

10.1071/AH21251

Australian Health Review

Healthcare resource utilisation and predictors for critical care unit admissions after primary bariatric surgery in an Australian public hospital setting: an exploratory study using a mixed-methods approach

Qing Xia^{1,6} MMedSci, PhD Candidate

*Julie A. Campbell*¹ PhD, Research Fellow

*Lei Si*² PhD, Research Fellow

*Hasnat Ahmad*¹ MPhil, Postdoctoral Research Fellow

*Barbara de Graaff*¹ PhD, Research Fellow

*Kevin Ratcliffe*³ MPA, Senior Advisor

*Julie Turtle*³ AssocDip, Clinical Coding Auditor/Educator

*John Marrone*³ PhD, Casemix Risk Officer

*Alexandr Kuzminov*⁴ MD, Adjunct Researcher

Andrew J. Palmer^{1,5,6} BMedSci, MBBS, Professor

¹Menzies Institute for Medical Research, University of Tasmania, 17 Liverpool Street, Hobart, Tas. 7000, Australia. Email: julie.campbell@utas.edu.au; hasnat.ahmad@utas.edu.au; barbara.degraaff@utas.edu.au

²The George Institute for Global Health, UNSW Sydney, Kensington, NSW 2042, Australia. Email: lsi@georgeinstitute.org.au

³Tasmanian Department of Health, Tasmanian State Government, 22 Elizabeth Street, Hobart, Tas. 7000, Australia. Email: Kevin.Ratcliffe@health.tas.gov.au; Julie.Turtle@health.tas.gov.au; John.Marrone@health.tas.gov.au

⁴Department of Surgery, Royal Hobart Hospital, 48 Liverpool Street, Hobart, Tas. 7000, Australia. Email: alexandr.kuzminov@utas.edu.au

⁵Centre for Health Economics, School of Population and Global Health, The University of Melbourne, 207 Bouverie Street, Carlton, Vic. 3000, Australia.

⁶Corresponding authors. Email: Andrew.Palmer@utas.edu.au; Qing.Xia@utas.edu.au

Table S1. Surgical procedure codes

Procedure	Codes		
	ICD-8 (from July 2013)	ICD-9 (from July 2015)	ICD-10 (from July 2017)
Laparoscopic sleeve gastrectomy [LSG]	30511-09		
Sleeve gastrectomy [SG]	30511-10		
Laparoscopic adjustable gastric banding [LAGB]	30511-02	30511-13	
Laparoscopic nonadjustable gastric banding [LNGB]	30511-03	30511-13	
Adjustable gastric banding [AGB]	30511-04	30511-14	
Nonadjustable gastric banding [NGB]	30511-05	30511-14	
Laparoscopic gastric banding	30511-13	30511-02	30511-03
Gastric banding	30511-14	30511-04	30511-05
Laparoscopic gastric bypass	30512-03		
Gastric bypass	30512-00		

Bold text indicates the procedure codes that were changed between 2013 and 2019.

Abbreviations: ICD-8/9/10: International Classification of Diseases, Eighth/Ninth/Tenth Revision.

Table S2. Predicted preoperative variables for HDU/ICU admission

	Scenario 2*			Scenario 3*		
	HDU (n=34)	non-HDU (n=220)	P-value	ICU (n=25)	non-ICU (n=229)	P-value
Age at surgery, years	45.7 ± 12.3	44.9 ± 11.8	0.714 [#]	48.2 ± 12.8	44.6 ± 11.7	0.147 [#]
Gender, %						
<i>Females</i>	21 (61.8%)	161 (73.2%)	0.169 [£]	15 (60.0%)	167 (72.9%)	0.173 [£]
<i>Males</i>	13 (38.2%)	59 (26.8%)		10 (40.0%)	62 (27.1%)	
BMI at surgery, kg/m ²	53.9 ± 9.1	48.6 ± 6.9	0.002[#]	52.5 ± 9.3	49.0 ± 7.2	0.024[#]
Occupation status, %						
<i>Employed</i>	8 (23.5%)	52 (23.6%)	0.825 [§]	5 (20.0%)	55 (24.0%)	0.536 [§]
<i>Home duties</i>	6 (17.6%)	37 (16.8%)		3 (12.0%)	40 (17.5%)	
<i>Retired</i>	2 (5.9%)	18 (8.2%)		1 (4.0%)	19 (8.3%)	
<i>Pensioner</i>	8 (23.5%)	32 (14.5%)		5 (20.0%)	35 (15.3%)	
<i>Unemployed</i>	3 (8.8%)	20 (9.1%)		1 (4.0%)	22 (9.6%)	
<i>No specified</i>	7 (20.6%)	61 (27.7%)		10 (40.0%)	58 (25.3%)	
Smoking						
<i>Yes</i>	9 (26.5%)	41 (18.6%)	0.285 [£]	2 (4.0%)	49 (21.4%)	0.185 [£]
<i>No</i>	25 (73.5%)	179 (81.4%)		23 (96.0%)	180 (78.6%)	
Indigenous (ATSI) origin, %						
<i>Yes</i>	5 (11.4%)	25 (11.9%)	0.574 [£]	3 (12.0%)	27 (11.8%)	1.000 [§]
<i>No</i>	39 (88.6%)	185 (88.1%)		22 (88.0%)	202 (88.2%)	
Type of surgery						
<i>GB</i>	17 (11.4%)	132 (88.6%)	0.467 [§]	6 (4.0%)	143 (96.0%)	0.001[§]
<i>SG</i>	15 (15.6%)	81 (84.4%)		18 (18.8%)	78 (81.2%)	
<i>GBP</i>	2 (22.2%)	7 (77.8%)		1 (11.1%)	8 (88.9%)	
Co-morbidity individual						
<i>Respiratory diseases</i>	19 (55.9%)	45 (20.5%)	<0.001[£]	16 (64.0%)	48 (21.0%)	<0.001[£]
<i>Diabetes mellitus</i>	18 (52.9%)	86 (39.1%)	0.126 [£]	16 (64.0%)	88 (38.4%)	0.014[£]
<i>Cardiovascular diseases</i>	17 (50.0%)	76 (34.5%)	0.082 [£]	18 (72.0%)	75 (32.8%)	<0.001[£]
<i>Musculoskeletal diseases</i>	6 (17.6%)	23 (10.5%)	0.220 [£]	7 (28.0%)	22 (9.6%)	0.006[£]
<i>Mental health diseases</i>	10 (29.4%)	38 (17.3%)	0.092 [£]	9 (36.0%)	39 (17.0%)	0.021[£]
<i>Genitourinary diseases</i>	4 (11.8%)	7 (3.2%)	0.022[£]	3 (12.0%)	8 (3.5%)	0.047[§]
<i>Gastrointestinal tract diseases</i>	5 (14.7%)	17 (7.7%)	0.178 [£]	6 (24.0%)	16 (7.0%)	0.004[£]
Number of comorbidities	2.3 ± 1.5	1.3 ± 1.2	<0.001[#]	3.0 ± 1.5	1.3 ± 1.2	<0.001[#]

