergo surgical interventions for diagnostic, therapeutic, symptom-directed, or emergency indications.^{36,37} Thus, restricting the cohort to inpatient surgical patients within a single public healthcare cluster allowed the authors to evaluate the perioperative burden of SI within a clinically important and resource-intensive healthcare context. However, the lack of data from other public healthcare clusters, private hospitals, and community settings limits generalisability to the national surgical population and to all adults with SI across the broader healthcare system.

This study has several limitations. First, although the authors adapted a previously established US-based consensus definition of SI in surgery,^{5,6,20} they were unable to fully replicate all original criteria because of differences in available registry variables between the US and Singapore healthcare systems. In particular, measures relating to frailty, nursing home residence, functional or cognitive impairment, and certain healthcare utilisation-based criteria were unavailable within the SingHealth eHints dataset. As a result, the adapted Singapore definition relied predominantly on ICD-10 diagnosis-based criteria and may have misclassified some adults with SI, particularly frail or functionally impaired individuals without qualifying diagnostic codes. Consequently, the estimated prevalence of SI and its observed associations with healthcare utilisation may differ from studies using more comprehensive multidimensional definitions. Future work should validate this operational definition against medical record review or a clinically adjudicated reference standard in the Singapore population.

Second, for individuals with multiple qualifying surgical admissions, the authors retained a single index

admission based on the highest TOSP code. Although this provided a pragmatic approach to identifying the highest-complexity surgical episode, it may have preferentially selected more resource-intensive admissions and may not necessarily represent the most clinically meaningful episode for individual patients. Nevertheless, sensitivity analyses using the first eligible surgical admission as the index admission demonstrated findings consistent with the primary analysis.

Third, several limitations relate to the scope of data captured within eHints. Death data were unavailable, so the authors were unable to assess postoperative mortality or perform competing-risk analyses. Mortality rates are likely higher among adults with SI, and differential mortality may have influenced longer-term estimates of readmissions and ED utilisation, as patients who died earlier had less opportunity to experience these outcomes. As the eHints registry captures healthcare utilisation within the SingHealth cluster, healthcare encounters occurring in other public healthcare clusters, private institutions, or community settings were not captured. Similarly, the gross inpatient bill size examined in this study represents the pre-subsidy bill for the index surgical admission rather than an economic cost or total healthcare-system expenditure. Costs associated with subsequent readmissions and ED visits were unavailable, and the financial estimates should therefore not be interpreted as the total downstream healthcare expenditure associated with SI.

Finally, the observational nature of this study precludes causal inference. While SI was associated with increased healthcare utilisation and inpatient costs, the findings do not establish that earlier identification or intervention would necessarily reduce downstream utilisation or expenditures. Further prospective interventional studies are required to evaluate whether targeted perioperative supportive care models can improve outcomes among seriously ill surgical populations.

CONCLUSION

An adapted ICD-10-based definition of SI identified a substantial population of adults undergoing inpatient surgery with high healthcare needs. SI was associated with greater short- and longer-term healthcare utilisation, including longer hospital stays, increased ED visits and hospital readmissions, and higher index-admission gross inpatient bill sizes. The findings support the potential utility of an ICD-10-based approach for the systematic identification of SI within surgical populations and provide a foundation for developing and prospectively evaluating targeted perioperative supportive care strategies to improve outcomes and address healthcare utilisation and costs.

Supplementary materials

Table S1. Adaptation of the definitions of serious illness in surgery in Singapore.

Table S2. International Classification of Diseases, 10th Edition codes used to define serious illness.

Table S3. Univariable analysis for serious illness and healthcare utilisation and cost outcomes among adults undergoing surgery.

Table S4. Sensitivity analysis of the association between serious illness and postoperative healthcare utilisation and gross inpatient bill size using the first eligible surgical admission as the index admission.

Ethics statement

This study was deemed “Not Human Subjects Research” by the SingHealth Centralised Institutional Review Board (ECOS reference number: 2024-4525).

Declaration

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