



Prince of Wales Hospital



The Chinese University of
Hong Kong



CARDIAC SURGERY REPORT

2021
2022

Prepared by :
Division of Cardiothoracic Surgery
Department of Surgery



Prince of Wales Hospital



The Chinese University of
Hong Kong

CARDIAC SURGERY REPORT

2021
2022

Prepared by :
Division of Cardiothoracic Surgery
Department of Surgery

ABBREVIATION LIST

ABBREVIATION LIST

ASD	Atrial Septal Defect
AVR	Aortic Valve Replacement
CABG	Coronary Artery Bypass Grafting
CPB	Cardiopulmonary Bypass
CUSUM	Cumulative sum
EACTS	European Association for Cardio-Thoracic Surgery
ECMO	Extracorporeal Membrane Oxygenation
EuroSCORE	European System for Cardiac Operative Risk Evaluation
HA	Hospital Authority
HK	Hong Kong Special Administrative Region of the People's Republic of China
IABP	Intra-aortic Balloon Pump
JCVSD/NCD	Japanese Cardiovascular Surgery Database/National Clinical Database
LAA	Left Atrial Appendage
LAD	Left Anterior Descending Artery
LIMA	Left Internal Mammary Artery
LMS	Left Main Stem
LV aneurysmectomy	Left Ventricular Aneurysmectomy
LVAD	Left Ventricular Assist Device
LVEF	Left Ventricular Ejection Fraction
MVR	Mitral Valve Replacement
MI	Myocardial Infarction
MIS	Minimally Invasive Surgery
NACSD	National Adult Cardiac Surgical Database
O/E Ratio	Observed versus Expected ratio
PCI	Percutaneous Coronary Intervention
PWH	Prince of Wales Hospital
SCTS	Society of Cardiothoracic Surgery
STS ACSD	The Society of Thoracic Surgeons Adult Cardiac Surgery Database
TEVAR	Thoracic Endovascular Aortic Repair
UK	The United Kingdom
US	The United States of America
VLAD	Variable Life-adjusted Display
VSD	Ventricular Septal Defect

EXECUTIVE SUMMARY

1. This report encompasses outcomes for all cardiac operations performed in the two years between January 2021 and December 2022 at the PWH. It highlights the advances in clinical practice and improvements in the cardiac surgical outcomes in terms of the crude in-hospital mortality rates, which have been achieved even in patient populations of increasing risk due to older age and comorbidities.
2. There is a modest improvement in the mortality rates in **isolated CABG operations** (from 1.4% to 0%) when we compare the current report with 2019-2020 results. We have maintained low crude in-hospital mortality rates for **isolated valve** (2.6%) and **major aortic** (6.8%) surgeries during 2021-2022, comparing well with international standards.
3. Case volumes for isolated CABG have decreased steadily, with a 18.4% decrease in reported volumes overall in comparison to the preceding report in 2019-2020. The differences in case-mix can be attributed to the difference in the percentage of isolated CABG at the PWH (28%) vs in the UK (41.7%) in 2015-2016 and the US STS ACSD ($\approx 72.2\%^3$) in 2020-2021. Highlighting there is a shift in PWH cardiac surgery workload to become more diversified.
4. We are undertaking proportionally more major aortic procedures in these ten years, with a doubling in the number of caseloads performed during the era of this study. The crude mortality rate of this group remains low despite increasing age, risk profile, the frailty of patients, and the inadequate workforce.
5. Despite the concrete differences in case-mix between PWH and the pooled UK & EACTS data, most of the cardiac surgical outcomes at the PWH are in line with UK & EACTS standards, in terms of the crude mortality and major morbidity rates.
6. The three major morbidity rates including re-operation for bleeding, new post-operative stroke, and new post-operative dialysis after cardiac surgery fall comfortably within the control limits, showing satisfactory quality of cardiac surgery at the PWH.
7. This report also demonstrates the added value of the use of data analysis to deliver quality improvement. The completeness of the data in the PWH database has improved over time and most fields now have a very low incidence of missing data. In terms of the audit trail, 5% cases of all major operation groups were randomly selected and cross-checked to ensure data accuracy.
8. We continue to drive a number of initiatives to improve both outcomes of care for patients and quality assurance processes and to maintain 'real-time' monitoring for the selected outcomes with mechanisms to address divergent practices.

TABLE OF CONTENT

ABBREVIATION LIST	3
EXECUTIVE SUMMARY	4
OUR EDITORIAL AND SURGICAL TEAM.....	6
PREFACE.....	7
A MESSAGE FROM OUR TEAM HEAD	8
INTRODUCTION	10
DATABASE OVERVIEW	13
CORONARY SURGERY	32
Isolated CABG in the context of the overall workload.....	33
Pre-operative risk factors.....	34
Logistic EuroSCORE and the crude mortality rate	43
VLAD plot of risk-adjusted mortality rate	46
Other immediate post-operative outcomes.....	48
Funnel plot of the crude mortality rate	50
VALVE SURGERY.....	51
Isolated valve surgery in the context of the overall workload.....	52
Pre-operative risk factors.....	53
Aortic valve surgery	56
Mitral valve surgery	59
Tricuspid valve surgery.....	62
Logistic EuroSCORE and the crude mortality rate	63
VLAD plot of risk-adjusted mortality rate	67
Other immediate post-operative outcomes.....	68
Funnel plot of the crude mortality rate	71
AORTIC SURGERY	73
Aortic surgery in the context of the overall workload.....	74
Number and details of segments treated.....	75
Pathology and arterial cannulation	76
Logistic EuroSCORE and the crude mortality rate	77
VLAD plot of risk-adjusted mortality rate	79
Other immediate post-operative outcomes.....	81
Funnel plot of the crude mortality rate	84
MINIMALLY INVASIVE CARDIAC SURGERY.....	86
CONCLUSION.....	88
APPENDIX	90

OUR EDITORIAL AND SURGICAL TEAM

EDITOR-IN-CHIEF

Executive Officer

- Ms. Karen Hoi-Ling NG

SURGEONS AT THE PWH

Division Chief and Consultant

- Prof. Randolph Hung-Leung WONG

Professors and Consultants

- Prof. Malcolm John UNDERWOOD¹
- Prof. Song WAN
- Dr. Innes Yuk-Pui WAN

Associate Consultants

- Dr. Takuya FUJIKAWA
- Dr. Micky Wai-Ting KWOK
- Dr. Simon Chi-Ying CHOW
- Dr. Jacky Yan-Kit HO

Residents

- Dr. Joyce Wing-Yan CHAN
- Dr. Kevin LIM
- Dr. Aliss Tsz-Ching CHANG
- Dr. Ivan Chi-Hin SIU
- Dr. Peter Sze-Yuen YU¹

¹ Surgeon who had left HA at the time of publication of this report
CARDIAC SURGERY REPORT 2021-2022

PREFACE

I am honored to introduce this biennial report on cardiac surgical outcomes, providing a comprehensive overview of the progress and achievements faced in the field of cardiac surgery over the past two years. This report serves as a testament to the unwavering commitment of the cardiac surgical team in PWH, whose tireless efforts have significantly impacted the lives of countless patients and their families.

Cardiac surgery, a discipline at the forefront of medical innovation, continues to evolve through advancements in surgical techniques, perioperative care, and multidisciplinary collaboration. This report highlights the collective achievements of cardiac surgeons, anesthesiologists, perfusionists, nurses, and allied healthcare professionals who work tirelessly to provide the highest level of care to patients with cardiovascular diseases. Therefore, I extend my deepest gratitude to the cardiac surgical team in PWH whose dedication and expertise made this report possible.

Within these pages, you will find a wealth of data, analyses, and insights derived from a wide range of cardiac surgical procedures. We delve into the outcomes of coronary artery bypass grafting (CABG), valve repair and replacement, and other complex aortic interventions. Despite a more pronounced pace of our population ageing, our team has consistently achieved a low overall crude mortality rate of 3.5% during the assessment period. Another impressive achievement is found in the *isolated CABG* surgery and *isolated aortic valve replacement* with a zero-mortality rate recorded. Hopefully, the meticulous collection and analysis of surgical data enable us to evaluate and refine our practices, ensuring the best possible outcomes for patients.

May this report serve as a valuable resource for healthcare professionals and stakeholders, inspiring continued advancements in cardiac surgical care. Together, let us strive for excellence, push the boundaries of innovation, and ultimately improve the lives of patients affected by cardiovascular diseases.



Dr. Kin-Lai CHUNG
Hospital Chief Executive
(Prince of Wales Hospital)
Cluster Chief Executive
(New Territories East Cluster)

A MESSAGE FROM OUR TEAM HEAD

"In the midst of difficulty lies opportunity"

-Chinese Proverb

The Chinese proverb "In the midst of difficulty lies opportunity" is a maxim that holds true in many aspects of life, and it is particularly relevant to the current challenges in our healthcare system. The latest report of our cardiac surgeries highlights a notable shift in our case mix, with a greater focus on complex procedures such as aortic root and arch surgeries, as well as descending and thoracoabdominal aortic surgeries. These procedures now account for 26% of all our cardiac activities.

Despite the increased complexity and risk profile of our patients, our dedicated team has excelled in maintaining exceptionally low observed mortality rates, which are better than expected across all categories when compared to international databases. Our team's remarkable achievements include zero mortality in coronary artery bypass graft surgery and exceptional fast-track management of patients with acute coronary syndrome which earned us the HA Outstanding Team Award for 2023. These successes are a testament to the collective efforts of our multidisciplinary team, which includes cardiologists, cardiac surgeons, anesthesiologists, perfusionists, ward nurses, critical care unit and operating room staff, as well as paramedical professionals such as physiotherapists, occupational therapists, and speech therapists. This recognition is a testament to our team's commitment to excellence, professionalism, and dedication to providing the highest quality of care to our patients.

The years 2021 and 2022 were challenging for Hong Kong, with the COVID-19 pandemic and a shortage of anesthetic manpower heavily impacting our cardiothoracic surgery service. This led to a reduction in operating sessions and an extended waiting list for patients. However, we firmly believe that "in the midst of difficulty lies opportunity." As such, it is crucial for administrators and policymakers to adopt flexible employment strategies that attract talent from private markets and both national and international arenas. This is especially important for smaller specialties providing essential, highly specialized services to the public patients of Hong Kong. By leveraging the expertise and experience of healthcare professionals from diverse backgrounds, we can enhance the quality of care that we provide to our patients and ensure that we continue to meet the evolving needs of our community.

In conclusion, the latest report on the state of our cardiac surgeries highlights the remarkable

achievements of our team in the face of challenges. We are proud to have received the HA Outstanding Team Award for 2023, and we remain committed to providing the highest quality of care to our patients. As we navigate the challenges of the present and future, we will continue to seek out opportunities for growth and improvement, guided by the wisdom of the Chinese proverb "In the midst of difficulty lies opportunity."



I am truly proud of the NTEC Multidisciplinary Complex Coronary Revascularization Team for winning one of the HA outstanding team awards in 2023. Kudos to all the team members.



Professor Randolph Wong
Professor and Chief
Honorary Consultant
Division of Cardiothoracic Surgery
Prince of Wales Hospital
Chinese University of Hong Kong

INTRODUCTION

Introduction to data collection and reporting

Methodology

We began data collection as part of a quality assurance programme for patients undergoing cardiac surgery in our Institute in November 2005. Since that time, we have moved purposefully from basic outcome analysis described in the first report in 2006 to advanced 'international benchmarking' with the Society for Cardiothoracic Surgery in the United Kingdom (documented in the 2009 & 2020 publications) and European Association for Cardio-Thoracic Surgery (documented in the 2010 publication). We also collaborated with colleagues from the other two Departments in Hong Kong which provide cardiac surgery, in a joint international benchmarking project of our coronary surgery activity and outcomes. This endeavor highlighted the value of our moves towards 'global' benchmarking for cardiac surgical activity and outcomes. In this current report, we again highlight our trend towards 'real-time' monitoring of mortality, morbidity, and other areas of quality provision. Our goal has always been public transparency and again this report is published and is freely available on the internet (<https://www.surgery.cuhk.edu.hk/cts/#reports>).

Our data collection, methodology, and principles have essentially remained unchanged. Our underlying principle has always been that to have a usable database, fit for purpose, particularly for 'real time' monitoring, the most accurate data is collected at the point of patient care and it is the professional responsibility of all individuals engaged in providing such care to ensure this is done.

In terms of clinical activity, our patient population continues to progressively change. The risk of the patients we are operating on has increased year on year. A constant change has been the increase in patients referred for urgent and emergency surgery. In the last two years, the number of cases undertaken on an urgent basis has again increased. There continue to be changes in the complexity of the operations undertaken with significant increases in the number of double and triple valvular operations and a maintained increase in the number of re-operative and combined surgeries. This again implies future resource usage and service provision. In past reports, we have excluded patients who underwent complex endovascular interventions on the aorta but with increasing numbers of these patients, this intervention has become a significant part of all major operation groups, which is now included in all our analysis. This will continue to significantly impact our activity and outcomes as these complex patients now have dedicated routine follow up which often identifies ongoing pathology which may require complex interventions, either open surgery or using endovascular techniques.

Despite all our efforts and attempts to maximize our case-load, we still have a significant number of patients waiting for cardiac surgery. Addressing this is now not so much a problem of the facility, but resource in terms of medical, nursing, and ancillary personnel. With the manpower issues which have been so well documented in the local media, it is unlikely that this situation will change significantly in the near future.

Despite the noted reduction in the recent numbers of our coronary revascularisation cases, there seems to be a continued under-provision of cardiac surgery for our local population. The reasons for this are most likely multi-factorial and may relate to access to primary care, cultural issues and perceptions of cardiac surgical safety and outcomes, follow-up facility after attending accident and emergency with chest pain, etc. There are many challenges to face to ensure we can provide a prompt and high-quality cardiac surgical service for our local population. The importance of collecting and collating accurate data so we can monitor activity and outcomes has never been clearer.

The Division of Cardiothoracic Surgery

The Division of Cardiothoracic Surgery, the Chinese University of Hong Kong (CUHK) is based at the Prince of Wales Hospital (PWH), an acute regional hospital as well as the teaching hospital associated with CUHK. It is situated in the New Territories and hosts the Regional Trauma Center as well as other acute surgical specialties. The Division of Cardiothoracic Surgery provides complete services within the specialty for a population of approximately 3.7 million people, excluding paediatric cardiac surgery, cardiac transplantation, and oesophageal surgery.

Within the Division of Cardiothoracic Surgery, there are now 36 designated beds in ward 7C (Level 7, New Build PWH). Ward 7C provides exclusive use of 6 High-Dependency beds for cardiac surgery. The Intensive Care Unit (ICU) is located on Level 5 adjacent to the operating suite. To maintain our level of activity however there needs to be close co-operation with colleagues in intensive care to allow flexibility in this arrangement. Cardiac surgical patients are looked after by accredited intensivists whilst on ICU with surgical input where appropriate. Patients transferred from ICU to the HDU are looked after by the cardiac surgical team with input from other support specialties when requested. We have one dedicated theatre solely for cardiac surgery which is currently funded for use 5 days a week and a second cardiac theatre which has been equipped as a fully functioning 'hybrid' suite. A pre-operative cardiac assessment clinic is currently held weekly.

Outcome: Presentation

Some of the outcomes presented in this report have again been ‘benchmarked’ against the national cardiac surgical database report from the UK, namely the *Sixth National Adult Cardiac Surgical Database Report 2008* and the *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*. Furthermore, we have related some approximate international results from the US publication *The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD): 2022 Update on Outcomes and Research* and Japan publication *Japan Association for Thoracic Surgery (JCVSD/NCD): Thoracic and cardiovascular surgeries in Japan during 2017 and 2018* for reference. We recognize that the populations treated may be inherently different, but the UK, STS ACSD, and Japan publications continue to be the robust and well-respected databases in the field of cardiac surgery.

In our report, we have reported ‘observed’ versus ‘expected’ outcomes. We have focused on cumulative activity for the consecutive calendar years 2021 and 2022. We have compared the cumulative data in 2021-2022 with that in 2019-2020 in some aspects.

DATABASE OVERVIEW



An overview of the outcome at the Prince of Wales Hospital

- There were 805 cardiac surgical procedures performed at the PWH during 2021-2022.
- Fig 1.01 shows the distribution of these procedures by operative category. The categories are grouped so comparative analysis of the major operative groups can be made with greater statistical power. The category "Other" contains procedures outside the main operative categories. This is a complex group and the bulk of procedures represented include mainly aortic procedures, and other complex operations.
- Fig 1.02a-b show the overall cardiac activities at the PWH over time. There is a growing trend towards major aortic procedures as seen by decreasing isolated CABG caseloads from 2011 to 2022.
- All comparisons with the data from the United Kingdom come from results published by the Society for Cardiothoracic Surgery (SCTS) in Great Britain & Ireland in their *Sixth National Adult Cardiac Surgical Database Report 2008* and *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*, and relate to the most up-to-date data in these two documents, during the calendar years 2002 and 2016.
- There are also limited comparisons on the *approximate* in-hospital mortality rates and the major morbidity rates from the United States publication *The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD): 2022 Update on Outcomes and Research*, and the Japan publication *Japan Association for Thoracic Surgery (JCVSD/NCD): Thoracic and cardiovascular surgeries in Japan during 2017 and 2018*, and relate to the most up-to-date data in these two documents, during 2020-2021 and 2017-2018 respectively.