[#]Student *t*-test; [£]Chi-square test; [§]Fisher's exact test.

*Scenario 2: n=34 patients were scheduled to HDU before surgery; Scenario 3: n=25 patients finally received ICU services. There were 15 overlaps within HDU in Scenario 2 and ICU in Scenario 3. These 15 patients were ended into ICU while they were preoperatively scheduled to HDU for further monitoring; therefore, these n=15 patients were also considered in scenario 2 to investigate the preoperative predictors to HDU.

Abbreviations: ATSI, Aboriginal or Torres Strait Islander; CCU, critical care unit; GB, gastric banding; GBP, gastric bypass; HDU, high dependency unit; ICU, intensive care unit; SG, sleeve gastrectomy.

Table S3. BMI distribution in patients with or without CCU admission

	CCU						non-CCU						<i>P</i> -value
	n	BMI	≤50	50-60	60-70	≥70	n	BMI	≤50	50-60	60-70	≥70	
GB	17	56.2±11.0*	41%	24%	24%	12%	132	50.0±9.2**	77%	15%	5%	2%	0.003
SG	25	50.7±7.6*	60%	38%	0%	4%	71	45.7±7.0**	73%	27%	0%	0%	NA
GBP	2	56.0±1.4	0%	100%	0%	0%	7	48.3±8.7	71%	29%	0%	0%	NA

Footnotes: the non-CCU patients undergoing GB had a significantly higher BMI than those undergoing SG (50.0±9.2 vs. 45.7±7.0, $P<0.001$), while in the CCU group this comparison did not achieve statistical significance (56.2±11.0 vs. 50.7±7.6, $P=0.061$) which could be partially explained by the small number of CCU patients. For patients undergoing GB procedure, the proportion with BMI ≤50 kg/m² was higher in non-CCU group than in CCU group (77% vs 41%; $P=0.003$).

Abbreviations: BMI, body mass index; CCU, critical care unit; GB, gastric banding; GBP, gastric bypass; NA, no applicable; SG, sleeve gastrectomy.

Table S4. BMI distribution among different surgical procedures

		Mean BMI	BMI category			
			≤50	50-60	60-70	≥70
			n=109	n=24	n=11	n=5
GB (n=149)	CCU	56.2±11.0	6.4%	16.7%	36.4%	40.0%
	non-CCU	50.0±9.2	93.6%	83.3%	63.6%	60.0%
			n=67	n=28	NA	NA
SG (n=96)	CCU	50.7±7.6	22.4%	32.1%	NA	NA
	non-CCU	45.7±7.0	77.6%	67.9%	NA	NA
			NA	NA	NA	NA
GBP (n=9)	CCU	56.0±1.4	NA	NA	NA	NA
	non-CCU	48.3±8.7	NA	NA	NA	NA

Footnotes: For people undergoing GB surgery, only 6.4% with BMI <50 kg/m² had less post-operative CCU support. Interestingly, this proportion almost tripled (16.7%) for those with a BMI of 50-60 kg/m², and was six-fold (36.4%) for those with a BMI of 60-70 kg/m², and seven fold (40.0%) for those with BMI>70 kg/m². For people who underwent SG, up to 22.4% of patients with a BMI <50 kg/m² were observed to have CCU requirements after surgery, and the proportion slightly increased for patients with BMI of 50-60 kg/m² (32.1%). Whilst no data exists in this study for SG in patients with BMI>60 and for GBP in all patients, previous literature showed a dramatic increase of CCU demand in patients with a BMI >60.

Abbreviations: BMI, body mass index; CCU, critical care unit; GB, gastric banding; GBP, gastric bypass; NA, no available; SG, sleeve gastrectomy.

