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Original Research

Risk factors and reasons for cancellation within 24 h of scheduled elective surgery in an academic medical centre: A cohort study

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ABSTRACT

Background: The Operating Theatre (OT) is the largest cost centre as well as the main revenue generator in most hospitals. One of the common problems affecting optimal OT utilization is the cancellation of scheduled surgeries. The goal of this study was to identify factors associated with cancellation within 24 h of scheduled surgeries in a tertiary hospital.

Methods: All elective surgeries performed on adults 18 years and above between June 2015 and December 2016 were included. Cancellations ≤24 h from the scheduled start time of the surgery were recorded, with their reasons for cancellation. Data relating to the patient, surgeon and planned surgery were obtained from the hospital operational database. Univariate analysis and multivariable analysis were conducted using logistic regression.

Results: A total of 4060 scheduled surgeries were included, of which 398 (9.8%) were cancelled within 24 h of surgery. On multivariate analysis, cancellation within 24 h of surgery was associated with history of heart failure (Adjusted odds ratio, AOR1.65; 95%CI 1.08–2.50), advanced chronic kidney disease (AOR2.33; 95%CI 1.58–3.39), or a history of hip fracture (AOR2.29; 95%CI 1.33–3.80), low socio-economic status (on Medifund financing, AOR3.16; 95%CI 1.37–6.72), history of ≥4 cancelled surgeries in the past 3 years (AOR2.38; 95%CI 1.30–4.19), and scheduled time in the afternoon (AOR1.83; 95%CI 1.44–2.32) and evening (AOR2.09; 95%CI0.73–5.13), compared to the morning. Attendance at preoperative anaesthesia assessment clinic was associated with reduced likelihood of cancellation (AOR0.55; 95%CI0.43–0.72).

Conclusions: Several patient and system factors can be used to identify scheduled surgeries that are at high likelihood of cancellation within 24 h of surgery, which may inform strategies to improve the efficiency of OT utilization, including having a dedicated preoperative anaesthesia assessment clinic.

1. Introduction

The Operating Theatre (OT) is the largest cost centre as well as the main revenue generator in most hospitals [1,2]. The operating theatre involves significant resources – materials, medications and manpower. One of the common problems affecting optimal OT utilization is the cancellation of scheduled surgeries. This results in a significant waste of resources, especially when cancellation occurs within 24 h of the scheduled surgery, when it is too late to arrange replacement surgery [2–6]. Cancellation also impacts the patient and their families [1].

Reported cancellation rates range between 5% and 40% [3,5,7–14]. Reasons for cancellations vary [15], including patient factors [13], surgeon factors [7], and system issues relating to the preoperative anaesthesia assessment clinic attendance [16], the surgery itself [5,17],

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and the availability of post-surgical care facilities [12]. Between 60% and 90% of cancellations have been reported to be potentially avoidable [5,12,16].

The goal of this study was to identify factors associated with cancellation within 24 h of scheduled surgery in a tertiary academic hospital, and the reasons for cancellation, with the goal of identifying areas for intervention to reduce avoidable surgery cancellations and reduce unnecessary waste.

2. Methods

2.1. Study design, data source and data collection

We conducted a retrospective cohort study examining the association between patient, surgeon and system factors taken from the time of listing for surgery (within 3-months in advance of surgery, as per institutional policy), and eventual proceeding with surgery or late cancellation (defined as cancellation within 24 h of scheduled surgery). We used de-identified hospital electronic administrative and health records, including patient demographics, surgical details, patient visit history prior to surgery, patient clinical disease codes, and the reason for cancellation, for all elective surgery at the hospital's Main Operating Theatre (MOT) and Ambulatory Surgical Centre (ASC) from June 2015 to December 2016. The association between cancellations and patient factors, surgeon factors and system factors was examined.

2.2. Study population

Adult patients (age 18 years and older) who were scheduled for elective surgery at the Singapore General Hospital MOT or ASC, regardless of surgical discipline, or residency, were included in the study. Only the first surgery in the study period, regardless of cancellation or proceeding, was included if a patient had multiple surgeries over this period. Minor surgeries under local anaesthesia were also excluded. We excluded those without previous admissions in the past 3 years prior to the surgery, as data for chronic disease history and healthcare utilization patterns were not available for these patients. As urology operations take place in a different operating theatre that was not part of the cancellation audit, there were no urology procedures in our study.