Fig 1.01 Volume of major adult cardiac surgery procedures at the PWH, 2021-2022

Countries or institutions Procedure grouping	PWH		UK		JAPAN
	2021-2022 Count (Prop.)	2011-2012 Count (Prop.)	2008 Prop.	2015-2016 Prop.	2017-2018 Prop. ²
Isolated CABG	230 (28.6%)	322 (44%)	58.3%	41.7%	≈17.8%
Isolated valve	153 (19.0%)	241 (33%)	18.9%	48.4%	≈34.1%
Valve & other	166 (20.6%)	35 (5%)	4.5%		
CABG & valve	31 (3.9%)	38 (5%)	11.5%		
CABG, valve & other	17 (2.1%)	6 (1%)	1.6%	N/A	≈48.1%
CABG & other	25 (3.1%)	6 (1%)	2.0%		
Other	183 (22.7%)	84 (11%)	3.2%		
Total	805 (100%)	732 (100%)	100%	100%	100%

² Approximate proportion/in-hospital mortality rate derived from the *Japan Association for Thoracic Surgery (JCVSD/NCD): Thoracic and cardiovascular surgeries in Japan during 2017 and 2018*

Fig 1.02a Overall workload at the PWH, 2017-2022

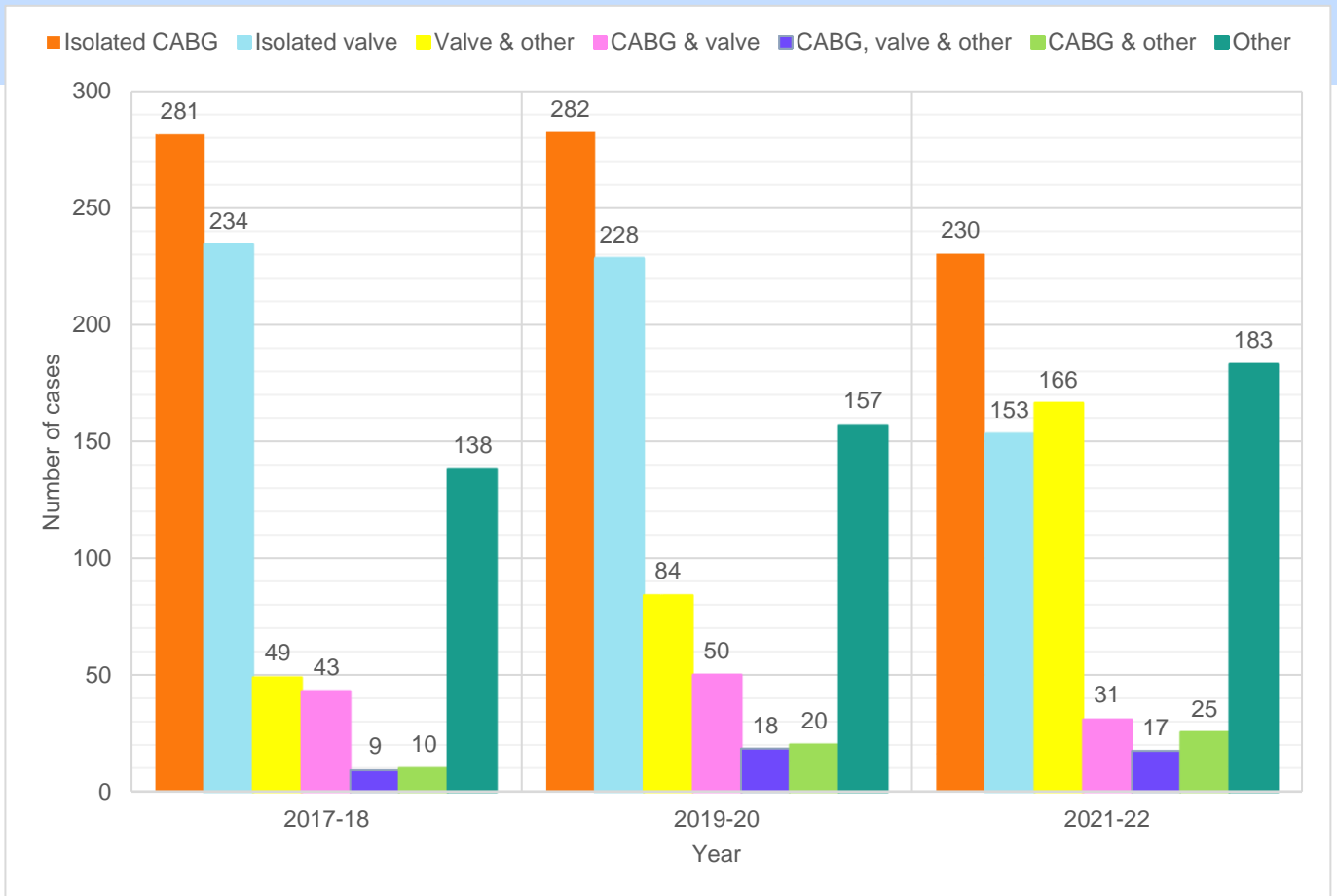
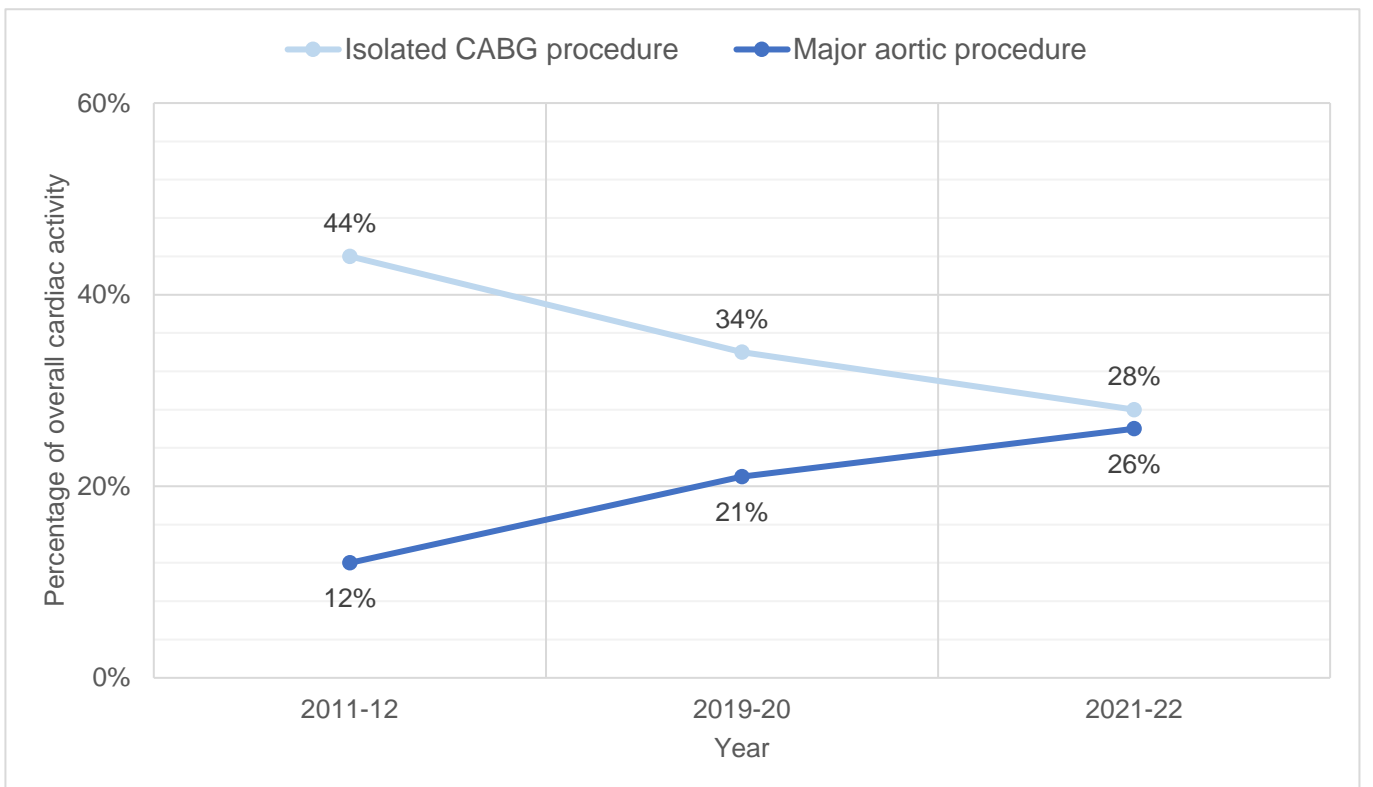


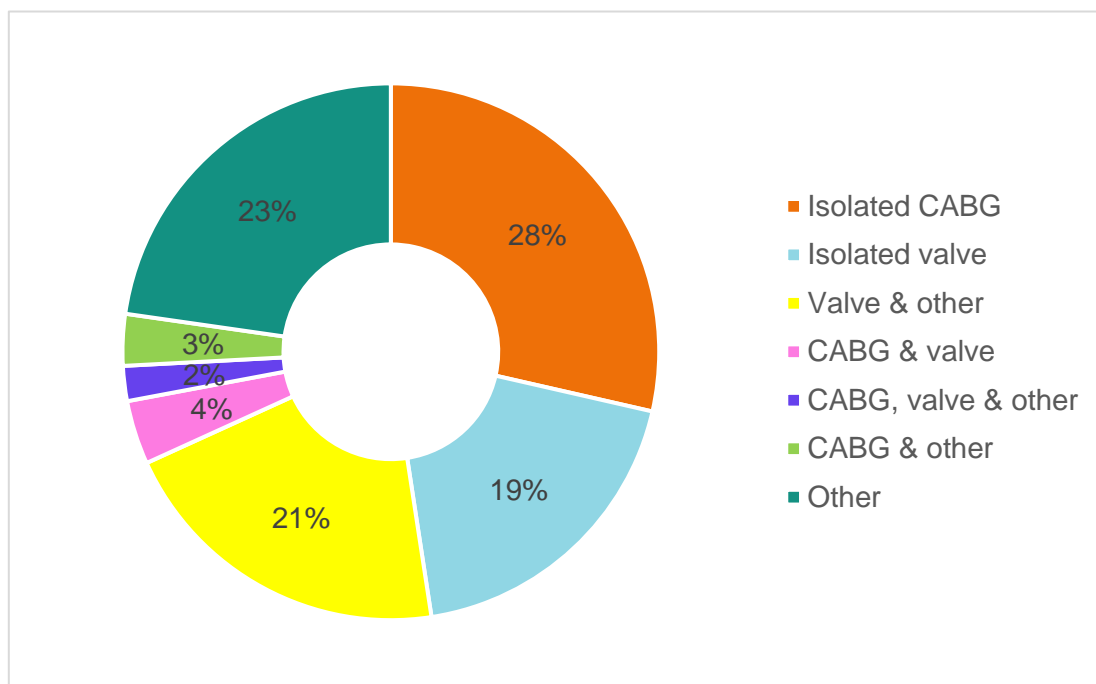
Fig 1.02b Future trend towards increasing major aortic procedures at the PWH, 2011-2022



Procedure groupings

- Fig 1.03 shows the same data presented as a percentage of overall activity.
- The activities of adult cardiac surgeries at the PWH have been largely static between the calendar years 2017 and 2022.
- Case volumes for isolated Coronary Artery Bypass Graft (CABG) have decreased steadily, with a 29% decrease in reported volumes overall from 2011 to 2022. Isolated CABG surgeries represented 28% of our workload, which was a lower proportion than those in the UK (PWH: 28%, 2021-2022 vs the UK: 41.7%, 2015-2016 vs the US STS ACSD: 72.2%³, 2020-2021 vs Japan JCVSD/NCD: $\approx 17.8\%$ ², 2017-2018).
- The proportion of valvular surgeries has remained steady from 2017 to 2022 at the PWH. Compared with the UK, valve procedures occupied a lower portion at the PWH (PWH: 46%, 2020-2021 vs the UK: 48.4%, 2015-2016 vs Japan JCVSD/NCD: $\approx 34.1\%$ ², 2017-2018).
- Aortic procedure has steadily and consistently increased over the years, from 12% in 2011-2012 to 26% in 2021-2022. We also have a higher workload percentage of major aortic procedures as compared to the UK data under the same category (PWH: 26%, 2021-2022 vs the UK: 3.47%, 2015-2016 vs Japan JCVSD/NCD: $\approx 30.5\%$ ², 2017-2018).

Fig 1.03 Overall workload at the PWH, 2021-2022



³ Procedural counts from 2021 in the *US STS ACSD publication: 2022 Update on Outcomes and Research* are based on those reported to date and may be subject to change due to late reporting.

Other procedure details

- Fig 1.04 shows the other procedure details for all cardiac surgeries performed.
- The patient may have had more than one of the other procedures.
- Surgery on the aorta was one of case-volume growth compared to the previous reports (207, 2021-2022 vs 177, 2019-2020) as in the last two years there has been an increase in minimally invasive, Thoracic Endovascular Aortic / Aneurysm Repair (TEVAR).
- There has been a doubling in the number of LA appendage occlusions performed, from 68 in 2019-2020 to 122 in 2021-2022.
- The group 'other procedures not listed above' includes all those patients for whom there was another procedure of some kind recorded, but who do not fall into any of the categories listed above such as patients who underwent ablation surgery for atrial fibrillation, etc.

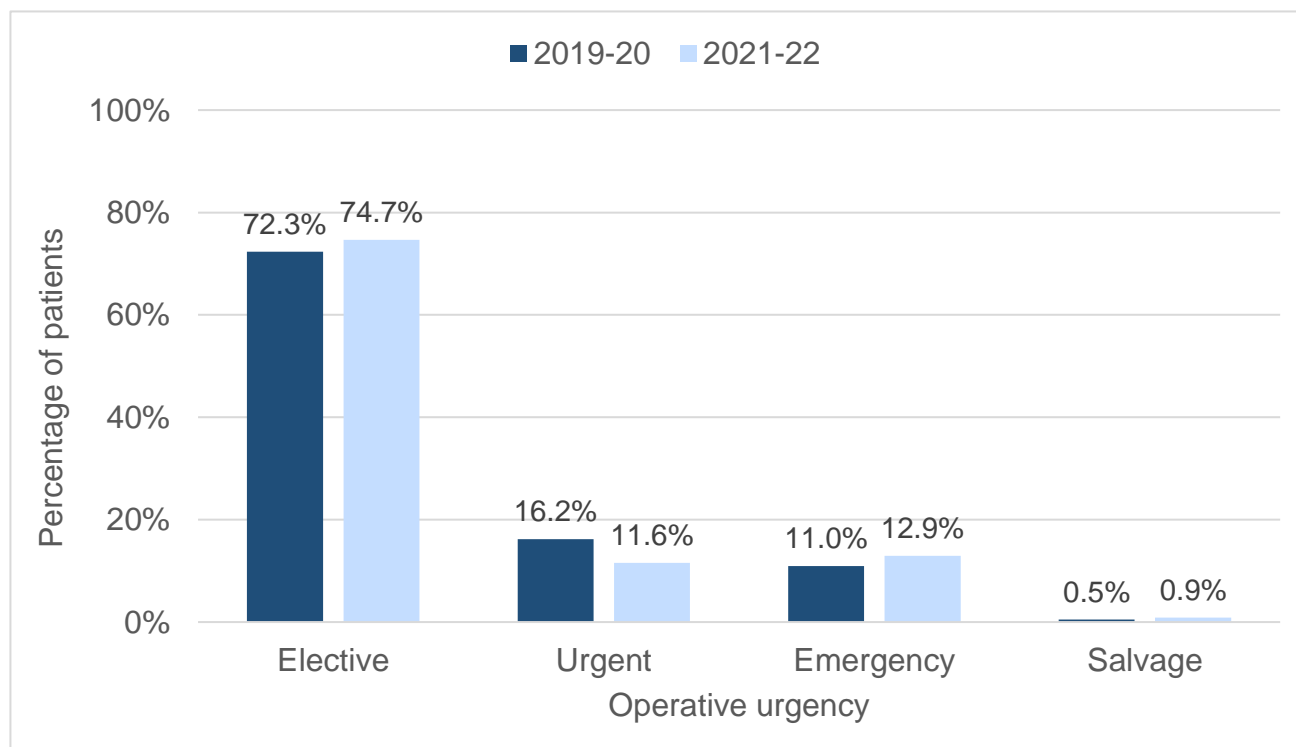
Fig 1.04 Case volume for other cardiac procedures performed at the PWH, 2021-2022

		Data	
		Count	Proportion
Other procedures	No other cardiac procedure performed	582	72.3%
	All operations with other procedure	223	27.7%
	Surgery on the aorta	207	25.7%
	TEVAR	30	3.7%
	LA appendage occlusion	122	15.2%
	Peripheral vascular	27	3.4%
	ASD closure	25	3.1%
	Atrial myxoma	20	2.5%
	ECMO	11	1.4%
	AF Ablation	11	1.4%
	Myomectomy	8	1%
	Acquired VSD	7	0.9%
	Pericardiectomy	2	0.2%
	LV aneurysmectomy	2	0.2%
	Other procedures not listed above	31	3.9%

Operative priority

- The definition of priority used in the adult cardiac surgery database in Hong Kong is that patients admitted from home for surgery are regarded as *elective* cases, those who have the operation on the next available working day are *urgent*, those for whom operative care is provided immediately on the same day are *emergency*, and those who require resuscitation into the operating theatre are designated as *salvage* cases.
- As shown in Fig 1.05, the proportion of patients undergoing elective surgery has been static over time. (74.7%, 2021-2022 vs 72.3%, 2019-2020).
- There has been a slight decrease in the proportion of urgent patients over time (11.6%, 2021-2022 vs 16.2%, 2019-2020).
- The number of emergency or salvage patients remained small between the calendar years 2021 and 2022, which accounted for 13.8% of our workload. This has had a serious resource and organizational impact on the Division. (13.8%, 2021-2022 vs 11.5%, 2019-2020).