Table S5. ICD-10-CM codes

Code	Description
A41.9	Sepsis, unspecified
B18.1 ^c	Chronic viral hepatitis B without delta-agent
B18.2 ^c	Chronic viral hepatitis C
B37.0	Candidal stomatitis
B96.2 ^c	Escherichia coli [E. coli] as the cause of diseases classified to other chapters
B96.81 ^c	Helicobacter pylori [H. pylori] as the cause of diseases classified elsewhere
D13.4 ^c	Liver
D18.03	Hemangioma of intra-abdominal structures
D62	Acute posthaemorrhagic anaemia
E09.21 ^a	Drug or chemical induced diabetes mellitus with diabetic nephropathy
E09.72 ^a	Drug or chemical induced diabetes mellitus with other diabetic ophthalmic complication
E10.9 ^a	Type 1 diabetes mellitus without complications
E11.21 ^a	Type 2 diabetes mellitus with incipient diabetic nephropathy
E11.22 ^a	Type 2 diabetes mellitus with established diabetic nephropathy
E11.29 ^a	Type 2 diabetes mellitus with other diabetic kidney complication
E11.31 ^a	Type 2 diabetes mellitus with unspecified diabetic retinopathy
E11.34 ^a	Type 2 diabetes mellitus with severe nonproliferative diabetic retinopathy
E11.35 ^a	Type 2 diabetes mellitus with proliferative diabetic retinopathy
E11.40 ^a	Type 2 diabetes mellitus with diabetic neuropathy, unspecified
E11.42 ^a	type 2 diabetes mellitus
E11.51 ^a	Type 2 diabetes mellitus with diabetic peripheral angiopathy without gangrene
E11.64 ^a	Type 2 diabetes mellitus with hypoglycemia
E11.65 ^a	Type 2 diabetes mellitus with poor control
E11.71 ^a	Type 2 diabetes mellitus with multiple microvascular and other specified non-vascular complications
E11.72 ^a	Type 2 diabetes mellitus with features of insulin resistance if hypertension met ACS 0001 or 0002
E11.73 ^a	Type 2 diabetes mellitus with foot ulcer due to multiple causes
E11.9 ^a	Type 2 diabetes mellitus without complications
E21.0	Primary hyperparathyroidism
E21.1	Secondary hyperparathyroidism, not elsewhere classified
E66.2 ^d	Extreme obesity with alveolar hypoventilation
E66.8	Other obesity
E66.9	Obesity not elsewhere classified
E66.90	Obesity, not elsewhere classified, body mass index [BMI] not elsewhere classified
E66.91	unspecified obesity
E66.92	unspecified obesity
E66.93	unspecified obesity
E78.9	Disorder of lipoprotein metabolism, unspecified
E83.3	Disorders of phosphorus metabolism and phosphatases
E83.4	Disorders of magnesium metabolism
E86	Volume depletion
E87.2 ^a	Acidosis
E87.6	Hypokalaemia
E87.7	Fluid overload
E88.0	Disorders of plasma-protein metabolism, not elsewhere classified
F17.2	Mental and behavioural disorders due to use of tobacco: dependence syndrome
F41.1 ^f	Generalized anxiety disorder

F41.9 ^f	Anxiety disorder, unspecified
G35	Multiple sclerosis
G43.9	Migraine, unspecified
G47.30 ^d	Sleep apnea, unspecified
G47.32 ^d	Obstructive sleep apnoea syndrome
G81.9	Hemiplegia, unspecified
H33.2	Serous retinal detachment
I10 ^b	Essential (primary) hypertension
I25.9 ^b	Chronic ischaemic heart disease, unspecified
I44.2 ^b	Atrioventricular block, complete
I48.9 ^b	Atrial fibrillation and atrial flutter, unspecified
I50.0 ^b	Congestive heart failure
I63.0 ^b	Cerebral infarction due to thrombosis of precerebral arteries
I89.0	Lymphedema, not elsewhere classified
I95.9 ^b	Hypotension, unspecified
I97.8 ^b	Other postprocedural disorders of circulatory system, not elsewhere classified
J06.9 ^d	Acute upper respiratory infection, unspecified
J69.0 ^d	Pneumonitis due to food and vomit
J93.9 ^d	Pneumothorax, unspecified
J95.8 ^d	Other postprocedural respiratory disorders
J96.99 ^d	Respiratory failure, unspecified
J98.0 ^d	Diseases of bronchus, not elsewhere classified
J98.1 ^d	Pulmonary collapse
K21.9 ^c	Gastro-oesophageal reflux disease without oesophagitis
K29.50 ^c	Chronic gastritis, unspecified
K30 ^c	Functional dyspepsia
K31.88 ^c	Other specified diseases of stomach and duodenum
K42.9	Umbilical hernia without obstruction or gangrene
K43.2	Incisional hernia without obstruction or gangrene
K43.9	Other and unspecified ventral hernia without obstruction or gangrene
K44.9	Diaphragmatic hernia without obstruction or gangrene
K66.0	Peritoneal adhesions
K74.6 ^c	Other and unspecified cirrhosis of liver
K75.8 ^c	Other specified inflammatory liver diseases
K76.0 ^c	Fatty (change of) liver, not elsewhere classified
K76.8 ^c	Other specified diseases of liver
K80.10 ^c	Calculus of gallbladder with chronic cholecystitis without obstruction
K80.20 ^c	Calculus of gallbladder without cholecystitis
K91.0 ^c	Vomiting following GIT surgery
K91.8 ^c	Other postprocedural disorders of digestive system, not elsewhere classified
K91.89 ^c	Other postprocedural complications and disorders of digestive system
L03.3	Cellulitis of trunk
L27.0	Generalized skin eruption due to drugs and medicaments
L50.0	Allergic urticaria
L97	Ulcer of lower limb, not elsewhere classified
L89.95	Pressure ulcer of unspecified site, unstageable
M25.51 ^e	Pain in shoulder

M54.5 ^e	Low back pain
M81.400 ^e	Drug-induced osteoporosis
M81.98 ^e	Osteoporosis, unspecified, other site
M91.200 ^e	Coxa plana
N17.9 ^g	Acute renal failure, unspecified
N18.2 ^g	Chronic kidney disease, stage 2
N18.3 ^g	Chronic kidney disease, stage 3
N18.5 ^g	Chronic kidney disease, stage 5
N18.9 ^g	Chronic kidney disease, unspecified
N39.0 ^g	Urinary tract infection, site not specified
N99.8 ^g	Other postprocedural disorders of genitourinary system
R000 ^b	Tachycardia, unspecified
R00.1 ^b	Bradycardia, unspecified
R011 ^b	Cardiac murmur, unspecified
R04.2	Haemoptysis
R06.8 ^d	Other and unspecified abnormalities of breathing
R07.4 ^b	Chest pain, unspecified
R09.0 ^d	Asphyxia
R10.1	Pain localized to upper abdomen
R10.4	Other and unspecified abdominal pain
R11	Nausea and vomiting
R20.2	Paraesthesia of skin
R21	Rash and other nonspecific skin eruption
R30.0	Dysuria
R33	Retention of urine
R34	Anuria and oliguria
R40.2	Coma, unspecified
R42	Dizziness and Giddiness
R51	Headache
R52.2	Other chronic pain
R55	Syncope and collapse
S03.2	Dislocation of tooth
S36.00	Unspecified injury of spleen
S36.13	Injury of bile duct
S36.5	Injury of colon
S36.52	Contusion of colon
S54.0	Injury of ulnar nerve at forearm level
T81.0	Haemorrhage or haematoma complicating a procedure, not elsewhere classified
T81.2	Accidental puncture and laceration during a procedure, not elsewhere classified
T81.3	Disruption of operation wound, not elsewhere classified
T81.83	Persistent postprocedural fistula
T855	Mechanical complication of gastrointestinal prosth dev/grft (Mechanical complication of gastrointestinal prosthetic devices, implants and grafts)
T85.88	Other complications of internal prosthetic device
T88.4	Failed or difficult intubation
T88.42	difficult intubation
T88.59	Other complications of anesthesia
T88.8	Other specified complications of surgical and medical care, not elsewhere classified
U73.8	Other specified activity
U73.9	Unspecified activity
U79.2 ^f	Schizophrenia
U79.3 ^f	Depression
U80.3 ^f	Epilepsy