2.3. Outcome measures

The primary outcome measure was cancellation within 24 h of the scheduled surgery.

2.4. Covariates

We extracted patient factors (patient demographics, and prior clinic attendance history), surgeon factors, and system factors from the hospital operational database.

Patient demographics were: age, gender, ethnicity, resident status and socioeconomic status. Socioeconomic status level was measured by two variables: whether they were in a subsidized ward class, and whether they were on Medifund, a national medical fees assistance scheme.

We assessed compliance to clinic attendance in terms of whether the patient did not attend the scheduled outpatient clinic (SOC) appointment ("no-show"), or whether they had cancelled the appointment over the past 1 year. We also measured the number of cancelled surgeries over the past 3 years.

Surgeon factors were: the admitting surgical department, and the seniority of the operating surgeon (associate consultant, consultant, or senior consultant).

System factors included: timing of the surgery, planned surgery duration, location (MOT vs ASC), type of surgery (admitted prior to the surgery/"inpatient", admitted only on the same day as the admission/"same-day admission", or day-surgery/no admission required), table code [18], whether the patient attended the preoperative anaesthesia assessment clinic, and whether it was a rescheduled surgery.

The surgery table code is a local categorisation and billing system for surgical procedures, determined by the Singapore Ministry of Health, based on complexity [18]. Table codes 1–4 covers less complex procedures such as a trucut biopsy or superficial skin lesion incision and drainage, while Tables 5 and above are more costly procedures that are considered more complex, such as a colectomy or Whipple's operation.

We also considered whether the surgery was scheduled to fall within 2 days of a gazetted public holiday, within culturally significant periods (Hungry Ghost month or Ramadan) or within major school holiday periods (defined as 30th May - 28th June 2015, 21st November – 31st December 2015, 28th May - 26th June 2016, and 19th November – 31st December 2016).

2.5. Statistical analysis

Patient characteristics at baseline were summarized by mean (standard deviation), median (inter-quartile range), or frequency (%) as appropriate. Univariate and multivariable logistic regression was conducted for comparisons between surgery cancellation and predictors of interest (patient, surgeon and system factors). A stepwise backward selection method was used for the multivariable logistic regression model. The AIC parameter of the generated models was used as the measure for model fit.

R v3.4.3 software was used. The work and results were reported in line with the STROCSS criteria [19].

2.6. Ethical approval

Ethical approval was given by the first author's Institutional Review Board (CIRB Ref: 2018/2286) and all data was de-identified and analysed on password-protected computers. Consent was not obtained because information was anonymized and de-identified prior to analysis. This study was registered with ClinicalTrials.gov Identifier: NCT03812133.

3. Results

3.1. Descriptive analysis

We identified 93,254 potentially eligible surgeries and excluded 61,505 emergency surgeries. A further 27,689 were excluded for: 24,388 not having at least one inpatient visit in the past 3 years, 1,564 were minor surgeries under local anaesthesia, 953 that were repeat surgeries for the same patient, and 109 not listed by an associate consultant/consultant/senior consultant surgeon, while 679 were excluded for being non-surgical admissions (for example, electro-convulsive therapy in psychiatry patients, or Hickmann line insertions for medical oncology patients). We thus analysed a total of 4060 scheduled surgeries.

Orthopaedic surgeries accounted for a third of all elective scheduled surgeries (1535, 38%), followed by Colorectal surgery (449, 11%) and General Surgery (358, 9%). Most were scheduled to be performed by a Senior Consultant (2494, 61%).

The median patient age was 68 years (IQR 63–75 years), with 44% being male patients and 80% Chinese. Majority were Singapore citizens or permanent residents (98%). Two-thirds of the surgical patients were in a subsidized ward class (2665, 66%). Only 2% required Medifund assistance.