Fig 1.05 Operative priority for all cardiac procedures at the PWH, 2021-2022

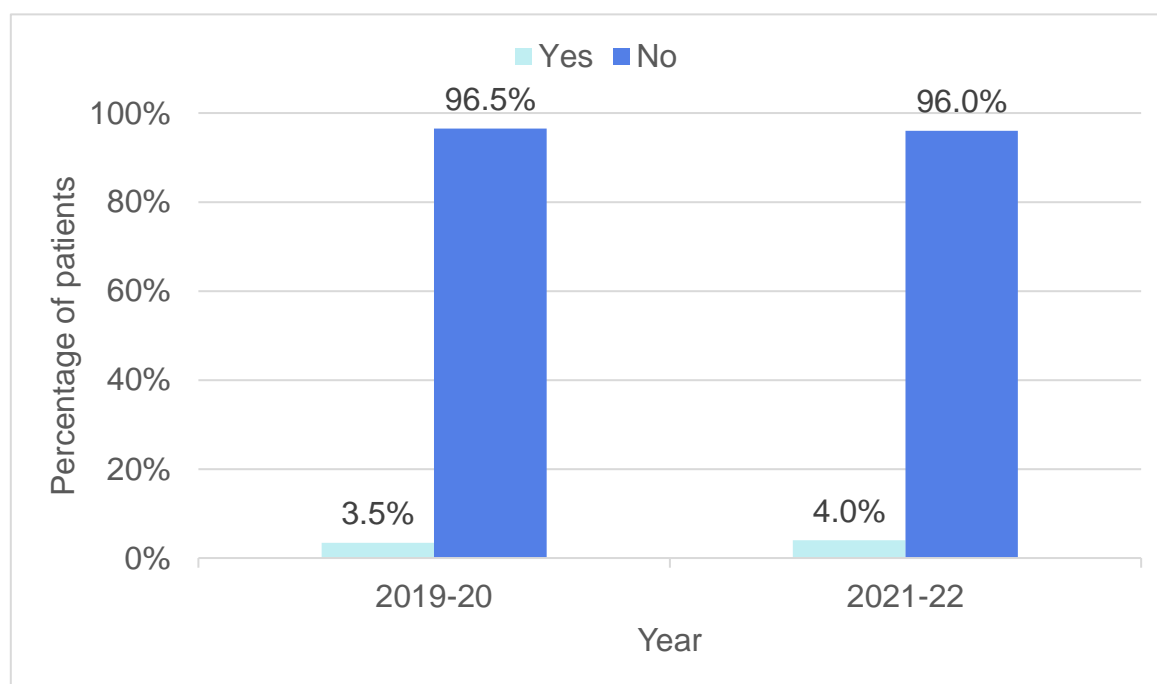


Cardiogenic shock

- Fig 1.06 shows the percentage of patients in the cardiogenic shock prior to surgery as an example of the critical changes we are facing.
- On face value, the graph may not seem significant but the percentage wise has increased from 3.5% between 2019 and 2020 to 4.0% between 2021 and 2022.

DATABASE OVERVIEW

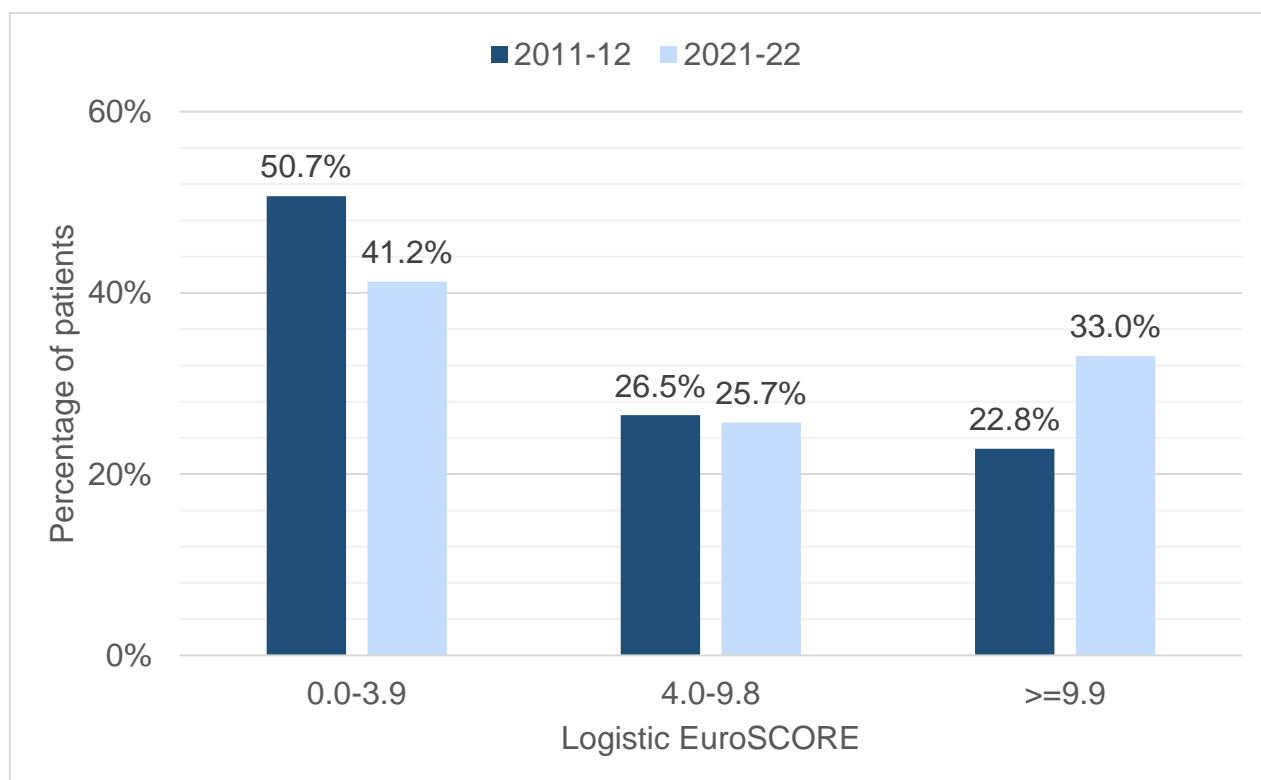
Fig 1.06 Cardiogenic shock at the PWH, 2017-2020



Risk profiling over time

- Fig 1.07 provides some idea of the ‘spread’ of patients within the variously designated risk groups.
- The median EuroSCORE for our population was 5.6% during 2021-2022.
- For comparison, we have found the mean logistic EuroSCORE for our population has increased from 8.2% during 2011-2012 to 11.0% during 2021-2022.
- We can see that this reflects a consistent reduction in the number of patients in the low-risk group and an increase in the number of patients scoring as very high (≥ 9) risk. This has been a universal finding in international cardiac surgical practice and our division represents we believe, a true reflection of the changing workload.

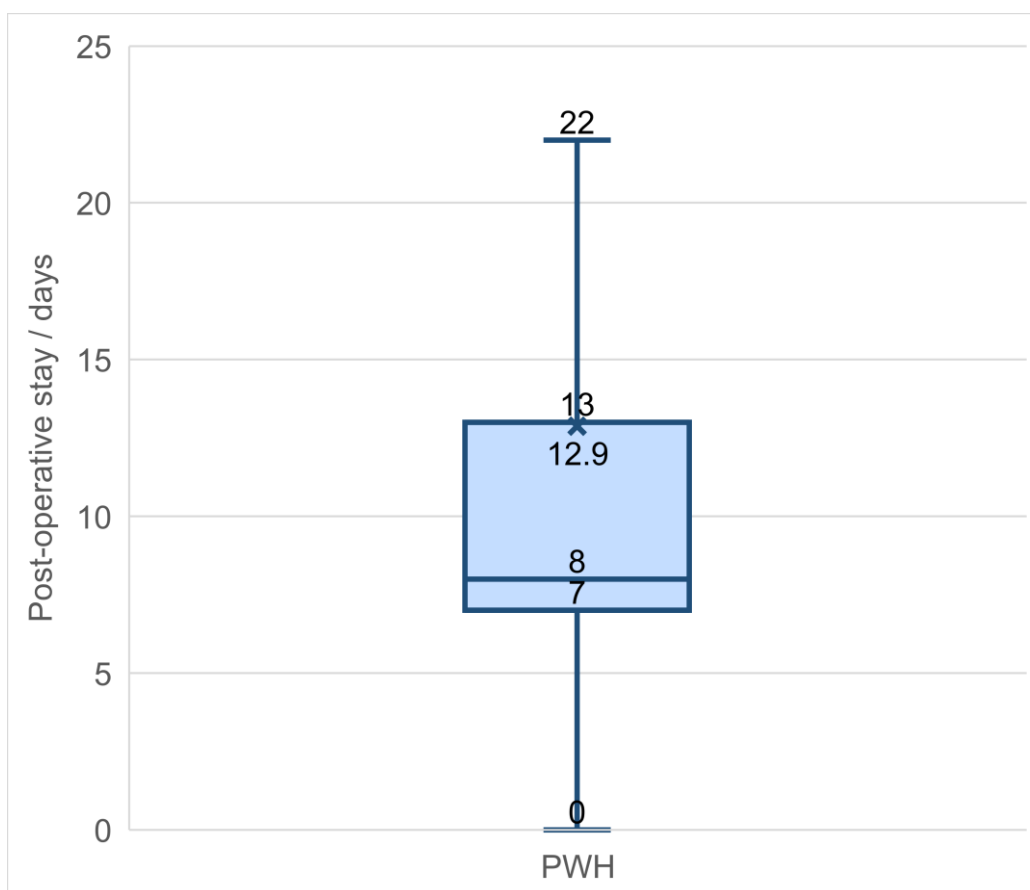
Fig 1.07 Change in logistic EuroSCORE values over time, 2021-2022 vs 2011-2012



Post-operative length of hospital stay

- Fig 1.08 shows the box plot of our length of hospital stay during 2021-2022.
- Length of stay has been purported as a measure of 'quality', in other words, the shorter the postoperative stay the inference the smoother the post-operative course and the occurrence of fewer complications.
- The average and the median length-of-stay were 13 and 8 days respectively. The interquartile range for the length-of-stay was 6 days.
- Cardiac surgery is associated with an increased length-of-stay for different reasons. The main reason is many of these patients are of higher risks and more comorbidities and likely to develop complications after surgery.

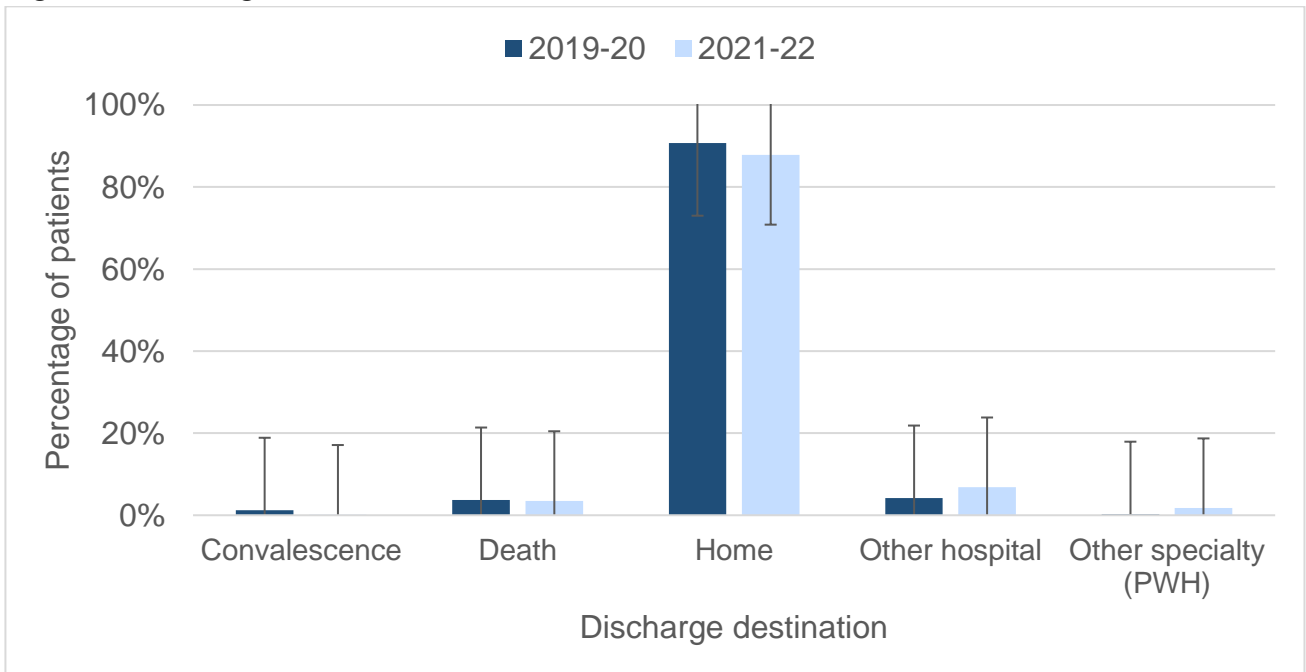
Fig 1.08 Post-operative stay for all cardiac surgeries, 2021-2022



Discharge destinations

- Fig 1.09 shows the destination of our patients after discharge from our Cardiothoracic Unit.
- We have very few facilities for patients to be discharged to convalescent places and the ability for them to be transferred back to referring facilities is also limited.
- The majority of our patients (87.8%) stay with us until they are fit for discharge directly home during 2021-2022.

Fig 1.09 Discharge destination, 2019-2022



Previous cardiac surgery

- As shown in Fig 1.10, the proportion of isolated CABG surgery with previous cardiac surgery at the PWH was 0.4% during 2021-2022, while the proportion of redo CABG operations was 0.2% in the UK over the period 2015-16 (PWH: 0.4%, 2021-2022 vs the UK: 0.2%, 2015-2016).
- The complexity and risk associated with re-operations are greater than with primary (first-time) operations.
- Patients with coronary artery disease and a history of previous cardiac surgery who then require further coronary intervention may now more frequently undergo PCI rather than surgery and the situation is similar in the UK.
- The proportion of isolated valve surgery with previous cardiac surgery was 11.8%.
- Overall, 10% of our adult cardiac surgery patients had previous cardiac surgery performed at the PWH, which remains consistent with our preceding reports (PWH: 10%, 2021-2022 vs the UK: 1%, 2015-2016).

Fig 1.10 Previous cardiac surgery, 2019-2022

		Previous cardiac surgery			
		Yes	No	Proportion of prior surgery in 2021-2022	Proportion of prior surgery in 2019-2020
Cardiac procedure	Isolated CABG	1	229	0.4%	0.7%
	Isolated valve	18	135	11.8%	12.3%
	Valve & other	13	154	7.8%	4.8%
	CABG & valve	1	30	3.2%	0.0%
	CABG, valve & other	1	16	5.9%	5.6%
	CABG & other	2	23	8.0%	15.0%
	Other	44	138	24.2%	15.3%
All	80	725	9.9%	7.4%	

International comparison of operative mortality PWH, United Kingdom NACSD, and EACTS database

- Operative mortality is defined as (1) all deaths, regardless of cause, occurring during the hospitalization in which the operation was performed, even if after 30 days (including patients transferred to other acute care facilities); and (2) all deaths, regardless of cause, occurring after discharge from the hospital but before the end of the 30th postoperative day.
- Fig 1.11 shows the crude mortality rates of all cardiac procedures at the PWH and the respective figures in the UK and the European Association for Cardio-Thoracic Surgery (EACTS) database.
- The crude mortality rates of the major operation groups (isolated CABG, isolated valve, and major aortic surgery) at the PWH were on par with the UK data and the EACTS database.
- As expected, the crude mortality rates for the CABG surgeries in addition to the valve and/or other procedures (CABG, valve & other and CABG & other) were higher than that for isolated CABG surgery. Combined procedures involve more than one procedure during surgery and are generally more complex than isolated procedures.
- The mortality in the 'Other category' was mainly attributed to post-operative stroke, cardiac failure, multiple organ failure, respiratory failure, visceral organ ischemia, etc. Those ECMO patients without cardiac surgery were not included in the mortality calculation.

Fig 1.11 International comparison of post-operative mortality rates

		Mortality data					
		PWH		United Kingdom NACSD		EACTS database	
		Dead	2021-22	2019-20	2008	2015-16	2006-08
Cardiac procedure	Isolated CABG	0	0.0% (230; 0%-2.0%)	1.4% (282; 0.5%-3.8%)	1.5% (22808; 1.3%-1.6%)	1.0% (15078; 0.9%-1.2%)	2.2% (219053; 2.2%-2.3%)
	Isolated valve	4	2.6% (153; 0.8%-7.0%)	3.9% (228; 1.9%-7.6%)	3.5% (7379; 3.1%-4.0%)	3.60% (17486; 3.3%-3.9%)	3.4% (75247; 3.3%-3.5%)
	Valve & other	8	4.8% (166; 2.2%-9.6%)	3.6% (84; 0.9%-10.8%)	5.5% (1780; 4.5%-6.7%)		4.9% (12883; 4.5%-5.3%)
	CABG & valve	2	6.5% (31; 1.1%-22.9%)	2.0% (50; 0.1%-12.0%)	6.1% (4508; 5.4%-6.8%)		6.2% (37721; 6.0%-6.5%)
	CABG, valve & other	1	5.9% (17; 0.3%-30.8%)	16.7% (18; 4.4%-42.3%)	11.5% (617; 9.2%-14.4%)	N/A	11.3% (3097; 10.2%-12.5%)
	CABG & other	2	8.0% (25; 1.4%-27.5%)	15.0% (20; 4.0%-38.9%)	7.8% (766; 6.1%-10.0%)		7.0% (4327; 6.3%-7.8%)
	Other	11	6.0% (183; 3.2%-10.8%)	5.1% (157; 2.4%-10.1%)	7.9% (1271; 6.5%-9.5%)	N/A	7.7% (11562; 7.2%-8.2%)
	All	28	3.5% (805; 2.3%-5.1%)	3.7% (839; 2.6%-5.3%)	3.1% (39129; 2.9%-3.3%)	2.8% (36166; 2.6%-3.0%)	3.3% (363890; 3.2%-3.3%)

Overall mortality and risk scores at the PWH

- Fig 1.12 shows the mortalities for the operative sub-groups and gives a representation of observed versus expected (risk score) for each.
- The risk associated with cardiac surgery depends on several different factors including the type of surgery, pre-operative cardiac function, and comorbidities. The risk stratification model, such as European System for Cardiac Operative Risk Evaluation (EuroSCORE), predicts operative mortality based on these risk factors.
- Values of the logistic EuroSCORE broadly correlate with the predicted operative mortality in percentage terms.
- The crude mortality rate was 3.5% for all cardiac procedures at the PWH during the calendar years 2021 and 2022 (PWH: 3.7%, 2019-2020). Cardiac surgery outcomes in the UK reported mortality of 2.8% for the period 2015-2016 (PWH: 3.5%, 2021-2022 vs the UK: 2.8%, 2015-2016).
- During 2021 and 2022, logistic EuroSCORE predicted a mortality rate of 11.1% at the PWH. The average logistic EuroSCORE in the UK was 8.5% for the period 2015-2016 (PWH: 11.1%, 2021-2022 vs the UK: 8.5%, 2015-2016).
- During 2021 and 2022, the O/E ratio was 0.32 at the PWH indicating PWH is performing better than expected.