U82.1	Resistance to methicillin
U82.2	Extended spectrum betalactamase (ESBL) resistance
U82.3 ^b	Hypertension
U83.2	Resistance to quinolones
U83.3 ^d	Asthma, without mention of chronic obstructive pulmonary disease
U86.1 ^e	Rheumatoid arthritis
U86.2 ^e	Arthritis and osteoarthritis
U86.3	Systemic lupus erythematosus
U86.4 ^e	Osteoporosis
U87.1	Chronic kidney disease, stage 3-5
W80.9	Unspecified object
X58	Exposure to other specified factors
Y40.8	Other systemic antibiotics
Y48.2	Other and unspecified general anaesthetics
Y52.6	Antihyperlipidaemic and antiarteriosclerotic drugs
Y60.0	Unintentional cut, puncture, perforation or haemorrhage during surgical operation
Y60.8	During other surgical and medical care
Y65.8	Other specified misadventures during surgical and medical care
Y70.0	Diagnostic and monitoring anesthesiology devices associated with adverse incidents
Y83.1	Surgical operation with implant of artificial internal device
Y83.6	Removal of other organ (partial) (total)
Y83.8	Other surgical procedures
Y83.9	Surgical procedure, unspecified
Y84.8	Other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure
Y92.22	Religious institution as the place of occurrence of the external cause
Y92.24	Public administrative building as the place of occurrence of the external cause
Z00.6	Encounter for examination for normal comparison and control in clinical research program
Z06.51	Resistance to penicillin
Z45.89	Encounter for adjustment and management of implanted devices
Z46.5	Fitting and adjustment of ileostomy and other intestinal appliances
Z72.0	Tobacco use
Z85.3	Personal history of malignant neoplasm of breast
Z85.8	Personal history of malignant neoplasms of other organs and systems
Z86.43	Personal history of tobacco use disorder
Z90.5	Acquired absence of kidney
Z91.1 ^f	Personal history of noncompliance with medical treatment and regimen
Z92.1	Personal history of long-term (current) use of anticoagulants
Z92.21	Personal history of long-term (current) use of medicaments aspirin
Z92.22	Personal history of monoclonal drug therapy
Z93.2	Ileostomy status
Z95.0 ^b	Presence of electronic cardiac devices
Z95.5 ^b	Presence of coronary angioplasty implant and graft

Codes for considered co-morbidities: ^aCodes for diabetes; ^bCodes for cardiovascular diseases; ^cCodes for gastrointestinal tract diseases; ^dCodes for respiratory diseases; ^eCodes for musculoskeletal diseases; ^fCodes for mental diseases; ^gCodes for genitourinary diseases.

Table S6. Co-morbidity matrix

Cohort group	Patients' ID	Respiratory difficulties	Diabetes	Cardiovascular diseases	Musculoskeletal diseases	Gastrointestinal tract diseases	Genitourinary diseases	Mental health	Number of co-morbidities
CCU	12	1	1	0	0	0	0	0	2
CCU	18	0	1	0	0	0	0	0	1
CCU	29	1	1	1	0	0	0	0	3
CCU	31	1	1	1	0	0	0	0	3
CCU	33	0	0	0	0	0	0	0	0
CCU	53	0	1	0	0	0	0	0	1
CCU	88	0	0	1	0	0	1	0	2
CCU	96	1	0	1	0	0	0	0	2
CCU	118	0	1	0	0	0	0	0	1
CCU	125	0	0	0	1	1	0	1	3
CCU	127	1	1	1	0	1	1	0	5
CCU	128	0	0	0	0	0	1	0	1
CCU	129	1	1	1	0	0	0	1	4
CCU	130	1	1	1	1	0	0	0	4
CCU	131	1	1	1	1	1	0	1	6
CCU	137	0	1	1	0	1	1	0	4
CCU	139	1	0	1	0	0	0	1	3
CCU	140	1	1	1	1	1	0	0	5
CCU	141	1	0	1	0	0	0	0	2
CCU	142	0	0	1	1	0	0	1	3
CCU	143	0	0	0	0	0	0	0	0
CCU	144	0	1	1	0	0	0	0	2
CCU	150	1	0	0	0	0	0	0	1
CCU	151	0	0	0	0	1	0	0	1
CCU	152	1	1	1	0	0	0	0	3
CCU	154	1	1	1	0	1	1	0	5
CCU	159	0	1	1	0	0	0	1	3
CCU	170	1	1	1	0	0	0	0	3
CCU	172	0	0	0	1	0	0	0	1
CCU	178	0	0	0	0	0	0	0	0
CCU	187	1	0	1	0	0	0	0	2
CCU	188	1	0	1	0	0	0	0	2
CCU	194	1	0	0	0	0	0	1	2
CCU	202	1	0	0	1	0	0	1	3
CCU	210	0	1	1	0	0	0	1	3
CCU	216	1	1	0	0	0	0	1	3
CCU	217	0	1	1	0	0	0	0	2
CCU	224	1	0	0	0	0	0	0	1
CCU	225	1	0	0	0	0	0	0	1
CCU	226	0	0	0	1	0	0	0	1
CCU	236	1	1	1	1	0	0	1	5
CCU	240	0	1	0	0	0	0	1	2
CCU	246	0	0	1	0	0	0	0	1
CCU	255	1	0	0	0	0	0	1	2
non-CCU	1	0	1	0	0	0	0	0	1
non-CCU	2	0	0	0	0	0	0	0	0
non-CCU	3	0	0	0	0	0	0	0	0
non-CCU	4	0	0	1	0	0	0	0	1
non-CCU	5	0	1	1	0	0	0	0	2
non-CCU	6	0	0	0	0	0	0	0	0