Nearly 1-in-10 surgeries were cancelled within 24 h (398, 9.8%). Cancellations were higher among males than females (11 vs 9%, $p = 0.002$). Non-Chinese ethnicities had higher proportion of cancellations (Malays 16%, Indians 14%, $p < 0.001$). Low socioeconomic status patients had more cancellations: subsidized vs non-subsidized

Table 1
Summary descriptive statistics.

Variable	Total		Proceeded		Cancelled		p-value
	(n = 4060)		(n = 3662)		(n = 398)		
Patient factors							
Age (years)	68	(63–75)	68	(63–74)	69	(63–76)	0.02
Gender							
Male	1769		1566	(89%)	203	(11%)	0.002
Female	2291		2096	(91%)	195	(9%)	
Ethnicity							
Chinese	3257		2966	(91%)	291	(9%)	< 0.001
Malay	227		190	(84%)	37	(16%)	< 0.001
Indian	258		222	(86%)	36	(14%)	0.01
Others	318		284	(89%)	34	(11%)	0.3
Non-resident status	85		77	(91%)	8	(9%)	0.90
Subsidized class	2665		2391	(90%)	274	(10%)	0.16
On Medifund	42		32	(76%)	10	(24%)	0.002
Cancelled clinic appointments in past 1 year							
None	797		707	(89%)	90	(11%)	0.11
1–3	1462		1325	(91%)	137	(9%)	0.49
4 and above	1801		1630	(91%)	171	(9%)	0.56
"No-show" clinic appointments in past 1 year							
None	752		660	(88%)	92	(12%)	0.01
1–3	2406		2214	(92%)	192	(8%)	< 0.001
4 and above	902		788	(87%)	114	(13%)	0.001
Cancelled surgeries in past 3 years							
None	2712		2457	(91%)	255	(9%)	0.22
1–3	1260		1137	(90%)	123	(10%)	0.95
4 and above	88		68	(77%)	20	(23%)	< 0.001
Presence of Comorbidity							
Hypertension	1205		1036	(86%)	169	(14%)	< 0.001
Hyperlipidaemia	903		780	(86%)	123	(14%)	< 0.001
Diabetes	770		661	(86%)	109	(14%)	< 0.001
Coronary Heart Disease or Myocardial Infarction	424		351	(83%)	73	(17%)	< 0.001
Heart Failure or Fluid Overload	252		196	(78%)	56	(22%)	< 0.001
Chronic Kidney Disease (Grades 1–4)	414		333	(80%)	81	(20%)	< 0.001
Chronic Kidney Failure (CKD Grade 5 or Endstage renal failure)	282		216	(77%)	66	(23%)	< 0.001
Hip Fracture	133		107	(80%)	26	(20%)	< 0.001
Stroke	24		18	(75%)	6	(25%)	0.01
Dementia	22		19	(86%)	3	(14%)	0.54
Depression	203		174	(86%)	29	(14%)	0.03
Surgeon factors							
Department							
Breast	208		197	(95%)	11	(5%)	0.02
Cardiothoracic	179		151	(84%)	28	(16%)	0.01
Colorectal	449		409	(91%)	40	(9%)	0.50
General Surgery	358		312	(87%)	46	(13%)	0.04
Hand	139		126	(91%)	13	(9%)	0.86
Neurosurgery	57		50	(88%)	7	(12%)	0.53
O&G	210		200	(95%)	10	(5%)	0.01
Orthopaedic	1535		1398	(91%)	137	(9%)	0.14
Otolaryngology	228		216	(95%)	12	(5%)	0.02
Plastics	97		86	(89%)	11	(11%)	0.61
Upper GI & Bariatric	269		248	(92%)	21	(8%)	0.25
Vascular	331		269	(81%)	62	(19%)	< 0.001
Title							
Senior Consultant	2494		2280	(91%)	214	(9%)	0.001
Consultant	1219		1082	(89%)	137	(11%)	0.04
Associate Consultant	347		300	(86%)	47	(14%)	0.01
System factors							
Day of week							
Monday	722		653	(90%)	69	(10%)	0.81
Tuesday	803		699	(87%)	104	(13%)	0.001
Wednesday	913		846	(93%)	67	(7%)	0.004
Thursday	784		700	(89%)	84	(11%)	0.34
Friday	838		764	(91%)	74	(9%)	0.29
Month of year							
January	222		192	(86%)	30	(14%)	0.06
February	196		177	(90%)	19	(10%)	0.96
March	254		223	(88%)	31	(12%)	0.18
April	242		224	(93%)	18	(7%)	0.20
May	232		215	(93%)	17	(7%)	0.19
June	455		413	(91%)	42	(9%)	0.66
July	454		407	(90%)	47	(10%)	0.68