Fig 1.12 Overall mortality and risk scores at the PWH, 2021-2022

		Patient status at discharge		Observed vs Expected mortality		
		Alive	Dead	Observed risk	Logistic EuroSCORE	EuroSCORE II
Cardiac procedure	Isolated CABG	230	0	0.0%	3.8%	2.3%
	Isolated valve	149	4	2.6%	8.6%	4.3%
	Valve & other	158	8	4.8%	12.2%	7.2%
	CABG & valve	29	2	6.5%	8.3%	6.8%
	CABG, valve & other	16	1	5.9%	17.4%	12.4%
	CABG & other	23	2	8.0%	13.4%	7.0%
	Other	172	11	6.0%	20.6%	7.3%
	All	777	28	3.5%	11.1%	5.4%

CUSUM plot of the crude mortality rate

- The cumulative sum (CUSUM) technique is a method of graph plotting an accumulation of events (in-hospital mortality) over time.
- CUSUM charts are based on sequential monitoring of cumulative performance over time.
- Observed CUSUM mortality plot allows the detection of trends and corrective actions and it provides an excellent audit to surgeons and hospital administrators.
- There were no indications of odd results in the CUSUM plot for the PWH.
- In 2021-2022, the overall number of deaths for all cardiac surgeries was 28 at the PWH as shown in Fig 1.13.
- Fig 1.13 also shows the overall crude mortality rate by surgery type. Between 2021 and 2022, the overall number of deaths for isolated CABG and isolated valve surgeries were 0 and 4 at the PWH respectively.
- Fig 1.14 shows the overall crude mortality rate by operative priority. Between 2021 and 2022, the overall number of deaths for elective, and urgency & emergency (including salvage cases) cardiac surgeries were 7 and 21 at the PWH respectively.

Fig 1.13 CUSUM plot of crude mortality for **all** cases, and by **surgery type** at the PWH, 2021-22

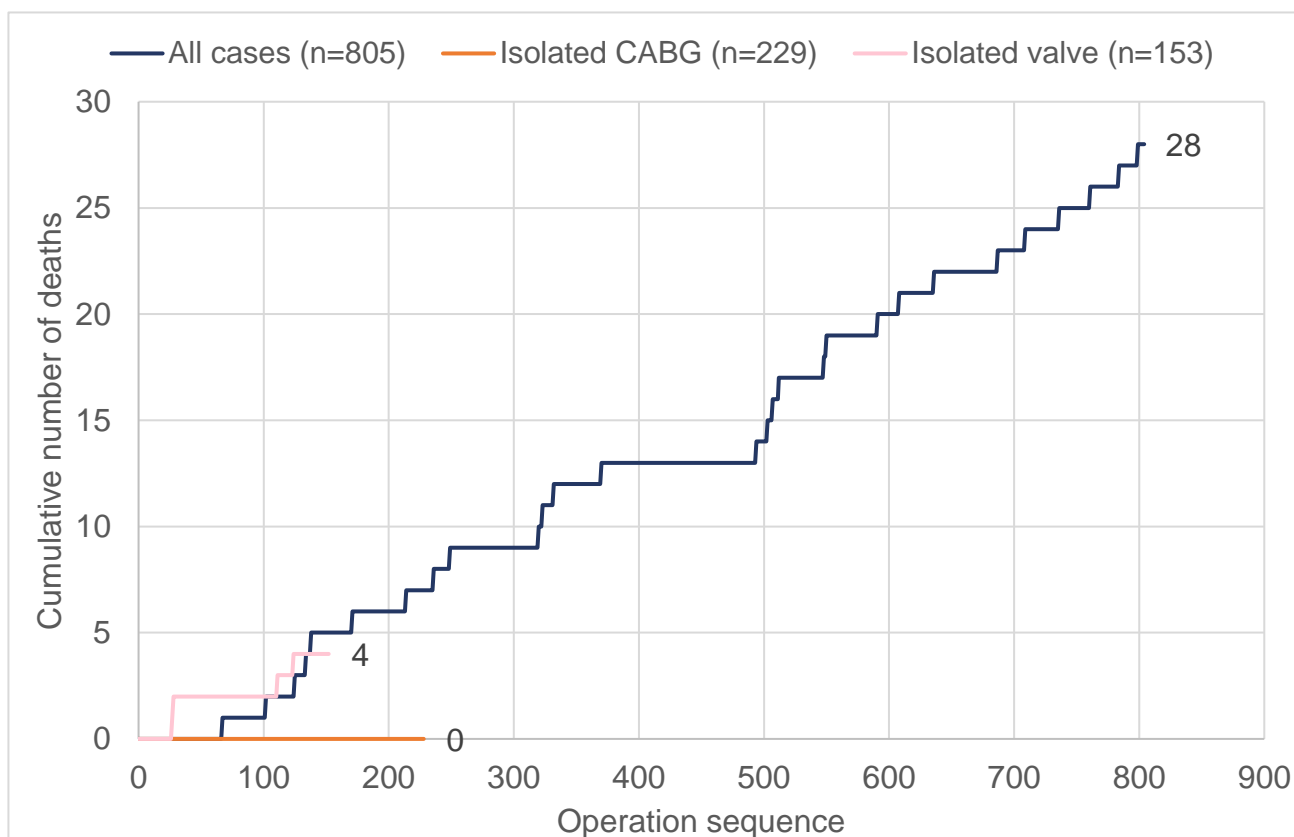
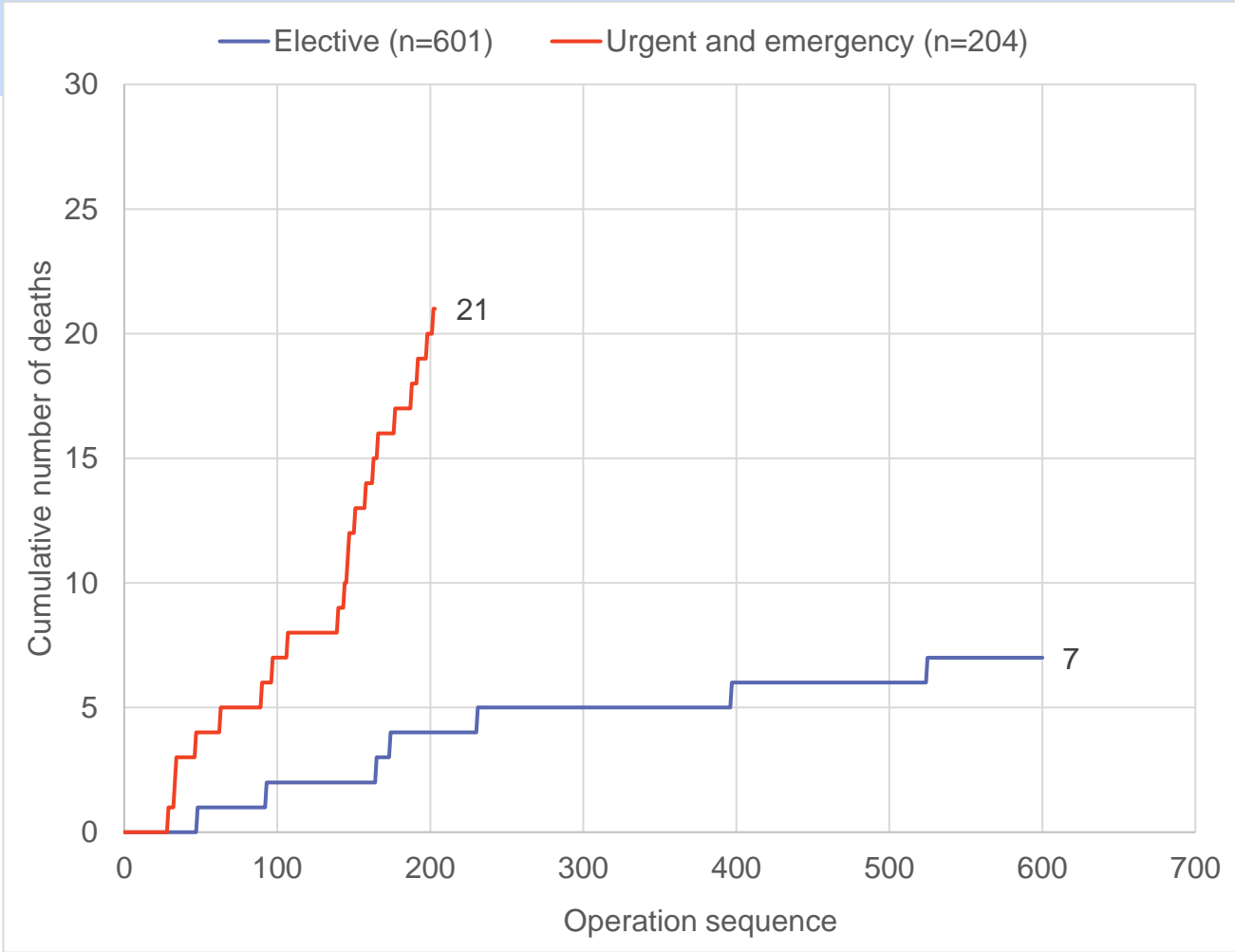


Fig 1.14 CUSUM plot of crude mortality by **operative priority** at the PWH, 2021-2022



DATABASE OVERVIEW

VLAD plot of risk-adjusted mortality rate

- Fig 1.15 shows a Variable Life-Adjusted Display (VLAD) graph that covers all risk-scored procedures performed for the calendar years 2021 and 2022. The EuroSCORE II is also shown in the graph.
- The plot is risk-adjusted and performance as predicted should run approximately around the horizontal zero line (the heavy black line).
- The plotted line goes up for each survival and down for each death. The degree of rising and falling is determined by the predicted risk associated with the case.
- The upslope of the curve demonstrated a net gain in patients' life and that the performance was better than expected.
- Between 2021 and 2022, PWH saved more than 60 extra lives for all cardiac surgeries at the end of the curve derived from the logistic EuroSCORE as shown in Fig 1.15.
- Fig 1.16 shows a VLAD graph that covers all risk-scored procedures performed by operative priority for the calendar years 2021 and 2022.
- We can see that around 36 and 24 extra lives had been saved for *elective* and *urgent and emergency (including salvage cases)* cardiac surgeries respectively.

Fig 1.15 VLAD plot of **all** cardiac surgeries at the PWH, 2021-2022

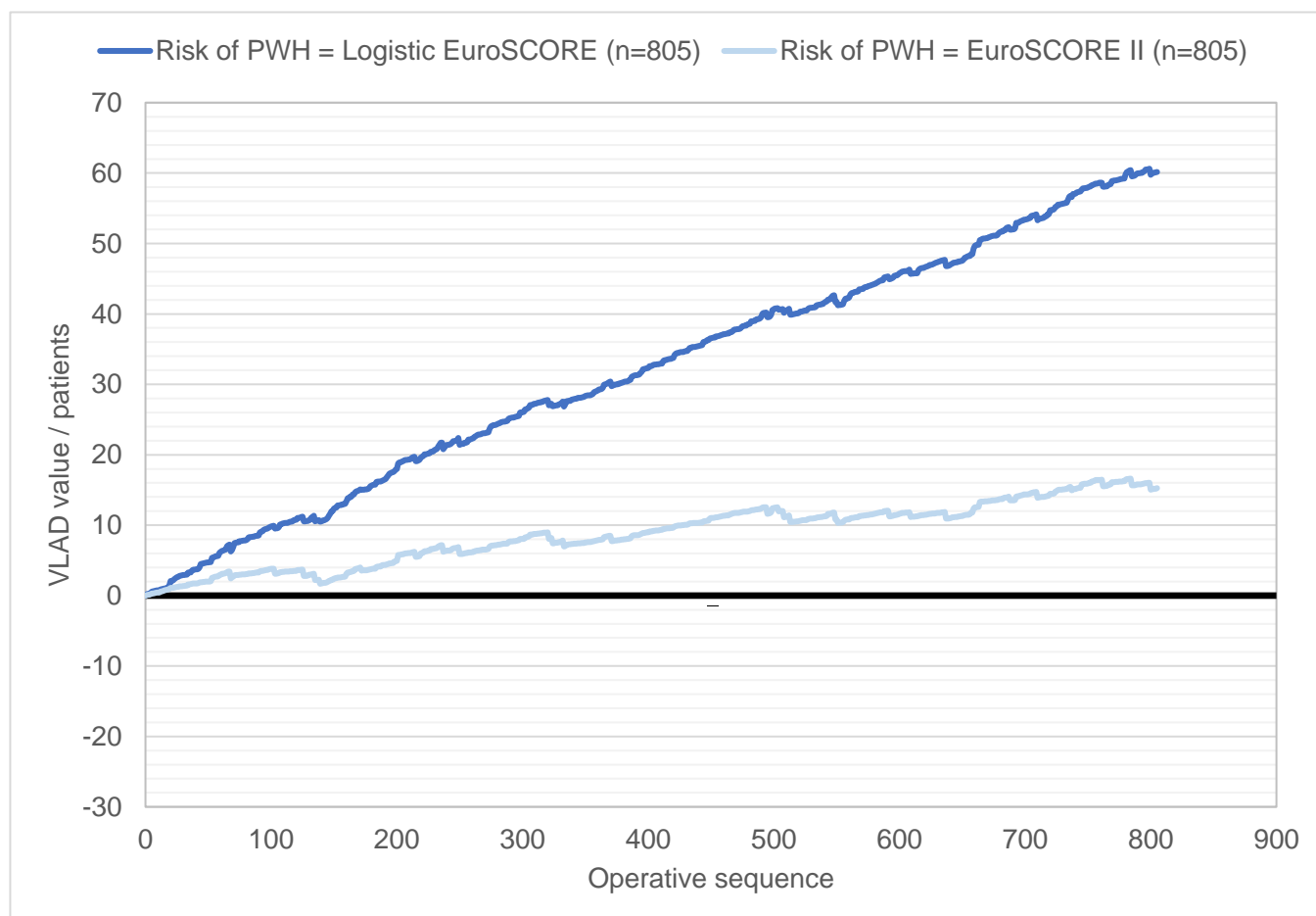
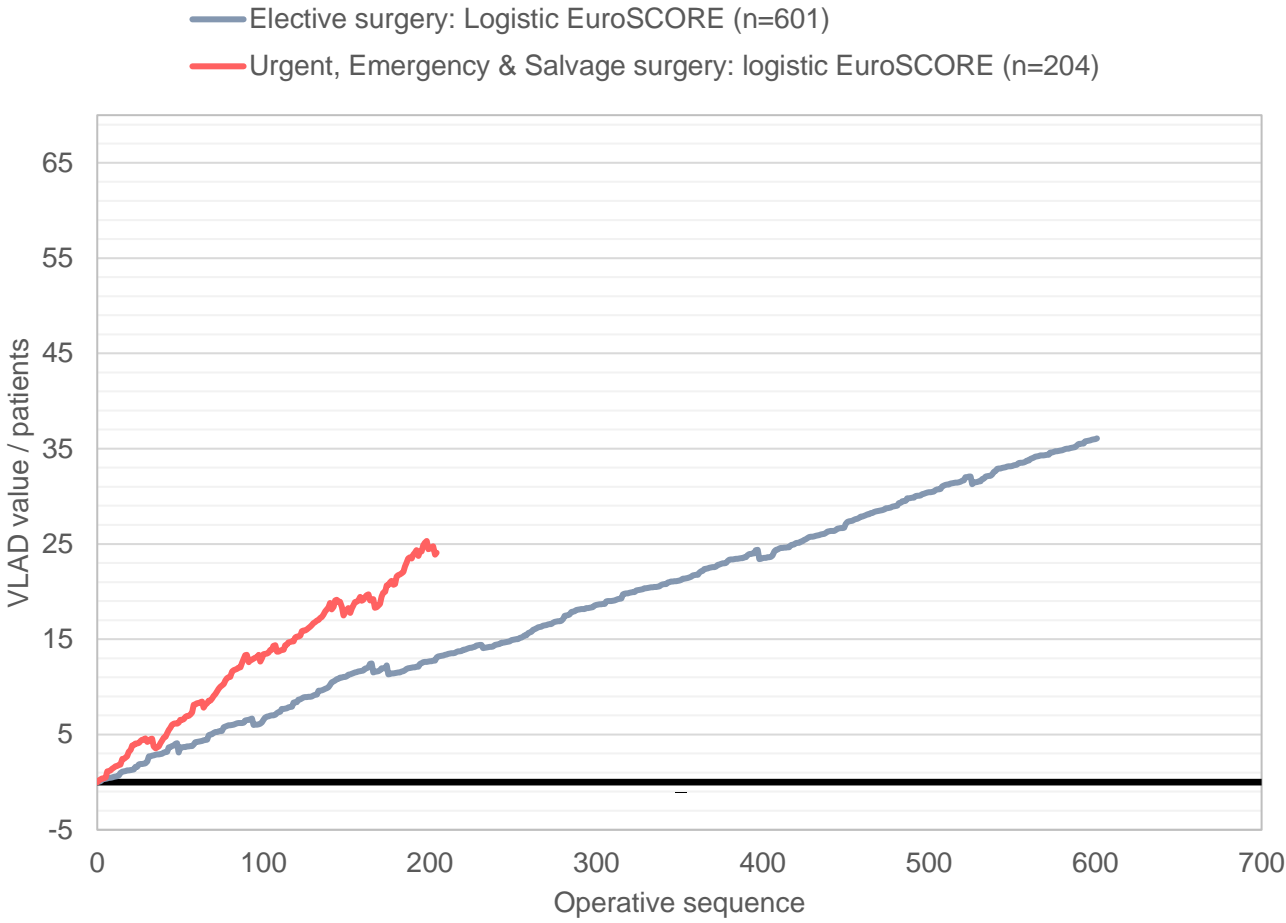


Fig 1.16 VLAD plot by **operative priority** at the PWH, 2021-2022



DATABASE OVERVIEW

Funnel plot of the crude mortality rate

- A non-risk-adjusted funnel plot for mortality for all cardiac procedures performed in the assessment period is shown in Fig 1.17.
- Two other non-risk-adjusted funnel plots for mortality rates for all cardiac procedures performed by operative priority in the assessment period are shown in Fig 1.18 and Fig 1.19.
- Outcomes at the PWH fall comfortably within the control limits for all operative groups, showing satisfactory quality.
- The improvement in the crude mortality rate of *elective* cardiac surgeries was more pronounced at the PWH during the period 2021–2022 than that during 2019-2020.
- PWH demonstrates a very low crude mortality rate when compared with the HK average. Although the crude mortality for all cardiac surgeries appeared to be slightly higher than the NACSD in-hospital mortality rate in 2015-2016, this could be explained by the differences in case-mix and risk profile between the two databases. This will be addressed in the subsequent sections.