non-CCU	7	0	0	0	0	0	0	0	0
non-CCU	8	0	0	0	0	0	0	0	0
non-CCU	9	0	1	1	0	0	1	0	3
non-CCU	10	1	0	1	0	0	0	0	2
non-CCU	11	0	1	0	0	0	0	0	1
non-CCU	13	0	1	1	0	0	0	0	2
non-CCU	14	0	1	0	0	0	0	0	1
non-CCU	15	1	0	1	0	0	0	0	2
non-CCU	16	1	1	0	0	0	0	0	2
non-CCU	17	0	0	0	0	0	0	0	0
non-CCU	19	0	0	0	0	0	0	0	0
non-CCU	21	0	0	0	0	0	0	0	0
non-CCU	22	0	1	0	0	0	0	0	1
non-CCU	23	0	0	0	0	0	0	0	0
non-CCU	24	0	0	0	0	0	0	0	0
non-CCU	25	1	0	0	0	0	1	0	2
non-CCU	26	0	1	1	0	0	0	0	2
non-CCU	27	0	1	0	0	0	0	0	1
non-CCU	28	0	1	1	0	0	0	0	2
non-CCU	30	0	1	0	0	0	0	0	1
non-CCU	32	0	0	0	0	0	0	0	0
non-CCU	34	0	0	0	0	0	0	0	0
non-CCU	35	0	0	0	0	0	0	0	0
non-CCU	36	0	0	0	0	0	0	0	0
non-CCU	37	0	1	1	0	0	0	0	2
non-CCU	38	0	1	0	0	0	0	0	1
non-CCU	39	0	0	0	0	0	0	0	0
non-CCU	40	0	0	0	0	0	0	0	0
non-CCU	41	0	0	0	0	0	0	0	0
non-CCU	42	0	0	0	0	0	0	0	0
non-CCU	43	0	1	0	0	0	0	0	1
non-CCU	44	0	1	0	0	0	1	0	2
non-CCU	45	0	0	0	0	0	0	0	0
non-CCU	46	0	0	0	0	0	0	0	0
non-CCU	47	0	0	0	0	0	0	0	0
non-CCU	48	0	0	1	0	0	0	0	1
non-CCU	49	0	0	0	0	0	0	0	0
non-CCU	50	0	1	1	0	0	0	0	2
non-CCU	51	0	0	0	0	0	0	0	0
non-CCU	52	1	1	0	0	0	0	0	2
non-CCU	54	1	1	1	0	1	0	0	4
non-CCU	55	0	0	0	0	0	0	0	0
non-CCU	56	0	1	0	0	0	0	0	1
non-CCU	57	0	0	0	0	0	0	0	0
non-CCU	58	0	0	0	0	0	0	0	0
non-CCU	59	0	1	0	0	0	0	0	1
non-CCU	60	0	1	0	0	0	0	0	1
non-CCU	61	0	0	0	0	0	0	0	0
non-CCU	62	0	0	0	0	0	0	0	0
non-CCU	63	0	0	0	0	0	0	0	0
non-CCU	64	0	0	0	0	0	0	0	0
non-CCU	65	0	1	0	0	0	0	0	1
non-CCU	66	0	0	0	0	0	0	0	0

non-CCU	67	0	0	0	0	0	0	0	0
non-CCU	68	0	0	0	0	0	0	0	0
non-CCU	69	0	1	0	0	0	0	0	1
non-CCU	70	0	1	0	0	0	0	0	1
non-CCU	71	0	0	0	0	0	0	0	0
non-CCU	72	0	1	0	0	0	0	0	1
non-CCU	73	0	0	0	1	0	0	0	1
non-CCU	74	0	0	1	0	0	0	0	1
non-CCU	75	0	1	1	0	1	0	0	3
non-CCU	76	0	1	1	0	0	0	0	2
non-CCU	77	0	1	1	0	0	0	0	2
non-CCU	78	0	0	0	0	0	0	0	0
non-CCU	79	0	0	0	0	0	0	0	0
non-CCU	80	0	1	0	0	0	0	0	1
non-CCU	81	0	1	0	0	0	0	0	1
non-CCU	82	0	0	0	0	0	0	0	0
non-CCU	83	0	1	0	0	1	0	0	2
non-CCU	84	0	1	0	0	1	0	0	2
non-CCU	85	0	1	1	0	1	0	0	3
non-CCU	86	0	0	0	0	0	0	0	0
non-CCU	87	1	1	0	0	0	0	0	2
non-CCU	89	0	1	0	0	0	0	0	1
non-CCU	90	0	1	1	0	0	0	0	2
non-CCU	91	0	0	0	0	0	0	0	0
non-CCU	92	0	1	0	0	0	0	0	1
non-CCU	93	0	0	0	0	0	0	0	0
non-CCU	94	0	1	1	0	1	0	0	3
non-CCU	95	0	1	0	0	0	0	0	1
non-CCU	97	0	1	0	0	0	0	0	1
non-CCU	98	0	0	0	0	0	0	0	0
non-CCU	99	0	0	0	0	1	0	0	1
non-CCU	100	0	0	0	0	0	0	0	0
non-CCU	101	0	0	0	0	0	0	0	0
non-CCU	102	0	0	0	0	0	0	0	0
non-CCU	103	0	0	0	0	0	0	0	0
non-CCU	104	0	0	1	0	0	0	0	1
non-CCU	105	0	0	1	0	0	0	0	1
non-CCU	106	0	1	1	0	0	0	0	2
non-CCU	107	0	0	0	1	0	0	0	1
non-CCU	108	1	0	1	0	0	0	0	2
non-CCU	109	0	1	0	1	1	0	0	3
non-CCU	110	0	1	0	0	0	0	0	1
non-CCU	111	0	1	0	0	0	0	0	1
non-CCU	112	0	0	0	0	0	0	0	0
non-CCU	113	0	0	0	0	0	0	0	0
non-CCU	114	0	1	0	0	0	0	0	1
non-CCU	115	0	0	0	0	0	0	0	0
non-CCU	116	0	1	1	0	0	0	0	2
non-CCU	117	1	0	1	0	1	0	0	3
non-CCU	119	0	0	1	0	0	0	0	1
non-CCU	120	0	1	1	1	0	0	1	4
non-CCU	121	0	1	1	0	0	0	0	2
non-CCU	122	0	0	0	0	0	0	0	0