(*continued on next page*)

Table 1 (*continued*)

Variable	Total	Proceeded		Cancelled		p-value
	(n = 4060)	(n = 3662)		(n = 398)		
August	401	360	(90%)	41	(10%)	0.76
September	407	366	(90%)	41	(10%)	0.85
October	461	417	(90%)	44	(10%)	0.84
November	410	377	(92%)	33	(8%)	0.21
December	326	291	(89%)	35	(11%)	0.55
Public holiday	102	97	(95%)	5	(5%)	0.09
School holiday	866	783	(90%)	83	(10%)	0.81
Hungry Ghost month	387	345	(89%)	42	(11%)	0.47
Ramadan month	473	431	(91%)	42	(9%)	0.47
Time of day						
Morning (Before 12nn)	2477	2299	(93%)	178	(7%)	< 0.001
Afternoon (After 12nn)	1545	1335	(86%)	210	(14%)	< 0.001
Evening (After 5pm)	38	28	(74%)	10	(26%)	0.001
Planned duration						
< 1 h	530	472	(89%)	58	(11%)	0.34
1–3 h	2694	2432	(90%)	262	(10%)	0.82
> 3 h	836	758	(91%)	78	(9%)	0.61
Location						
MOT	3663	3307	(90%)	356	(10%)	0.58
ASC	397	355	(89%)	42	(11%)	
Type						
Inpatient	2020	1764	(87%)	256	(13%)	< 0.001
SDA	1660	1564	(94%)	96	(6%)	< 0.001
Day Surgery	380	334	(88%)	46	(12%)	0.11
Table code						
1–4	1725	1517	(88%)	208	(12%)	< 0.001
5 and above	2335	2145	(92%)	190	(8%)	< 0.001
Rescheduled surgery	1533	1373	(90%)	160	(10%)	0.29
Attendance at the preoperative anaesthesia assessment clinic	2808	2604	(93%)	204	(7%)	< 0.001

For continuous variables, data is presented in medians and interquartile ranges. Mann-Whitney *U* test was used to test for differences.
For categorical variables, data is presented in frequencies and percentages. Chi square test was used to test for association.

Table 2
Breakdown of reasons for cancellation within 24 h (n = 398).

Reason	n	(%)
Patient factors	293	(73.62%)
Medical conditions	158	(39.70%)
Cardiac (eg. high BP, ECG changes, heart failure)	57	(14.30%)
Respiratory (eg. asthma/COPD exacerbation, pneumonia)	11	(2.80%)
Haematological (eg. anaemia, thrombocytopenia, hyponatremia)	9	(2.30%)
Endocrine (eg. abnormal thyroid function)	3	(0.80%)
Dental (eg. loose tooth)	5	(1.30%)
Others (eg. URTI, fever, sepsis)	73	(18.30%)
Did not follow pre-op instructions (eg. fasting, stop anticoagulants)	16	(4.00%)
Surgery no longer indicated (eg. recovery, death)	18	(4.50%)
Personal/financial reasons (including no-show)	101	(25.40%)
Surgeon factors	**10**	**(2.51%)**
Surgeon unavailable (eg. busy attending to emergency, unwell)	10	(2.50%)
System factors	**83**	**(20.85%)**
Listing issues (eg. overlisting, wrong listing, earlier cases overrun)	61	(15.30%)
Process issues (eg. awaiting investigations/results, missing consent)	14	(3.50%)
Unavailable ICU bed	6	(1.50%)
Unavailable equipment/blood products	2	(0.50%)
Missing/unspecified reason	**12**	**(3.00%)**

ward class (10% vs 9%, p = 0.16) and Medifund assistance patients (24% vs 10% non-Medifund, p = 0.002). Age and resident status appeared similar.