Fig 1.17 Funnel plot of crude mortality for **all** cardiac surgeries at the PWH, 2021-2022

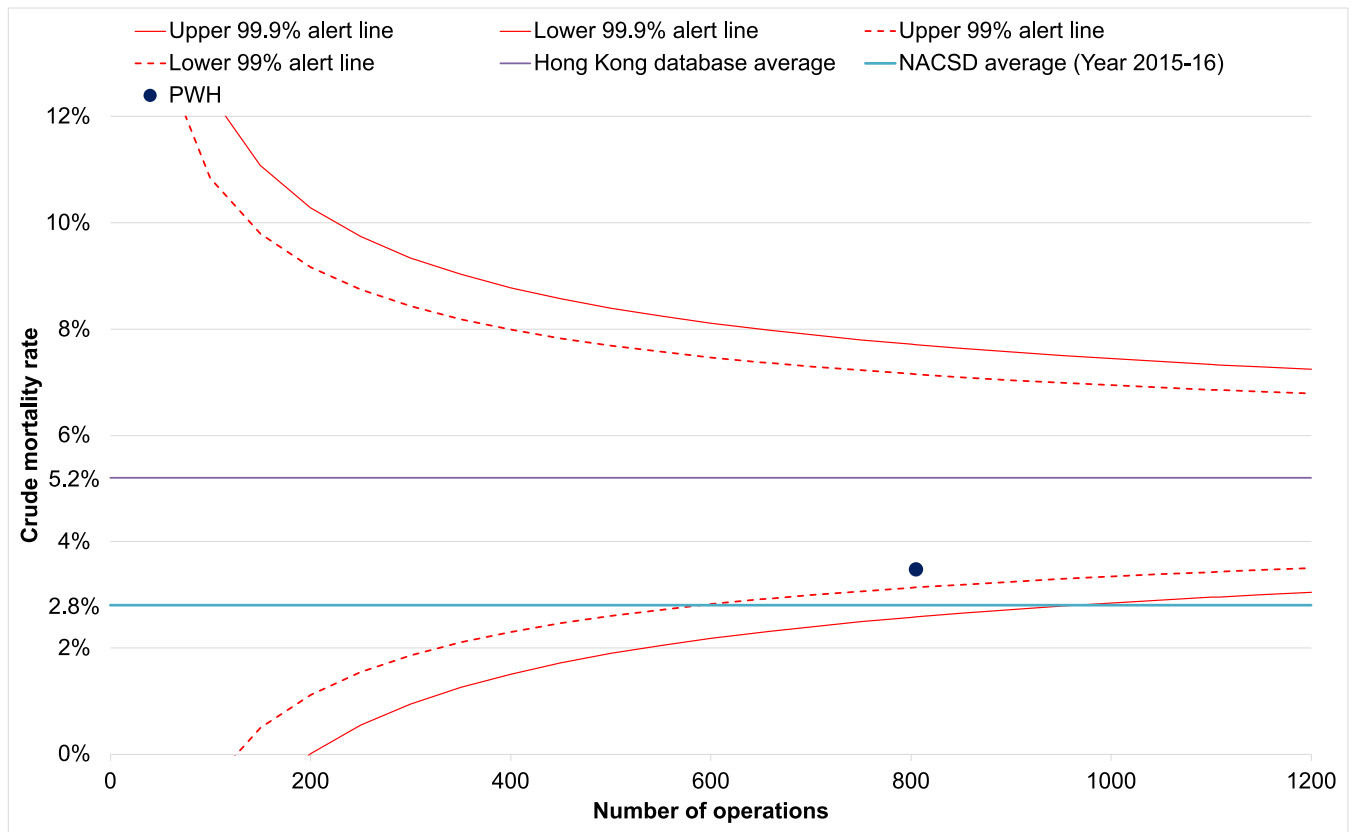


Fig 1.18 Funnel plot of crude mortality for all **elective** cardiac surgeries at the PWH, 2021-2022

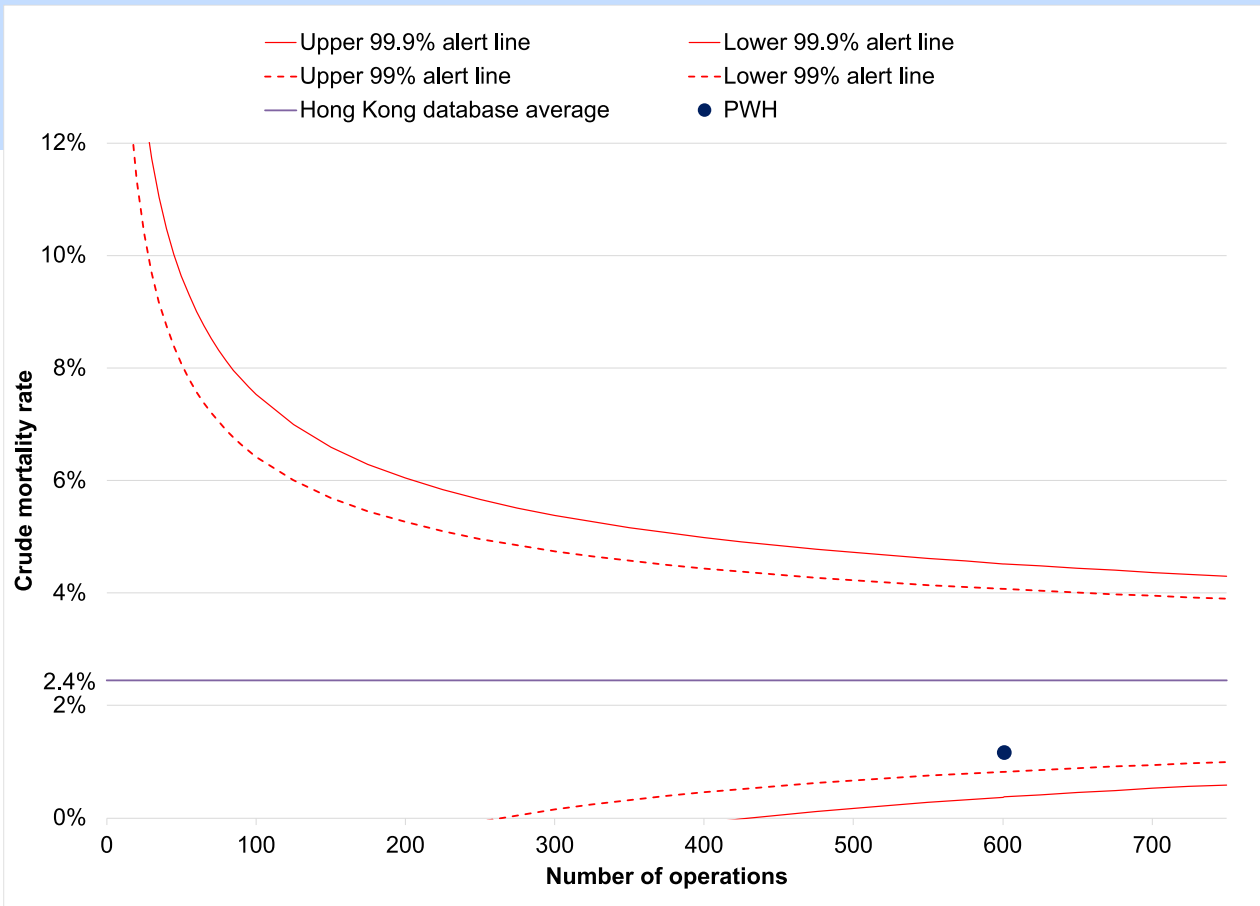
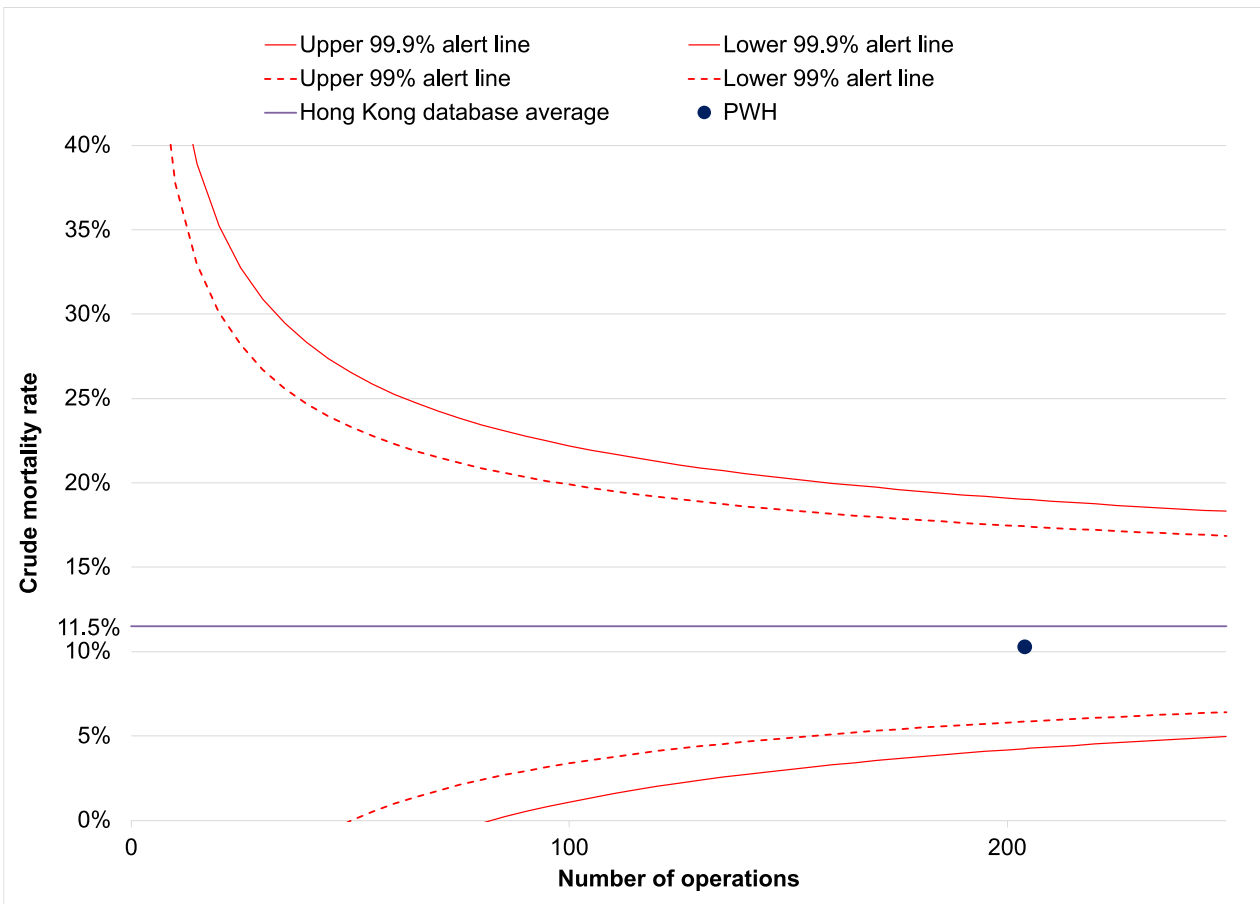
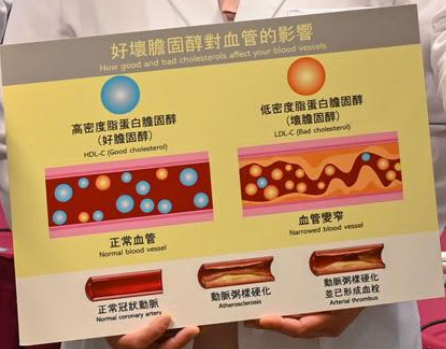
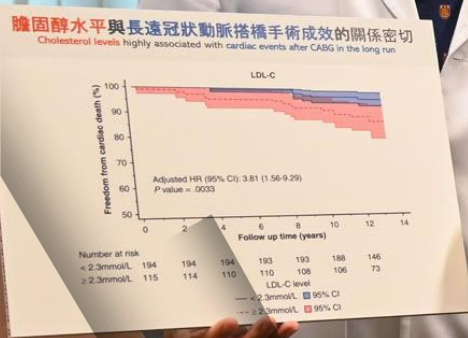


Fig 1.19 Funnel plot of crude mortality for all **urgent and emergency** cardiac surgeries at the PWH, 2021-2022



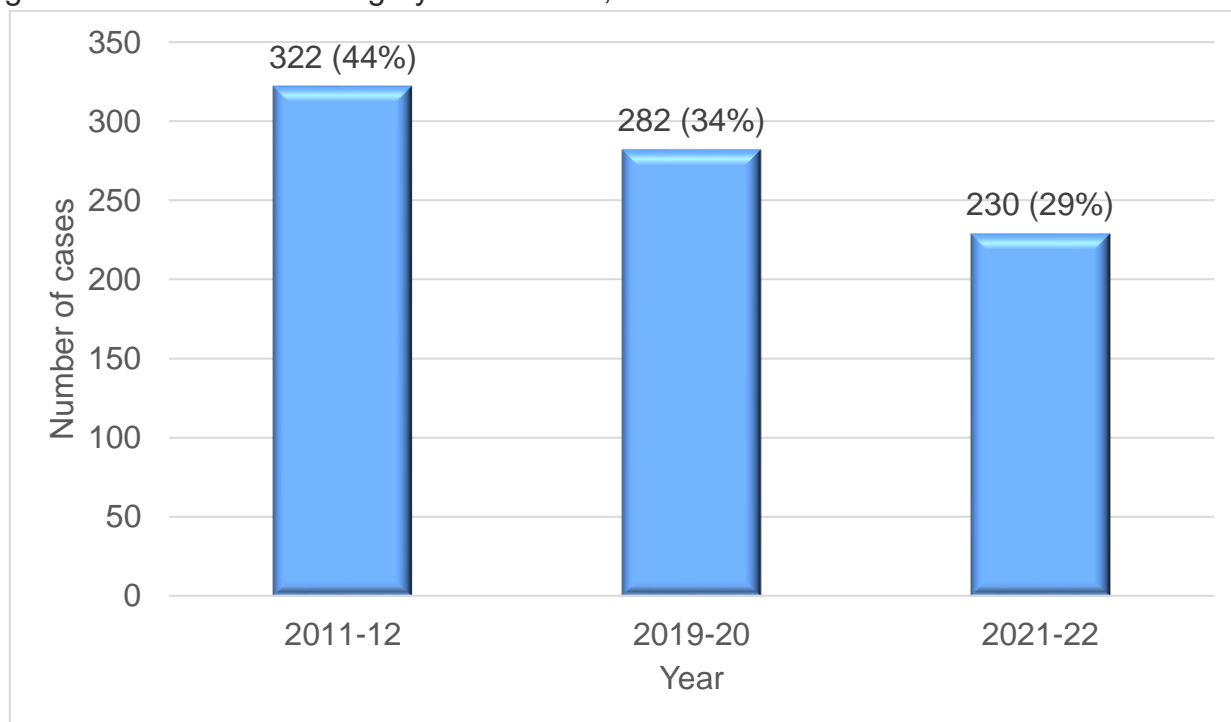
CORONARY SURGERY



Isolated CABG in the context of the overall workload

- Coronary artery bypass grafting has been chosen by the UK Society as the ‘marker’ operation for outcomes since it has been analyzed in-depth, it is commonly performed and the outcomes are reproducible and well-delineated.
- The primary objective was to analyze data reporting, quality, and outcomes for CABG at the PWH.
- Fig 2.01 shows the number of isolated CABG surgeries done over the years. As a proportion of overall cardiac surgical activity, isolated CABG has steadily and consistently declined over the years, from 44% in 2011–2012 to 29% in 2021–2022. There were 230 (29%) isolated CABG surgeries performed in total at the PWH during the calendar years 2021 and 2022 (PWH: 29%, 2021-2022 vs the UK: 41.7%, 2015-2016 vs the US STS ACSD: 72.2%³, 2020-2021 vs Japan JCVSD/NCD: ≈17.8%², 2017-2018).