non-CCU	123	0	0	0	0	0	0	0	0	0
non-CCU	124	0	1	1	0	0	0	0	0	2
non-CCU	126	0	0	0	0	0	0	0	0	0
non-CCU	132	1	0	0	0	0	0	0	0	1
non-CCU	133	0	1	1	1	0	0	0	0	3
non-CCU	134	0	1	1	0	0	0	0	0	2
non-CCU	135	0	0	0	0	0	0	0	0	0
non-CCU	136	0	1	0	0	0	0	0	0	1
non-CCU	138	1	0	0	1	0	0	0	0	2
non-CCU	145	0	0	1	0	0	0	0	1	2
non-CCU	146	1	1	0	0	0	0	0	1	3
non-CCU	147	1	1	1	0	0	0	0	1	4
non-CCU	148	0	1	1	0	1	0	0	0	3
non-CCU	149	1	0	1	0	0	0	0	0	2
non-CCU	153	1	0	0	1	1	0	0	0	3
non-CCU	155	0	1	1	0	0	0	0	0	2
non-CCU	156	0	0	0	0	0	0	0	0	0
non-CCU	157	1	1	1	0	0	0	0	1	4
non-CCU	158	0	1	1	0	0	0	0	0	2
non-CCU	160	0	0	0	0	0	0	0	1	1
non-CCU	161	0	0	0	0	0	0	0	0	0
non-CCU	162	0	1	0	0	1	0	0	1	3
non-CCU	163	1	0	0	0	0	0	0	0	1
non-CCU	164	0	0	1	0	0	0	0	0	1
non-CCU	165	0	1	1	0	0	0	0	1	3
non-CCU	166	0	0	0	0	0	0	0	0	0
non-CCU	167	0	1	0	0	0	0	0	1	2
non-CCU	168	1	1	1	1	0	0	0	1	5
non-CCU	169	1	1	1	0	0	0	0	0	3
non-CCU	171	1	0	1	0	1	0	0	0	3
non-CCU	173	1	0	0	0	0	0	0	1	2
non-CCU	174	0	0	0	0	0	0	0	0	0
non-CCU	175	1	0	0	1	0	0	0	1	3
non-CCU	176	0	0	1	0	0	0	0	1	2
non-CCU	177	0	0	0	0	0	0	0	0	0
non-CCU	179	1	1	1	0	0	1	0	0	4
non-CCU	180	0	0	0	1	0	0	0	0	1
non-CCU	181	0	0	1	0	0	0	0	0	1
non-CCU	182	0	0	0	0	0	0	0	1	1
non-CCU	183	0	0	0	1	0	0	0	0	1
non-CCU	184	1	0	1	0	0	0	0	0	2
non-CCU	185	0	0	0	0	0	0	0	0	0
non-CCU	186	1	0	0	0	1	0	0	1	3
non-CCU	189	0	0	0	1	0	0	0	0	1
non-CCU	190	0	0	0	0	0	0	0	0	0
non-CCU	191	0	0	0	0	0	0	0	0	0
non-CCU	192	0	1	1	0	0	0	0	1	3
non-CCU	193	1	0	0	0	0	0	0	0	1
non-CCU	195	0	1	0	0	0	1	0	1	3
non-CCU	196	0	0	1	0	0	0	0	0	1
non-CCU	197	0	1	1	0	0	0	0	0	2
non-CCU	198	0	1	0	1	0	0	0	1	3
non-CCU	199	0	0	1	1	0	0	0	1	3

non-CCU	200	0	0	0	0	0	0	1	1
non-CCU	201	0	0	0	1	0	0	1	2
non-CCU	203	0	0	0	0	0	0	1	1
non-CCU	204	0	0	1	1	0	0	0	2
non-CCU	205	1	0	0	0	0	0	1	2
non-CCU	206	0	0	0	0	0	0	0	0
non-CCU	207	0	0	0	0	0	0	0	0
non-CCU	208	0	0	0	0	0	0	0	0
non-CCU	209	1	0	0	0	0	0	0	1
non-CCU	211	1	1	1	0	0	1	0	4
non-CCU	212	0	1	1	0	0	0	1	3
non-CCU	213	0	0	1	0	0	0	0	1
non-CCU	214	0	0	0	0	0	0	1	1
non-CCU	215	1	1	1	1	0	0	0	4
non-CCU	218	1	1	1	0	0	0	0	3
non-CCU	219	1	0	0	0	0	0	1	2
non-CCU	220	0	0	0	0	0	0	0	0
non-CCU	221	0	0	0	0	0	0	0	0
non-CCU	222	0	1	1	0	0	0	0	2
non-CCU	223	1	0	0	0	0	0	0	1
non-CCU	227	0	0	0	0	0	0	0	0
non-CCU	228	0	0	1	1	0	0	0	2
non-CCU	229	0	0	0	0	0	0	0	0
non-CCU	230	0	0	0	0	0	0	0	0
non-CCU	231	0	0	1	0	0	0	1	2
non-CCU	232	0	0	1	0	0	0	1	2
non-CCU	233	0	1	1	0	0	0	0	2
non-CCU	234	1	1	0	1	0	0	1	4
non-CCU	235	0	0	0	0	0	0	1	1
non-CCU	237	0	0	1	0	0	0	0	1
non-CCU	238	1	0	0	0	0	0	1	2
non-CCU	239	0	0	0	0	0	0	0	0
non-CCU	241	0	0	1	0	1	0	0	2
non-CCU	242	1	0	0	0	0	0	0	1
non-CCU	243	0	1	1	0	0	0	0	2
non-CCU	244	1	1	0	0	0	0	1	3
non-CCU	245	1	0	1	0	0	0	0	2
non-CCU	247	0	1	1	1	0	0	1	4
non-CCU	248	0	0	1	0	0	0	0	1
non-CCU	249	1	0	0	0	0	0	0	1
non-CCU	250	0	0	0	0	0	0	0	0
non-CCU	251	0	1	1	0	0	0	1	3
non-CCU	252	0	1	0	0	0	0	0	1
non-CCU	253	1	1	0	0	0	0	0	2
non-CCU	254	0	0	0	0	0	0	1	1

Abbreviations: CCU, critical care unit.