Presence of comorbidity had higher cancellations, in particular hypertension (14% vs 8%, p < 0.001), hyperlipidaemia (14% vs 9%, p < 0.001), diabetes (14% vs 9%, p < 0.001), congestive heart failure or fluid overload (22% vs 9%, p < 0.001), and end-stage renal disease (Grade 5 or end-stage renal failure) (23% vs 9%, p < 0.001). Hip factures were also associated with greater cancellations (20% vs 9%, p < 0.001).

Patients who had ≥4 "no-show" clinic appointments over 1 year or ≥4 cancelled surgeries over the past 3 years had more cancellations compared to more compliant patients (13% vs 9%, p = 0.001 for "no-show" clinic appointments, and 23% vs 10%, p < 0.001 for cancelled surgeries).

Surgeries scheduled by senior consultants were less likely to be cancelled (9% vs 12% for non-senior consultants, p = 0.001). Cancelled surgeries tended to be scheduled in the afternoon or evening (14% vs 7% in the morning, p < 0.001), and were for less complex surgeries (Table code 1–4) (12% vs 8% for table code 5+, p < 0.001) (Table 1).

3.2. Reasons for cancellations within 24 h

Reasons for cancellations were collected for the 398 cases with cancellations ≤24 h, with 12 (3%) being unspecified.

Patient factors accounted for 73% (n = 293). Of these, majority were medically related (158, 39.7%), or no longer requiring surgery due to recovery or death (18, 4.5%). The remainder of the patient-related reasons were: Did not follow pre-operation instructions (16, 4%), or personal/financial reasons (101, 25.4%)

Surgeon factors accounted for only 10 cases (2.5%). The remaining 83 (20.9%) cases were due to system factors. The most common system cause of cancelation was due to listing issues (61, 15.3%), including overlisting, wrong listing or having the previous case overrun the scheduled timing. Breakdown of reasons for cancellations within 24 h are presented in Table 2 (see Table 3).

Table 3
Univariate and multivariable regression analysis.