Fig 2.01 Isolated CABG surgery at the PWH, 2021-2022 vs 2011-2012

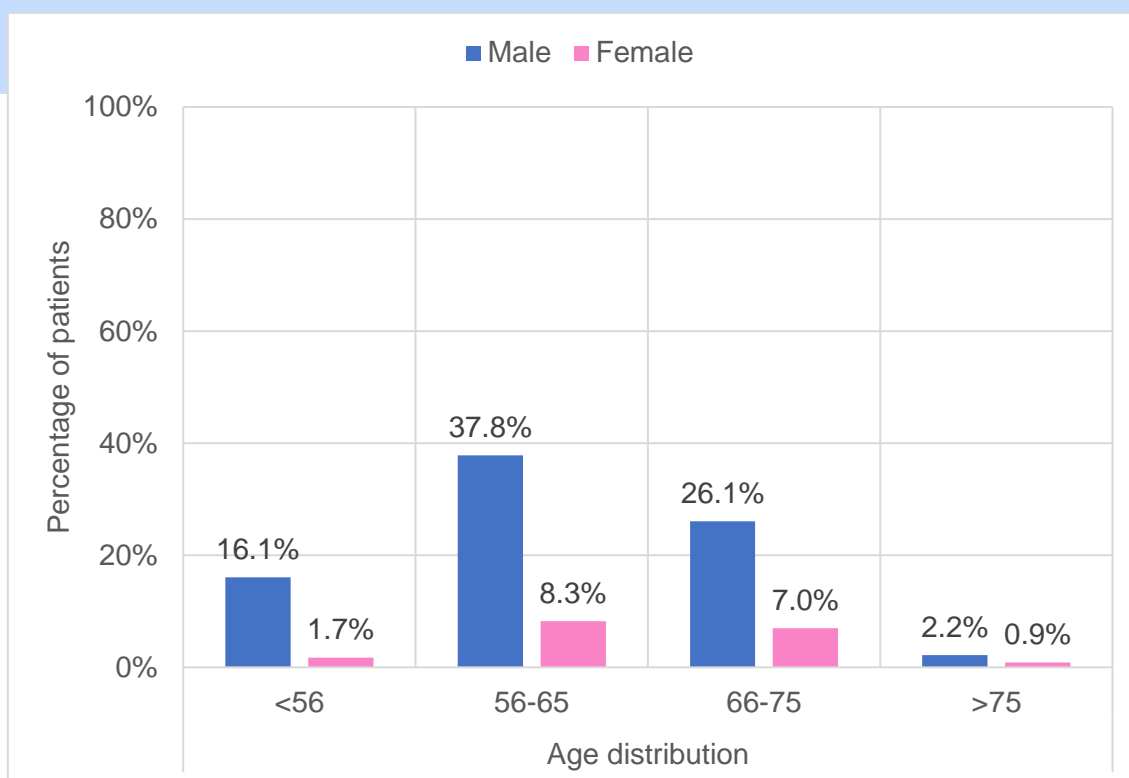


Pre-operative risk factors

Age and gender

- Fig 2.02 shows the patient demographics at the PWH between the calendar years 2021 and 2022. Intuitively age is a well-recognized risk factor for both mortality and morbidity.
- The mean age of patients undergoing isolated CABG was 62 years for PWH between 2021 and 2022. There has been a very slow but steady increase in the mean patient age for isolated CABG procedures at the PWH and the UK over the years (PWH: 62, 2021-2022 vs the UK: 66.1, 2015-2016).
- It does show, however, that on average over 36% of CABG patients were over 66 years of age at the PWH between 2021 and 2022, a significant proportion who have an associated increase in risk profile similar to the 2019-2020 data (PWH: 36.1%, 2021-2022 vs PWH: 43%, 2019-2020)
- On average, patient demographics remain essentially unchanged. There was a higher proportion of male patients, 82% (189) who underwent CABG compared to female patients, 18% (41) at the PWH. It reflects a widely known gender difference in the prevalence of coronary artery disease (PWH: 18%, 2021-2022 vs the US STS ACSD: 25%⁵, 2011-2019).
- However, there have been marked changes in the proportion of female patients with increasing age in recent years: in patients under the age of 56 years, 9.8% of patients were female on average, and in those over the age of 66 it rose to nearly 44% on average. It is understood that women present with acute coronary syndrome later in life compared to their male counterparts.
- Elderly women consistently have in-hospital mortality that is nearly twice that of their male counterparts.

Fig 2.02 Isolated CABG surgery: Age and gender distribution



CORONARY SURGERY

Mortality related to age and gender

- Fig 2.03 shows the crude mortality rates of patients according to age and gender.
- There has been a marked decrease in overall mortality over time, with the most marked improvement being seen in the elderly.
- Compared with the mortality rate of patients aged >75 years at the PWH (0.0%), the mortality rate reported in the octogenarians in the UK was 3.5% (PWH: 0.0%, 2021-2022 vs the UK: 3.5%, 2015-2016).
- The in-hospital mortality rate for females remains almost twice as high as that for males. The reasons for this are not completely understood, but almost certainly the increasing proportion of women in the older age groups is an important factor.

Fig 2.03 Isolated CABG surgery: Age distribution and the crude mortality rate

Age	Count	Proportion	Dead	Crude mortality rate
<56	41	17.8%	0	0.0%
56-65	106	46.1%	0	0.0%
66-75	76	33.0%	0	0.0%
>75	7	3.1%	0	0.0%

Left ventricular ejection fraction

- Ventricular function is mainly assessed by an echocardiogram and expressed as Left Ventricular Ejection Fraction (LVEF). The ejection fraction describes the proportion of blood that is pumped out each time the heart contracts and is an important index of cardiac function.
- For European System for Cardiac Operative Risk Evaluation (*EuroSCORE II*) any ejection fraction of greater than 50% is regarded as *good* (LVEF>50%), 30% to 50% is regarded as *moderate or fair* (LVEF 31-50%), 21% to 30% is regarded as *poor* (LVEF 21-30%), and less than 20% (LVEF 20% or less) is classified as *very poor*.
- Fig 2.04 shows the patient ejection fraction distribution and the respective crude mortality rates of patients at the PWH.
- There has been no real change in the proportion of patients with impaired ejection fraction over time. The proportion of patients with poor or very poor LVEF was 4.3% at the PWH between 2021 and 2022, which is smaller than that of the UK data over the period 2015-2016 (PWH: 4.3%, 2021-2022 vs the UK: 6%, 2015-2016).
- Over the period studied, the proportion of patients with a good ejection fraction was 69.1% at the PWH.
- Impaired ejection fraction remains strongly associated with increased mortality. However, the results for those who are under this category and still require isolated CABG are excellent, with the mortality rate for isolated CABG surgery between 2021-2022 at 0%.

Fig 2.04 Isolated CABG surgery: Ejection fraction distribution and the crude mortality rate

		Patient status at discharge			
		Alive		Dead	
		Count	Proportion	Count	Proportion
Ejection fraction category	Good	159	100.0%	0	0.0%
	Fair	61	100.0%	0	0.0%
	Poor	5	100.0%	0	0.0%
	Very poor	5	100.0%	0	0.0%
	All	230	100.0%	0	0.0%

Operative priority

- This CABG cohort included all cases whether elective, urgent, or emergency, and Fig 2.05 shows the outcomes according to operative priority.
- As mentioned before, the definition of priority used in the adult cardiac surgery database in Hong Kong is that patients admitted from home for surgery are regarded as *elective* cases, those who have the operation on the next available working day are *urgent*, and those for whom operative care is provided immediately on the same day are *emergency (including salvage cases)*.
- Most of the patients underwent CABG on an elective basis at the PWH (PWH: 85.2%, 2021-2022 vs the UK: $\approx 55.2\%^4$, 2015-2016 vs the US STS ACSD: $\approx 37\%^5$, 2016 vs Japan JCVSD/NCD: $\approx 82.5\%^2$, 2017-2018).
- PWH performed an average of 13.9% of CABG surgeries on an urgent basis between 2021 and 2022 compared to 42.6% in the UK over the period 2015-2016 (PWH: 13.9%, 2021-2022 vs the UK: 42.6%, 2015-2016).
- The number of emergency and salvage cases performed each year is small. The emergent and salvage CABG operations represented 0.9% of all coronary operations at the PWH between 2021 and 2022 (PWH: 0.9%, 2021-2022 vs the UK: $\approx 2.2\%^4$, 2015-2016).
- Operative mortality is strongly associated with an operative priority. Patients in urgencies or emergencies might have ongoing ischemia of the myocardium, frequent malignant arrhythmia, or even unstable haemodynamics.
- For all ***elective, urgent, and emergency (including salvage cases)*** CABG, no death was recorded in PWH during the same assessment period (PWH: 0.0%, 2021-2022 vs the UK: 1.0%, 2015-2016 vs the US STS ACSD: 2.1%³, 2020-2021 vs Japan JCVSD/NCD: $\approx 2.6\%^2$, 2017-2018). Overall, the outcome for isolated CABG surgery in terms of mortality was excellent during 2021-2022.

Fig 2.05 Isolated CABG surgery: Operative priority and the crude mortality rate

	Proportion				Patient status at discharge			
	2021-22 PWH	2015-16 The UK ⁴	2016 The US STS ACSD ⁵	2017-18 Japan JCVSD/NCD ²	Crude mortality rate			
					2021-22 PWH	2015-16 The UK	2017-18 Japan JCVSD/NCD ²	
Operative priority	Elective	85.2%	≈55.2%	≈37%	≈82.5%	0.0%	0.6%	≈1.5%
	Urgent	13.9%	42.6%	≈63%	≈17.5%	0.0%	1.3%	≈7.5%
	Emergency	0.9%	≈2.0%			0.0%	6.6%	
	Salvage		≈0.2%	N/A				
All	100%	100%	100%	100%	0.0%	1.0%	≈2.6%	

CORONARY SURGERY

⁴ Approximate proportion/in-hospital mortality rate in the UK from *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*

⁵ Approximate proportion in the US STS ACSD: *2018 update on outcomes and quality*

Mortality and other risk factors

- Fig 2.06 shows certain pre-operative risk factors affecting surgical outcomes in coronary surgery.
- Extra cardiac arteriopathy (ECA) is a major risk factor for increased in-hospital mortality. ECA is defined as any one of the following: claudication, carotid occlusion or >50% stenosis, previous or planned surgery on the abdominal aorta, limb arteries, or carotids. The proportion of patients with extra cardiac arteriopathy in isolated CABG was 3.9% at the PWH.
- Pre-op IABP insertion is one of the main risk factors. The proportion of patients with pre-op IABP insertion in isolated CABG was 8.3% at the PWH.

Fig 2.06 Isolated CABG surgery: Mortality and other risk factors

			Mortality		
			Alive	Dead	Rate
Risk factor	Gender	Female	41	0	0.0%
		Male	189	0	0.0%
	Body mass index	< 25 kg/m ²	99	0	0.0%
		≥ 25 kg/m ²	131	0	0.0%
	Diabetes	Yes	117	0	0.0%
		No	113	0	0.0%
	Hypertension	Yes	195	0	0.0%
		No	35	0	0.0%
	Left main stem disease	Yes	86	0	0.0%
		No	144	0	0.0%
	Previous cardiac surgery	Yes	1	0	0.0%
		No	229	0	0.0%
	Extra-cardiac arteriopathy	Yes	9	0	0.0%
		No	221	0	0.0%
	Previous CVA	Yes	20	0	0.0%
		No	210	0	0.0%
	Pre-op IABP Insertion	Yes	19	0	0.0%
		No	211	0	0.0%
Renal failure requiring dialysis	Yes	5	0	0.0%	
	No	225	0	0.0%	

Number of bypass grafts

- Fig 2.07 shows the number of bypass grafts per patient at the PWH in graphical form, and Fig 2.08 shows the respective crude mortality rate in table form as well.
- The proportion of patients undergoing multiarterial grafting (defined as two or more distal anastomoses with arterial conduit) was 99.1% in 2021-2022 (PWH: 99.1%, 2021-2022 vs the UK: 10.2%, 2015-2016 vs the US STS ACSD: 14.3%³, 2021), which reflects the severity of the coronary disease we treated.
- The in-hospital mortality rate for patients who received 3 bypass grafts was improved in 2021-2022 when compared to the result in 2019-2020. (0.0%, 2021-2022 vs 1.4%, 2019-2020)
- The use of the left internal mammary artery (LIMA) as a bypass graft to the left anterior descending artery is known to improve long-term survival and outcomes and its percentage use is often used as a quality surrogate for coronary surgery.
- LIMA usage is sometimes not used in very high-risk patients so its utilization will rarely reach 100%. A detailed analysis of LIMA usage is further discussed in the next part.

Fig 2.07 Isolated CABG surgery: Number of bypass grafts per patient

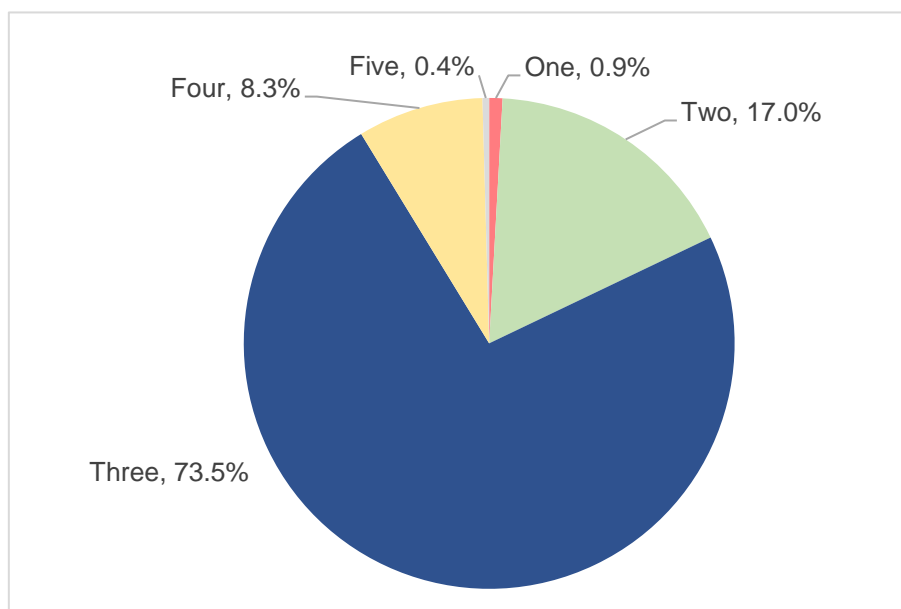


Fig 2.08 Isolated CABG surgery: Number of bypass grafts

	Number of bypass grafts				
	One	Two	Three	Four	Five
Count	2	39	169	19	1
Proportion	0.9%	17.0%	73.5%	8.3%	0.4%
Dead	0	0	0	0	0
Crude mortality rate	0.0%	0.0%	0.0%	0.0%	0.0%

Left Internal Mammary Artery usage

- Myocardial protection is an important component of any coronary operation. The use of the LIMA graft is known to be associated with better patient outcomes in the short-term and longer-term.
- Fig 2.09 shows the percentage of patients using the LIMA in graphical form, and Fig 2.10 shows the respective crude mortality rate in table form as well.
- The LIMA usage rate has remained constantly high over the twelve years as previously noted and approached 92.2% at the PWH during the calendar years 2021 and 2022, which is slightly higher than that of 88.3% in our 2019-2020 data.
- Zero crude mortality rate of patients with LIMA usage was achieved at the PWH.

Fig 2.09 Isolated CABG surgery: Proportion of LIMA usage

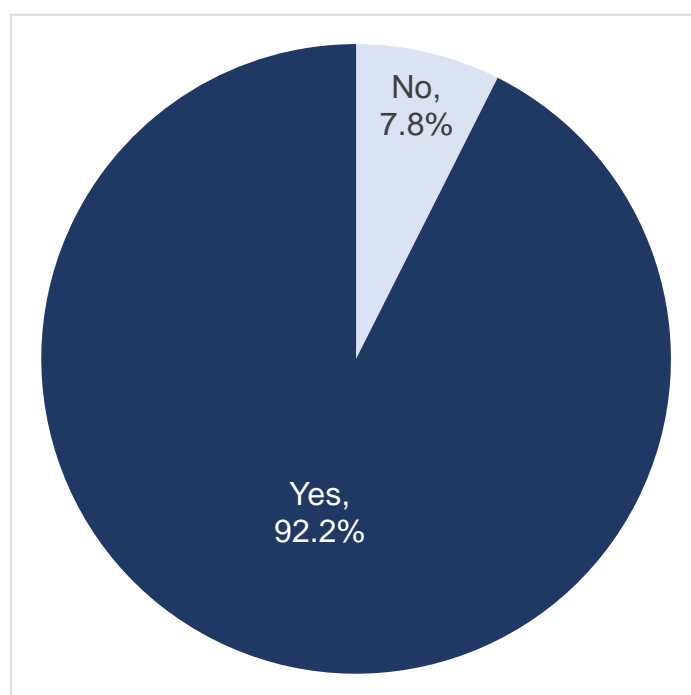


Fig 2.10 Isolated CABG surgery: LIMA usage

	LIMA usage	
	Yes	No
Count	212	18
Proportion	92.2%	7.8%
Dead	0	0
Crude mortality rate	0.0%	0.0%

Endoscopic harvest of conduits

- Endoscopic vein harvesting (EVH) to obtain conduits for coronary artery bypass grafting (CABG) has been developed to reduce leg wound complications and improve patient satisfaction. This has now become the standard and preferred way of harvesting these conduits in our practice.
- Fig 2.11 shows that the usage rate of the endoscopic method was 85.2% on average for vein graft harvest at the PWH between 2021 and 2022.