Table S7. Predictors for hospital length of stay (linear regression model)

Variables	All cohort (N=254)	Subgroup analyses		
		CCU (n=44)	HDU (n=34)	ICU (n=25)
CCU admission				
<i>yes</i>	2.915 (1.937, 3.894)	NA	NA	NA
<i>no (reference)</i>				
Age	0.007 (-0.026, 0.041)	0.035 (-0.118, 0.189)	0.091 (-0.121, 0.304)	-0.025 (-0.305, 0.255)
Gender				
<i>male</i>	-0.171 (-1.047, 0.705)	-1.688 (-5.787, 2.410)	-2.300 (-7.572, 2.971)	-3.333 (-10.380, 3.713)
<i>female (reference)</i>				
BMI	0.061 (0.008, 0.113)	0.223 (0.012, 0.435)	0.337 (0.075, 0.599)	0.412 (0.068, 0.756)
ATSI origin	0.667 (-0.558, 1.892)	7.246 (1.322, 13.171)	7.641 (0.856, 14.427)	12.803 (3.473, 22.133)
Surgery type				
<i>SG</i>	1.788 (0.998, 2.579)	-1.344 (-5.570, 2.883)	-1.890 (-7.293, 3.512)	-6.444 (-14.450, 1.561)
<i>GBP</i>	2.417 (0.344, 4.490)	-1.824 (-11.873, 8.226)	-1.824 (-13.224, 9.577)	-7.333 (-25.676, 11.009)
<i>GB (reference)</i>				
Number of co-morbidities	0.459 (0.161, 0.756)	0.069 (-1.321, 1.459)	0.004 (-1.761, 1.769)	-0.870 (-3.238, 1.497)

Abbreviations: CCU, critical care unit; GB, gastric banding; GBP, gastric bypass; HDU, high dependency unit; ICU, intensive care unit; NA, no applicable; SG, sleeve gastrectomy.

Table S8. Sensitivity analysis of linear regression analysis of hospital length of stay

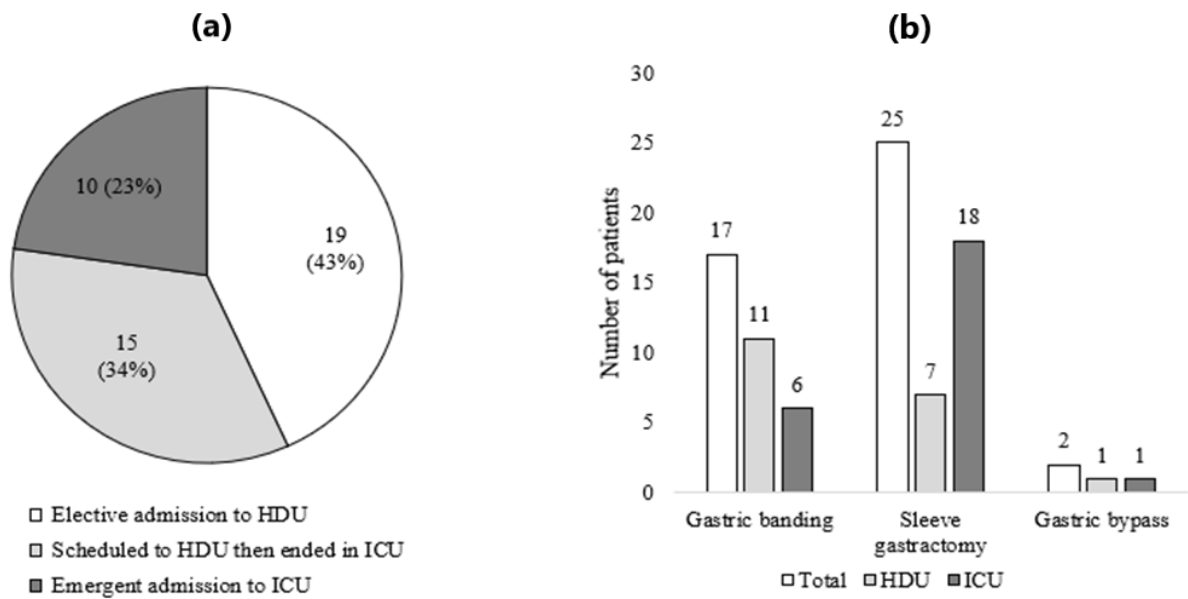
Variables	All cohort (N=253)	Subgroup analyses		
		CCU (n=43)	HDU (n=33)	ICU (n=24)
CCU admission				
<i>yes</i>	1.985 (1.465, 2.504)	NA	NA	NA
<i>no (reference)</i>				
Age	0.001 (-0.017, 0.020)	0.008 (-0.043, 0.059)	0.056 (0.006, 0.105)	-0.043 (-0.116, 0.031)
Gender				
<i>male</i>	0.063 (-0.416, 0.542)	-0.174 (-1.557, 1.209)	-0.338 (-1.672, 0.995)	-0.671 (-2.620, 1.277)
<i>female (reference)</i>				
BMI	-0.018 (-0.048, 0.011)	-0.032 (-0.112, 0.047)	0.022 (-0.057, 0.100)	-0.038 (-0.158, 0.083)
ATSI origin	-0.776 (-1.449, -0.103)	-1.154 (-3.544, 1.147)	-0.759 (-2.744, 1.227)	-0.864 (-4.359, 2.632)
Surgery type				
<i>SG</i>	2.080 (1.722, 2.438)	1.105 (-0.290, 2.500)	0.558 (-0.800, 1.916)	0.289 (-2.171, 2.749)
<i>GBP</i>	2.709 (1.770, 3.647)	0.625 (-2.644, 3.894)	0.625 (-2.209, 3.459)	-0.600 (-5.931, 4.731)
<i>GB (reference)</i>				
Number of co-morbidities	0.405 (0.248, 0.563)	0.231 (-0.226, 0.688)	0.186 (-0.247, 0.620)	-0.128 (-0.780, 0.524)

Abbreviations: CCU, critical care unit; GB, gastric banding; GBP, gastric bypass; HDU, high dependency unit; ICU, intensive care unit; NA, no applicable; SG, sleeve gastrectomy.