Variable	Univariate		Multivariable	
	Odds Ratio		Adjusted Odds Ratio	
	(95% CI)		(95% CI)	
Patient factors				
Age (years)	N.A.			
Male gender	1.39	(1.13–1.71)		
Ethnicity				
Chinese	Ref.			
Malay	1.98	(1.35–2.85)		
Indian	1.65	(1.12–2.37)		
Others	1.22	(0.83–1.75)		
Non-resident status	0.96	(0.42–1.87)		
Subsidized class	1.28	(1.01–1.64)		
On Medifund	2.92	(1.35–5.78)	3.16	(1.37–6.72)
Cancelled clinic appointments in past 1 year				
None	Ref.			
1–3	0.81	(0.61–1.08)		
4 and above	0.82	(0.63–1.08)		
"No-show" clinic appointments in past 1 year				
None	Ref.			
1–3	0.62	(0.48–0.81)		
4 and above	1.04	(0.77–1.39)		
Cancelled surgeries in past 3 years				
None	Ref.		Ref.	
1–3	1.04	(0.83–1.30)	1.06	(0.82–1.37)
4 and above	2.83	(1.65–4.66)	2.38	(1.30–4.19)
Presence of Comorbidity				
Hypertension	1.87	(1.51–2.31)		
Hyperlipidaemia	1.65	(1.31–2.07)		
Diabetes	1.71	(1.35–2.16)		
Coronary Heart Disease or Myocardial Infarction	2.12	(1.60–2.78)		
Heart Failure or Fluid Overload	2.9	(2.09–3.95)	1.65	(1.08–2.50)
Chronic Kidney Disease (Grades 1–4)	2.55	(1.94–3.33)		
Chronic Kidney Failure (CKD Grade 5 or Endstage renal failure)	3.17	(2.34–4.25)	2.33	(1.58–3.39)
Hip Fracture	2.32	(1.46–3.56)	2.29	(1.33–3.80)
Stroke	3.1	(1.12–7.44)		
Dementia	1.46	(0.34–4.30)		
Depression	1.58	(1.03–2.33)		
Surgeon factors				
Department				
Breast	0.38	(0.18–0.72)		
Cardiothoracic	1.26	(0.75–2.08)		
Colorectal	0.66	(0.42–1.04)		
General Surgery	Ref.			
Hand	0.7	(0.35–1.30)		
Neurosurgery	0.95	(0.37–2.10)		
O&G	0.34	(0.16–0.66)		
Orthopaedic	0.66	(0.47–0.96)		
Otolaryngology	0.38	(0.19–0.71)		
Plastics	0.87	(0.41–1.69)		
Upper GI & Bariatric	0.57	(0.33–0.98)		
Vascular	1.56	(1.03–2.38)		
Title				
Senior Consultant	Ref.			
Consultant	1.35	(1.07–1.69)		
Associate Consultant	1.67	(1.18–2.32)		
System factors				
Day of week				
Monday	Ref.			
Tuesday	1.41	(1.02–1.95)		
Wednesday	0.75	(0.53–1.07)		
Thursday	1.14	(0.81–1.59)		
Friday	0.92	(0.65–1.29)		
Month of year				
January	Ref.			
February	0.69	(0.37–1.25)		
March	0.89	(0.52–1.53)		
April	0.51	(0.27–0.94)		
May	0.51	(0.27–0.94)		
June	0.65	(0.40–1.08)		
July	0.74	(0.46–1.22)		
August	0.73	(0.44–1.21)		
September	0.72	(0.44–1.19)		
October	0.68	(0.41–1.12)		
November	0.56	(0.33–0.95)		
December	0.77	(0.46–1.30)		
Public holiday	0.47	(0.16–1.04)		
School holiday	0.97	(0.75–1.24)		
Hungry Ghost month	1.13	(0.80–1.57)		
Ramadan month	0.88	(0.62–1.22)		
Time of day				
Morning (Before 12nn)	Ref.		Ref.	
Afternoon (After 12nn)	2.03	(1.65–2.51)	1.83	(1.44–2.32)
Evening (After 5pm)	4.61	(2.10–9.35)	2.09	(0.73–5.13)
Planned duration				
< 1 h	Ref.			
1–3 h	0.88	(0.65–1.19)		
> 3 h	0.84	(0.59–1.20)		
Location				
MOT	Ref.			
ASC	1.1	(0.77–1.52)		
Type				
Inpatient	Ref.		Ref.	
SDA	0.42	(0.33–0.54)	0.62	(0.46–0.82)
Day Surgery	0.95	(0.67–1.31)	1.06	(0.72–1.54)
Table code				
1–4	Ref.		Ref.	
5 and above	0.65	(0.52–0.79)	0.64	(0.50–0.81)
Rescheduled surgery	1.12	(0.91–1.38)	1.32	(1.04–1.67)
Attendance at the preoperative anaesthesia assessment clinic	0.45	(0.36–0.58)	0.55	(0.43–0.72)

3.3. Univariate analysis

Male and non-Chinese ethnicity patients were more likely to cancel surgeries. Malay patients were the most likely to cancel (OR 1.98, 95% CI 1.35–2.85). Those with low socioeconomic status, ie. in subsidized ward class (1.28, 1.01–1.64) or receiving Medifund assistance (2.92, 1.35–5.78) were also more likely to cancel within 24 h (Table 3).

The presence of comorbidity increased the risk of cancellation. Conditions such as heart failure or fluid overload (OR 2.90, 2.09–3.95), stroke (OR 3.10, 1.12–7.44) and end-stage renal disease (OR 3.17, 2.34–4.25) had strong association with cancellation risk (Table 3).

Patient behaviour showed mixed results. Outpatient clinic attendance, either cancelled or “no-show”, did not appear to have significant relationship to cancellation within 24 h of scheduled elective surgeries. However, patients with a history of cancelling surgeries showed a greater propensity to cancel the surgery. The greater the number of previous cancelled surgeries, the greater the association with cancelling within 24 h of the current surgery (Table 3).