Fig 2.11 Isolated CABG surgery: Endoscopic conduit harvest

		Yes	No	All
Conduit	Endoscopic radial artery harvest	0	29	29
	Endoscopic vein harvesting	196	34	230

Logistic EuroSCORE and the crude mortality rate

- Logistic EuroSCORE is a commonly used risk stratification and prediction method in cardiac surgery. The value equals the expected mortality risk for a particular patient.
- Due to the improvements in surgical outcomes over time, the degree to which logistic EuroSCORE models over-predict observed mortality has increased.
- Fig 2.12 and Fig 2.13 show observed and expected mortality and the respective international comparison in table form. Fig 2.14 presents the same interpretations in graphical form.
- Fig 2.15 shows the distribution of isolated CABG cases by logistic EuroSCORE category.
- At the PWH, a logistic EuroSCORE higher than 9.9 contributes to 7.4% of patients.
- The overall **expected** mortality in the isolated CABG group of patients at the PWH was 3.8% (PWH: 3.8%, 2021-2022 vs the UK: 4.6%, 2015-2016).
- The overall **observed** mortality in the isolated CABG group of patients at the PWH was 0.0% (PWH: 0.0%, 2021-2022 vs the UK: 1.0%, 2015-2016 vs Japan JCVSD/NCD: $\approx 2.6\%^2$, 2017-2018).
- The **observed versus expected mortality ratio** for isolated CABG at the PWH was 0.0 in 2021-2022 (PWH: 0.37, 2019-2020). The observed versus expected mortality ratio for isolated first-time CABG (overall cohort) for the period 2015-2016 in the UK was 0.22 (PWH: 0.0, 2021-2022 vs the UK: $\approx 0.22^4$, 2015-2016).
- After risk adjustment, the PWH CABG outcome is better than expected.

Fig 2.12 Isolated CABG surgery: Logistic EuroSCORE distribution and the mortality rate at PWH

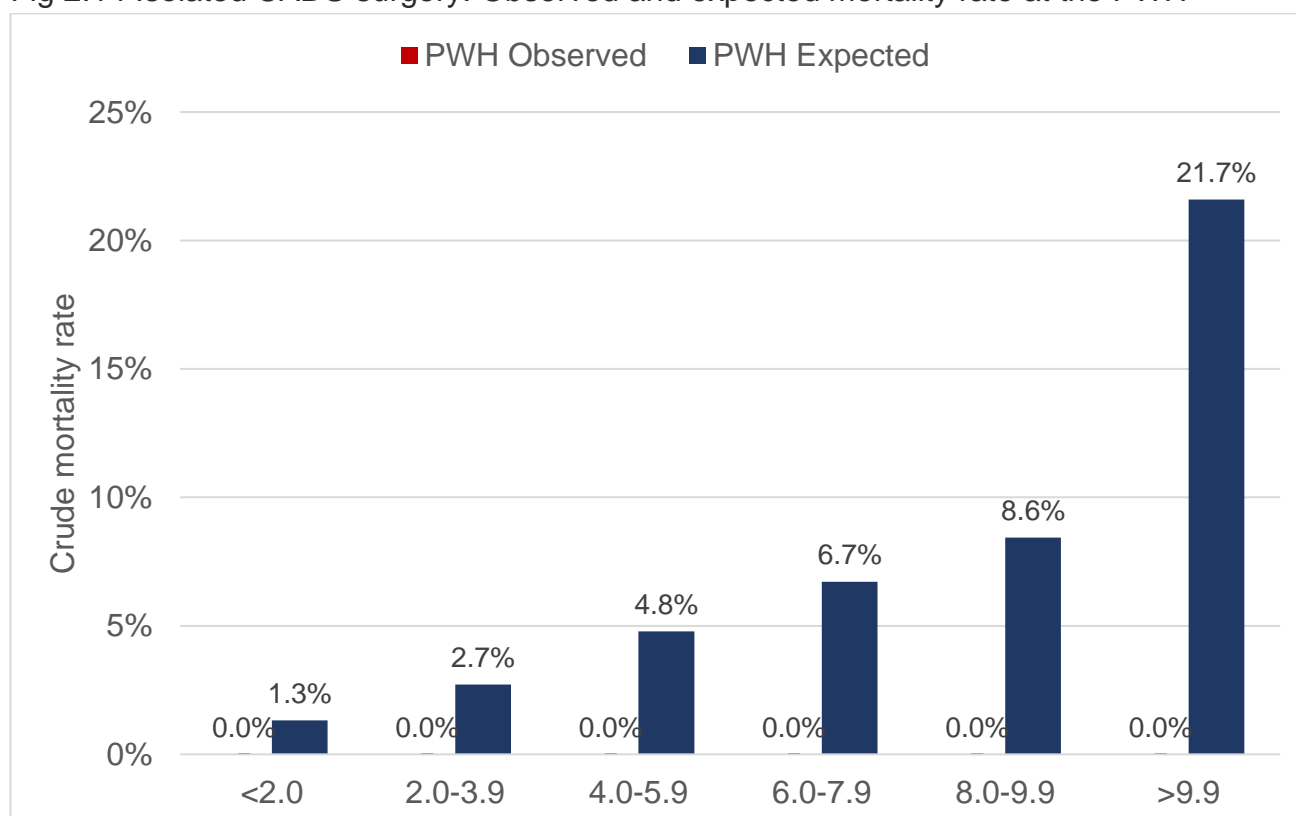
	Logistic EuroSCORE						All
	<2.0	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.9	>9.9	
Count	121	65	15	8	4	17	230
Dead	0	0	0	0	0	0	0
Observed mortality rate	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Expected mortality rate	1.3%	2.7%	4.8%	6.7%	8.6%	21.7%	3.8%

Observed and expected mortality rate at the PWH

Fig 2.13 Isolated CABG surgery: International comparison of observed and expected mortality rate

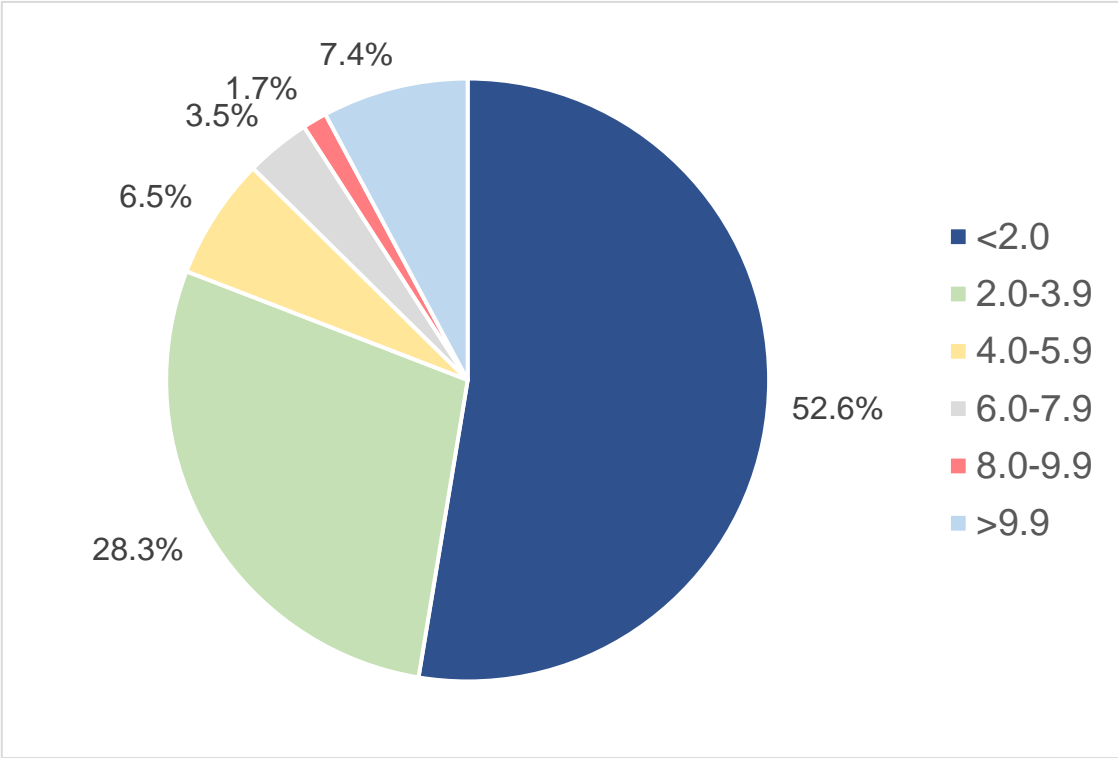
	PWH (2021-2022)		HK (2021-2022)		The UK (2015-2016)	
	Observed mortality	Expected mortality	Observed mortality	Expected mortality	Observed mortality	Expected mortality
Elective	0.0%	2.6%	1.1%	2.6%	0.6%	2.8%
Urgent	0.0%	9.2%	3.7%	8.3%	1.3%	5.5%
Emergency	0.0%	38.5%	3.3%	12.2%	6.6%	26.0%
All	0.0%	3.8%	1.6%	3.7%	1.0%	4.6%

Fig 2.14 Isolated CABG surgery: Observed and expected mortality rate at the PWH



Logistic EuroSCORE distribution at the PWH

Fig 2.15 Isolated CABG surgery: Logistic EuroSCORE distribution at the PWH

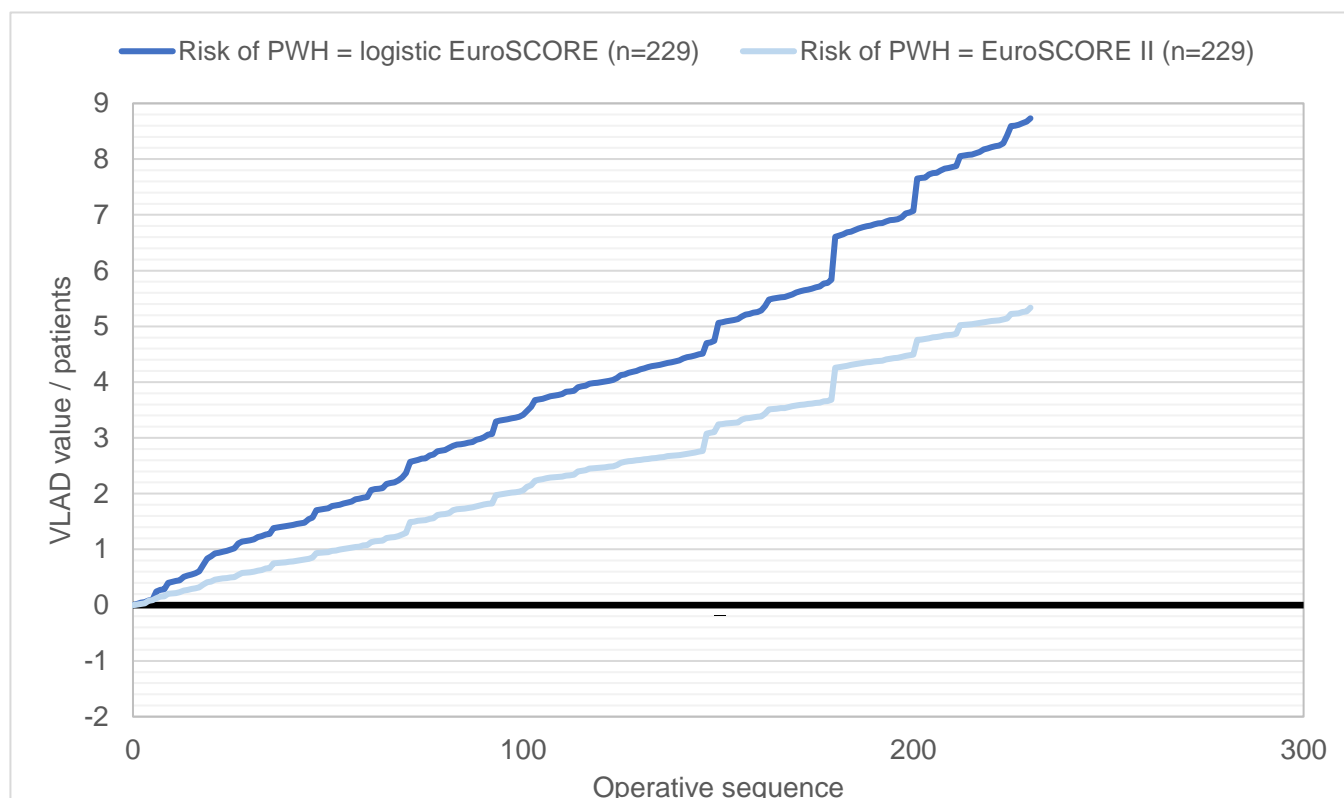


CORONARY SURGERY

VLAD plot of risk-adjusted mortality rate

- The Variable Life-Adjusted Display (VLAD) graph covers all risk-scored isolated CABG procedures performed during the calendar years 2021 and 2022.
- In the VLAD graph, an upward deviation demonstrates a net gain in patients' lives and outcomes over time that match or are better than expected by risk prediction; a downward trend indicates that there has been a deviation over time and reflects a trend that needs to be addressed. The degree of fluctuation is determined by the predicted risk associated with the case.
- The plot is risk-adjusted and performance as predicted should run approximately around the horizontal zero line (the heavy black line).
- Fig 2.16 shows the VLAD plot for CABG outcomes using the logistic EuroSCORE and EuroSCORE II respectively. As stated, this provides a good graphical representation of any deviation in outcomes over time.
- We can see that there was an upward deflection for the PWH, which implied that PWH performed better than expected by risk scores. At the end of the VLAD curve derived by the logistic EuroSCORE, a maximum of 9 extra lives had been saved for the isolated CABG group at the PWH.

Fig 2.16 Isolated CABG surgery: VLAD plot for *all* isolated CABG surgeries at the PWH



International benchmarking of results

- The focus of this report as stated was on risk-adjusted outcomes in terms of mortality and morbidity for cardiac surgery at the PWH.
- Morbidity following surgery though is important as it might impact the patient's quality of life and also some instances of morbidity can reflect the quality of care and service given.
- For patients following coronary surgery, we picked four outcomes to look at:
 - **Re-operation for bleeding (Fig 2.17 and Fig 2.20):** The frequent need for a second operation to control bleeding may reflect some deviation in the team's performance in terms of surgical technique or blood product usage, and so is often used as a quality indicator.
 - **Post-operative stroke (Fig 2.18 and Fig 2.21):** A post-operative stroke has implications for a patient's quality of life and hence is an important factor to measure.
 - **New haemofiltration / dialysis (Fig 2.19 and Fig 2.22):** The need for the institution of new dialysis for renal failure is also seen as a surrogate for some deviation in postoperative care at several levels.
 - **Crude mortality (Fig 2.23):** The crude post-operative death rate of patients.
- Funnel plots are graphical means of displaying outcomes compared to a given standard, with upper and lower control limits to define a range of acceptable results.
- All charts (Fig 2.20 to Fig. 2.23) show the results at the PWH with alert and alarm lines set at 99.0% and 99.9% respectively. The **control limits** refer to those generated by the submission of data from all cardiac units in Hong Kong during 2021-2022. The **light purple** horizontal line represents the average data from all cardiac units in Hong Kong during 2021-2022. The **light blue** horizontal line is served as a reference on the charts, which represents the average of the data or the in-hospital mortality rate in the United Kingdom NACSD during 2007-2016. The **light green** and **pink** horizontal line are served as reference on the charts, which represents the *provisional* average of the data or the in-hospital mortality rate in the United States STS ACSD during 2020-2021 and the in-hospital mortality rate in Japan JCVSD/NCD during 2017-2018 respectively.
- The crude mortality rates and all major morbidity rates mentioned above for isolated CABG at the PWH fell well within the alert lines during the assessment period.
- The results of these four key outcomes at the PWH have been excellent and compare well with international standards.

Other immediate post-operative outcomes

Re-operation for bleeding

Fig 2.17 Isolated CABG surgery: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	Count	2	228
	Proportion	0.9%	99.1%
	Dead	0	0
	Crude mortality rate	0.0%	0.0%

Post-operative stroke

Fig 2.18 Isolated CABG surgery: New post-operative stroke

		Yes	No
New post-operative stroke	Count	2	228
	Proportion	0.9%	99.1%
	Dead	0	0
	Crude mortality rate	0.0%	0.0%

Post-operative HF / dialysis

Fig 2.19 Isolated CABG surgery: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	Count	5	225
	Proportion	2.2%	97.8%
	Dead	0	0
	Crude mortality rate	0.0%	0.0%