Table S9. Main reasons (or complications) for unplanned ICU admission following bariatric surgery (n=25)

Indication	Number of patients
<i>Delayed gastric emptying</i>	1
<i>Systemic and wound infection</i>	1
<i>Leakage or perforation</i>	1
<i>Bleeding</i>	2
<i>Incisional hernia or wound dehiscence</i>	5
<i>Nausea and vomiting</i>	7
<i>Respiratory insufficiency or failure (ventilator)</i>	12
<i>Cholecystitis, pancreatitis</i>	1
<i>Renal failure</i>	8
<i>Abdominal Adhesions</i>	4
<i>Severe electrolyte disturbances</i>	6

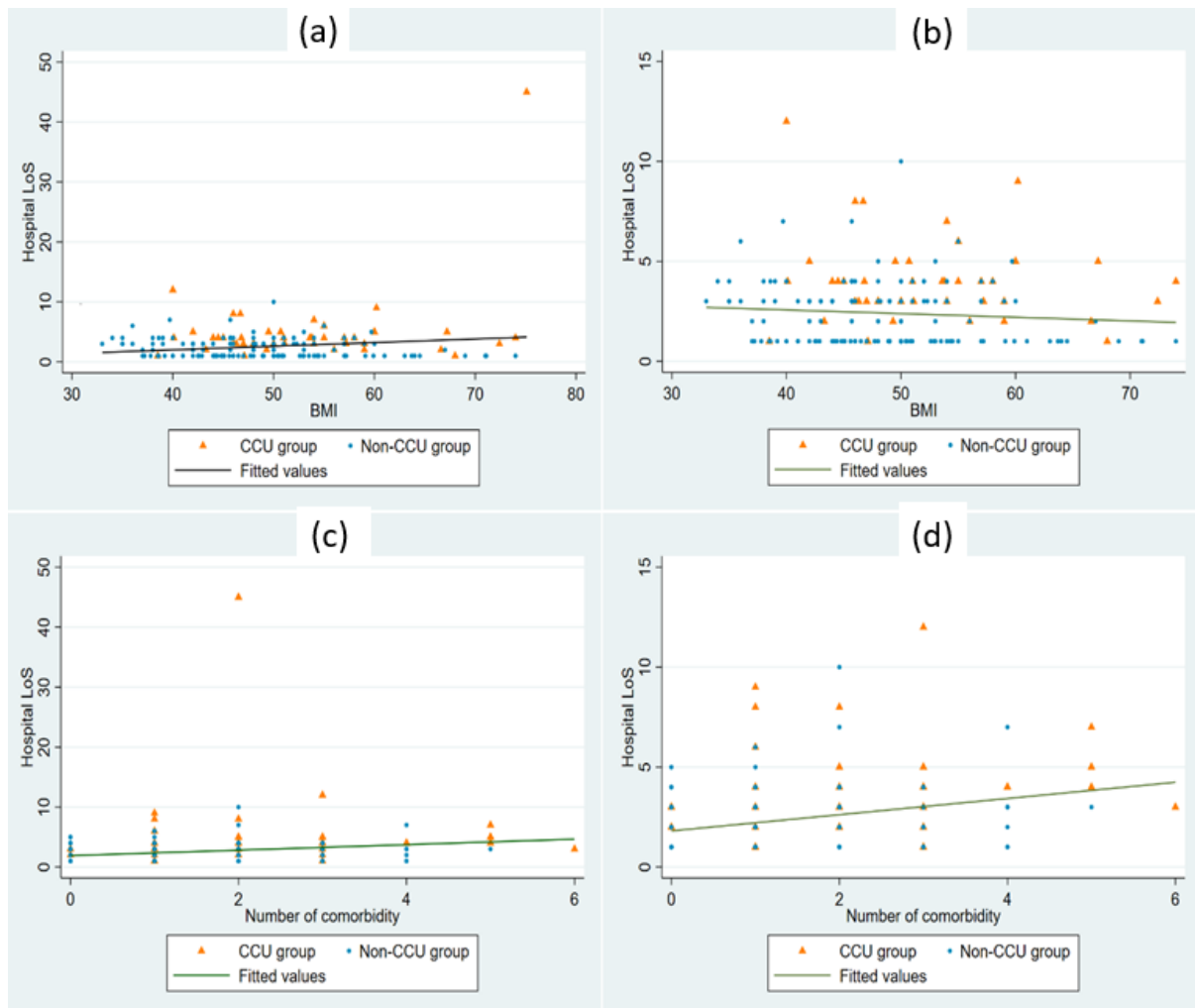
Figure S1. Distribution of (N=44) patients who needed CCU support by admission type (a) and by surgery type (b).



Footnote: 1) n=34 patients were scheduled to HDU before surgery, and 15 of them were ended into ICU; therefore, n=19 patients received HDU support and n=25 received ICU support.

2) The n=10 patients with emergency (unplanned) admission to ICU were all conducted using sleeve gastrectomy procedure (SG).

Figure S2: Scatter plot and Spearman correlation analysis of hospital LoS with covariables. (a) BMI and LoS [$P=0.142$]; (b) BMI and LoS [sensitivity analysis by excluding one outlier, $P=0.091$]; (c) comorbidity and LoS [$P<0.001$]; (d) comorbidity and LoS [sensitivity analysis by excluding one outlier, $P<0.001$].



Footnote: Orange triangles indicate the CCU group and blue circles indicate non-CCU group.