Surgical departments such as Obstetrics & Gynaecology (OR 0.34, 0.16–0.66), Otolaryngology (0.38, 0.19–0.71), Breast (0.38, 0.18–0.72) and Orthopaedic (0.66, 0.47–0.96) were less likely to be cancelled, while Vascular surgeries were more likely to be cancelled (1.56, 1.03–2.38), relative to General Surgeries. Surgeon seniority was negatively associated with surgery cancellations, with higher seniority having lower odds of cancellation.

Surgeries scheduled for morning (before 12 noon) were at lowest risk of cancellation, compared to afternoon (OR 2.03, 1.65–2.51) or evening (4.61, 2.10–9.35). Surgeries scheduled in April/May (0.51, 0.27–0.94) or November (0.56, 0.33–0.95) were also less likely to be cancelled.

In terms of surgical characteristics, same-day admission (0.42, 0.33–0.54) surgeries were less likely to be cancelled. More complex surgeries (Table Codes ≥5) were less likely to be cancelled (0.65, 0.52–0.79). A patient who had attended the preoperative anaesthesia assessment clinic was less likely to be cancelled in the last 24 h (0.45, 0.36–0.58). Surgery duration and location did not appear to be significantly associated with cancellation (Table 3).

3.4. Multivariable analysis

On multivariate analysis, low socioeconomic status (Medifund), presence of specific comorbidities (heart failure or fluid overload, end-stage renal disease, and hip fracture), and patient behaviour (previous cancelled surgeries) were associated with cancellation of surgery (Table 3).

Patient attendance at the preoperative anaesthesia assessment clinic, surgery timings in the morning, and more complex surgeries (Table code 5 or higher), were factors associated with a lower likelihood of cancellation (Table 3).

AIC for our multivariable model was 1923, with a c-statistic of 0.70.

4. Discussion

Our study is the first study of factors associated with cancellations within 24 h of elective surgery in Singapore, an urban city state in Asia. Rate of cancellation within 24 h of elective surgery in our study (9.8%) was slightly lower than the reported rates in other developed countries: Australia (11.9%) [12], United States (12.4%) [13], United Kingdom (5.2%) [1].

When evaluating factors associated with cancellation within 24 h of surgery, our results were similar to that of the international literature. Patient behaviour (cancellations of previous surgeries) was independently associated with cancellation [9]. We postulate that this behaviour was an indicator of patient non-compliance or social factors related to willingness for surgery [20,21], and the surgery cancellation arose out of this non-compliance. Some factors found to be associated with other studies of non-compliance (for example, depression [22–24], previous no-show for clinic appointments [9,20,21,25]) were not independently associated with cancellation of surgery. Specific studies to address non-compliance may be difficult as these patients may also be difficult to recruit into a study [25,26].

Socioeconomic factors also played a role: we found that low socioeconomic status (on Medifund assistance) was strongly associated with surgery cancellation [13]. This may be due to these patients having financial difficulties beyond that of assistance, lack of access, or low patient empowerment. This hypothesis would explain our finding that a quarter of cases were cancelled due to personal or financial reasons.

In line with existing literature, attendance at preoperative anaesthesia assessment clinic was associated with a reduced likelihood of cancellation [5,10,15]. Patients who completed the assessment were more likely to have any medical-related issues highlighted and controlled before culminating into a surgery cancellation [6]. Another explanation was that the completion of assessment was an indicator of patient compliance and readiness for surgery.

Improving the quality of the preoperative anaesthesia assessment clinic and preparation system has been shown to not only reduce surgery cancellations within 24 h, but also improve other parameters such as increasing operating theatre flow by up to 35%, reducing length of stay, and reducing wound infection rates by 70%, while also reducing cost by between 8 and 18% [15]. In our study, we found a significant proportion of cancellations were due to patient medical conditions (40%), with many arising from chronic conditions such as cardiac heart failure, hypertension, or chronic obstructive pulmonary disease. This was in keeping with our findings, where certain conditions (heart failure/fluid overload, end-stage renal failure, and hip fractures) increased in the risk of surgery cancellation [27]. Improving the quality of our preoperative anaesthesia assessment clinic, and controlling these conditions, would thus help to reduce cancellations due to medical conditions [28,29].

We found that more of our cancellations occurred in the later-half of the day (after 12 noon). This could be due to listing issues, which we found to account for 15% of all cancellations. Other system factors such as date of surgery did not appear very significant. Duration and location of surgery did not appear related to cancellation.

Cancellations due to equipment/blood products, and post-operation bed availability (ICU beds) accounted for only 2% in our study. This was much lower than other reports, of up to 18% and 20% in Australia and the United States [12,13]. Although small in volume, such cases are still potentially avoidable and should be assessed for any addressable service gaps to prevent such events [29].

Our study was limited to a single institution. However, our study institution is the largest hospital in Singapore, providing approximately 20% of the public acute tertiary inpatient care and covering over 1 million patients annually including outpatient specialty clinic care and Emergency attendances [30,31]. Hence, we felt that it would be representative of hospital-based care in a multi-ethnic urban population with a developed healthcare system.

Another potential limitation is reliance on prior admissions to extract co-morbid conditions for patients, which limits the validity of our model for patients without prior admissions. Not surprisingly, patients who were excluded from our analysis because they did not have a prior admission were younger (mean 50.5, SD 15.6 vs 66.7 SD 12.9 in the sample). Nevertheless, our study population had a cancellation rate of 9.8%, which was only slightly higher than that of the excluded patients (8.8%). Hence, we felt that our findings from the study sample would still be valid when extrapolated to that of the greater population.

Future studies could include evaluation of any interventions to address avoidable causes of cancellations. We found approximately 25% of cancellations to be likely preventable (20% from system issues, 4% of patients not following pre-operative instructions). A certain proportion of the 40% cancellations due to patient medical conditions may also be amenable to intervention. This would allow for improved operating theatre usage and reduce wastage and ‘empty’ time.

In light of our findings that attendance at the preoperative anaesthesia assessment clinic appeared to be the only positive modifiable systems factor, the role of a point coordination centre (pre-admission centre) has since been expanded to oversee and coordinate all matters relating to a patient's surgery right from confirmation of surgery timing. Changes have included a standardised set of instructions and information for patients, with a systematic communication process to encourage all patients to attend their preoperative assessments, and a dedicated telephone hotline. We anticipate a substantial reduction in surgery cancellations.

5. Conclusion

Cancellation within 24 h of surgery rates were low, but could be improved. Patients with co-morbid conditions, low socioeconomic status and those exhibiting non-compliant behaviours were more likely to cancel or be cancelled. Surgeries conducted by senior physicians and for more complex conditions were less likely to be cancelled. Patient and system factors are potential areas for intervention, such as improving attendance at the preoperative anaesthesia assessment clinic, and ensuring coordination between the operation theatre, equipment providers and post-op bed planning. Reasons for cancellations require more in-depth analysis to identify treatable root causes, in order to reduce avoidable surgery cancellations and improve operating theatre flow and reduce waste.

Ethical Approval

Ethical approval was given by the first author's (Singapore General

Hospital) Institutional Review Board (CIRB Ref: 2018/2286) and all data was de-identified and analysed on password-protected computers. Consent was not obtained because information was anonymized and de-identified prior to analysis.

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Author contribution

THW, MEHO and HKT conceived and designed the study. CJC, SW and SL performed the data analysis. ALT drafted the initial manuscript with all authors contributing substantially to the final manuscript. All authors read and approved the final manuscript.

Conflicts of interest

The Authors declare no competing interests.

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THW takes responsibility for the paper as a whole.

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Availability of data and materials

Data is not publicly available as it is derived from operational and patient records data, hence it is kept confidential. Data may be shared to researchers if approval is obtained from the institution.

CRediT authorship contribution statement

Aidan L. Tan: Visualization, Writing - original draft, Writing - review & editing. **Calvin J. Chiew:** Data curation, Formal analysis, Software, Writing - review & editing. **Sijia Wang:** Data curation, Formal analysis, Software, Writing - review & editing. **Hairil Rizal Abdullah:** Investigation, Writing - review & editing. **Sean SW. Lam:** Data curation, Formal analysis, Resources, Software, Writing - review & editing. **Marcus EH. Ong:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing - review & editing. **Hiang Khoon Tan:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing - review & editing. **Ting Hway Wong:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Visualization, Writing - review & editing.

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Appendix A. Supplementary data

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