Fig 2.20 Isolated CABG surgery: Crude **re-operation** rate **for bleeding**

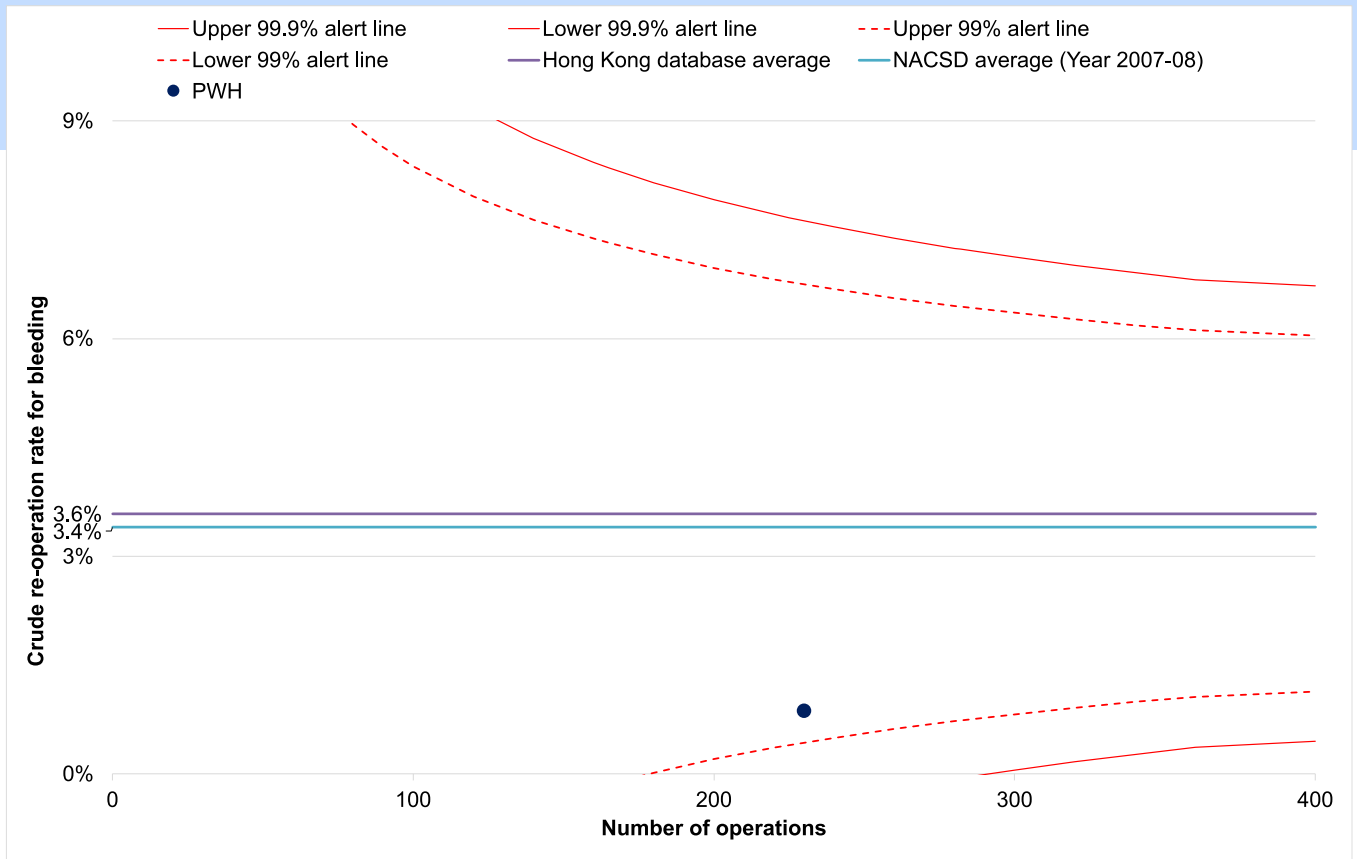


Fig 2.21 Isolated CABG surgery: Crude **post-operative stroke** rate

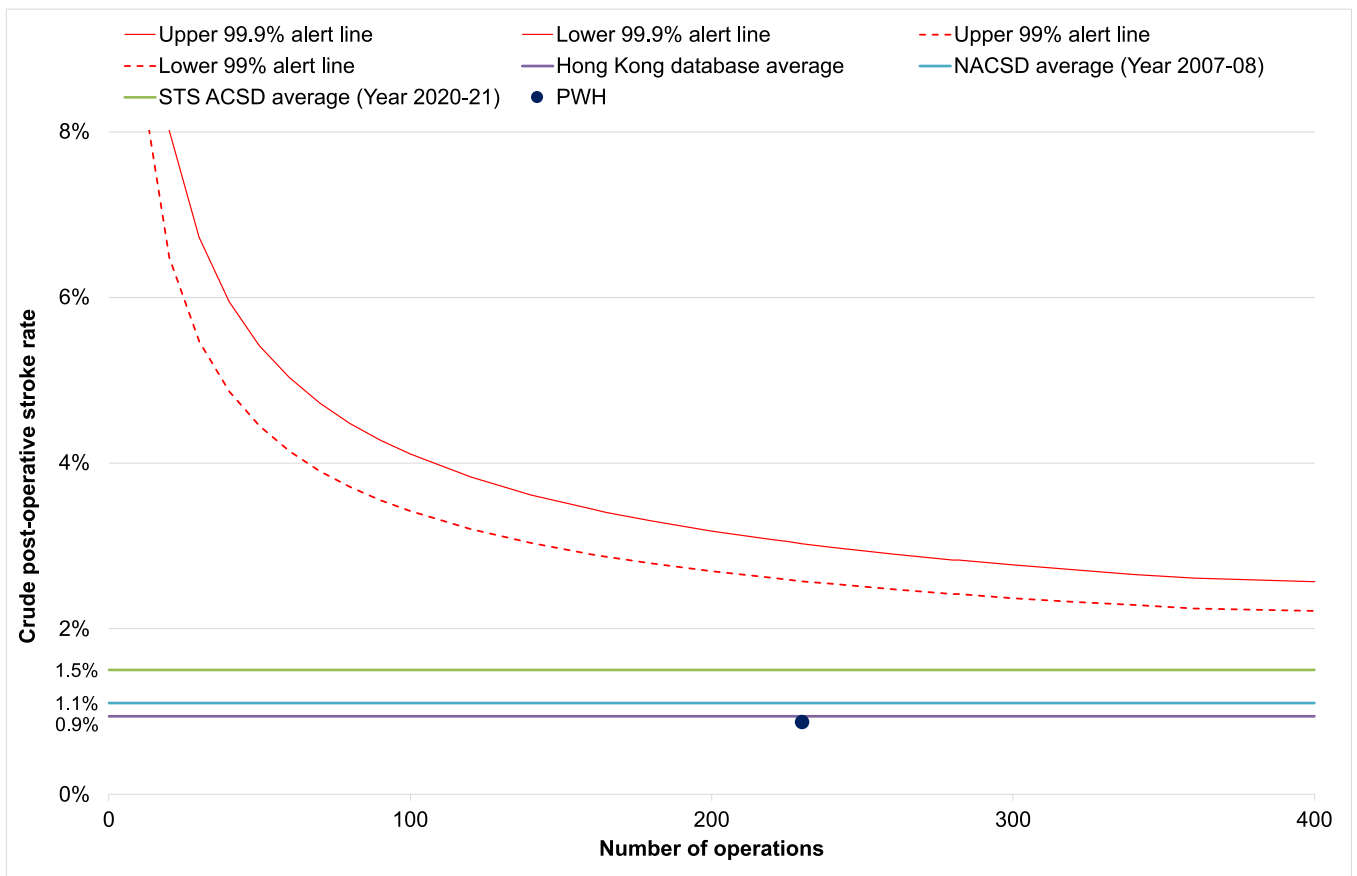
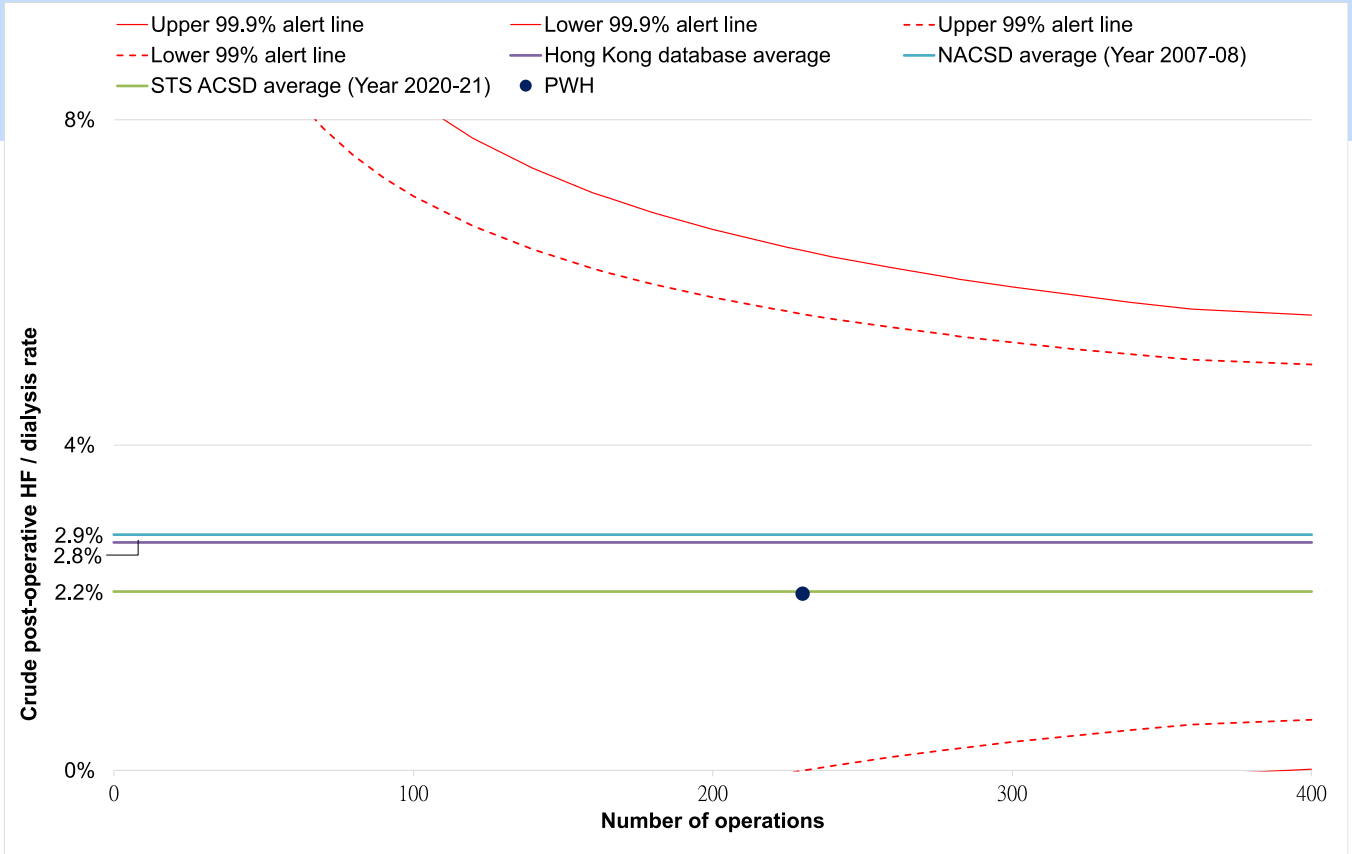
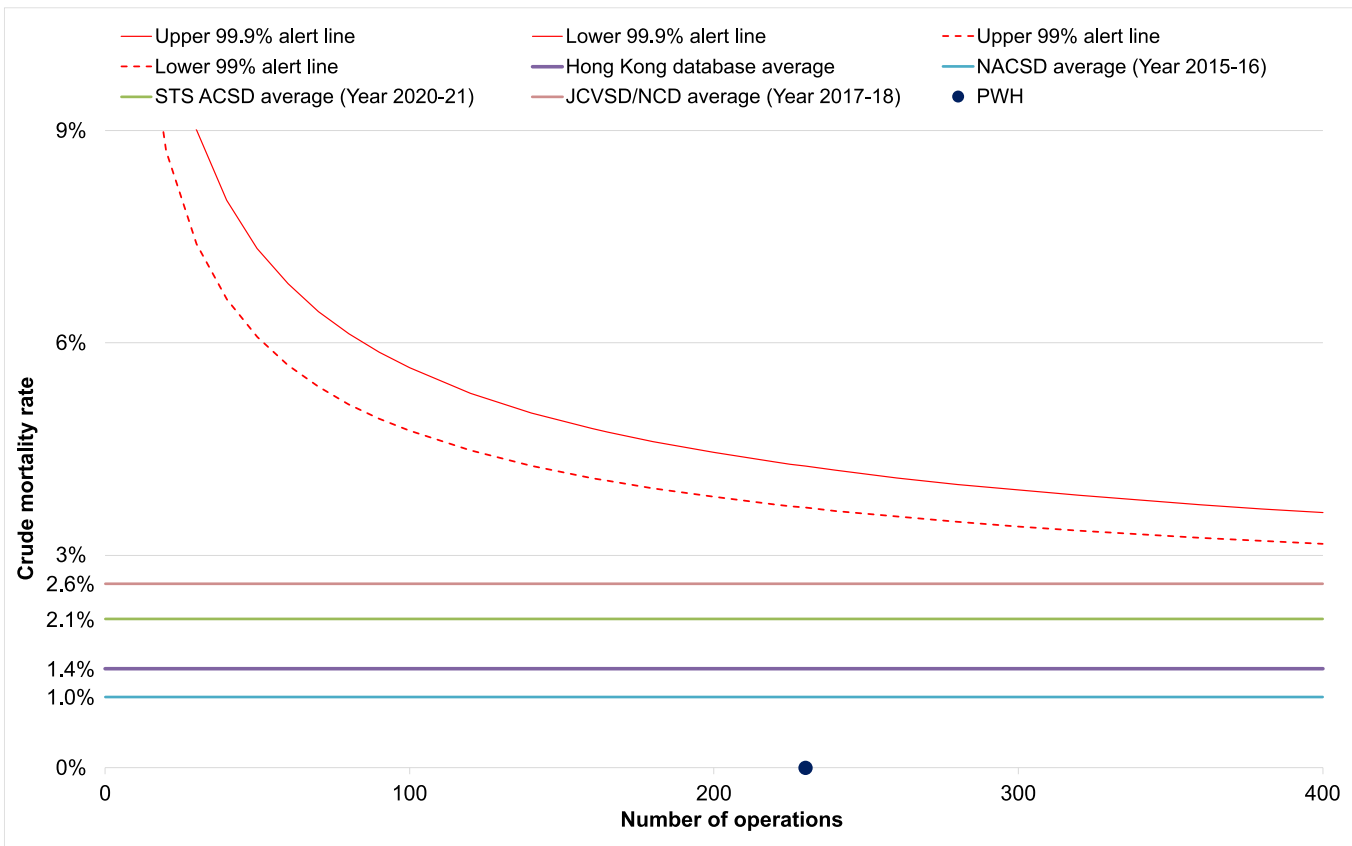


Fig 2.22 Isolated CABG surgery: Crude *post-operative HF / Dialysis* rate



Funnel plot of the crude mortality rate

Fig 2.23 *All* isolated CABG surgery: Crude *mortality* rate



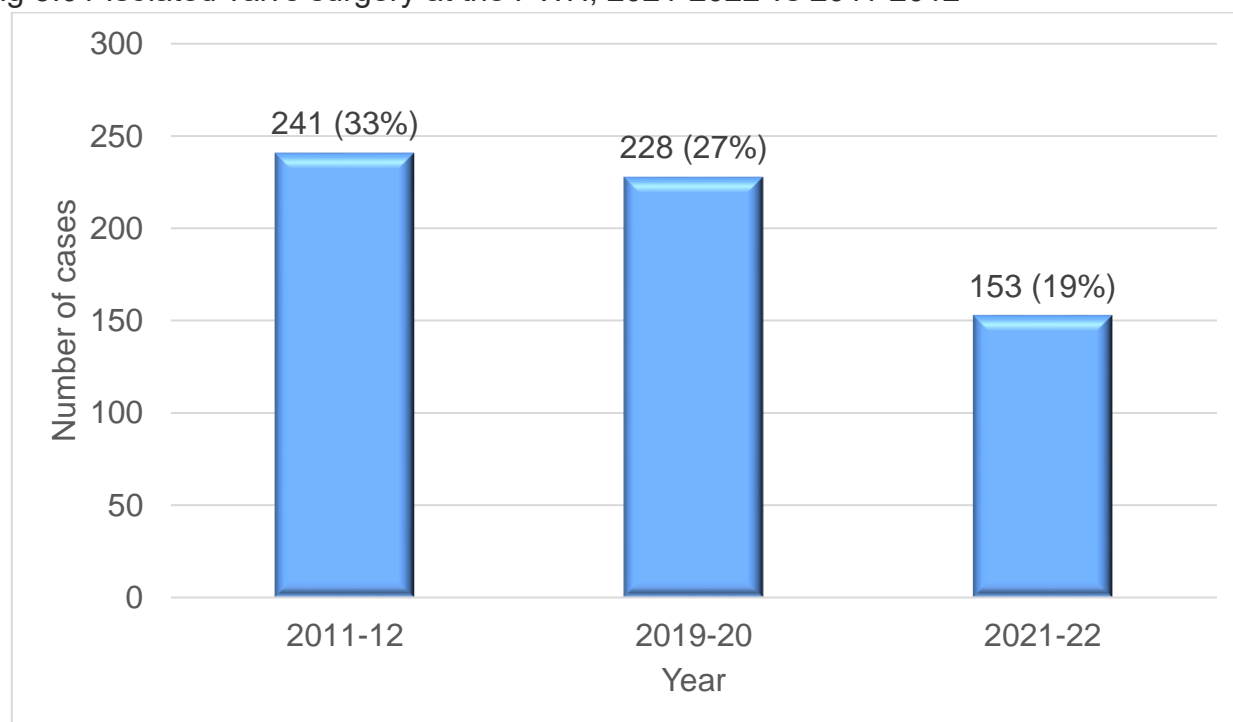
VALVE SURGERY



Isolated valve surgery in the context of the overall workload

- Fig 3.01 shows the number of isolated valve surgeries done over the years. There were 153 isolated valve surgeries performed in total during the calendar years 2021 and 2022, which comprised 19% of all cardiac surgical operations at the PWH.
- The number of valvular procedures remained stable in recent years. The overall incidence for all valvular procedures was 46% in PWH during 2021-2022. (PWH: 46%, 2021-2022 vs the UK: 48.4%, 2015-2016 vs Japan JCVSD/NCD: $\approx 34.1\%^2$, 2017-2018).
- There were 214 (27%) valvular operations performed in combination with the other procedures including CABG, radiofrequency atrial ablation, aortic surgery, and septal defect repair at the PWH respectively. There has been a consistent increase in this group over the last several years (27%, 2021-2022 vs 18%, 2019-2020).
- Combined valve and **LA appendage occlusion** procedures (104) become increasingly common during 2021-2022. However, this patient group is classified as “valve & other” surgery, but not “isolated valve” surgery in the Dendrite system. Therefore, we **exclude** this group of patients in this section. This may also lead to the decreasing number of isolated valve surgery performed in 2021-2022.

Fig 3.01 Isolated valve surgery at the PWH, 2021-2022 vs 2011-2012



Pre-operative risk factors

Operative priority

- Priority of surgery has a marked association with operative mortality. Urgent and emergency patients consistently stay in the hospital longer than elective patients.
- Fig 3.02 shows the operative priority distribution and the crude mortality rate of isolated valve surgery. Fig 3.03 presents the distribution of isolated aortic valve, mitral valve, and tricuspid valve surgery according to the operative priority in absolute number.
- There were 123 isolated single valve operations performed during 2021-2022.
- The proportion of all isolated single valve operations performed electively has remained consistent around 85% at the PWH over the period reviewed.
- There has been a small proportion of patients who undergo isolated valve surgeries as urgent, emergency, or salvage cases. The remaining 15% were urgent, emergency, or salvage operations at the PWH between 2021 and 2022.

VALVE SURGERY

Fig 3.02 Isolated single valve surgery: Operative priority and the crude mortality rate

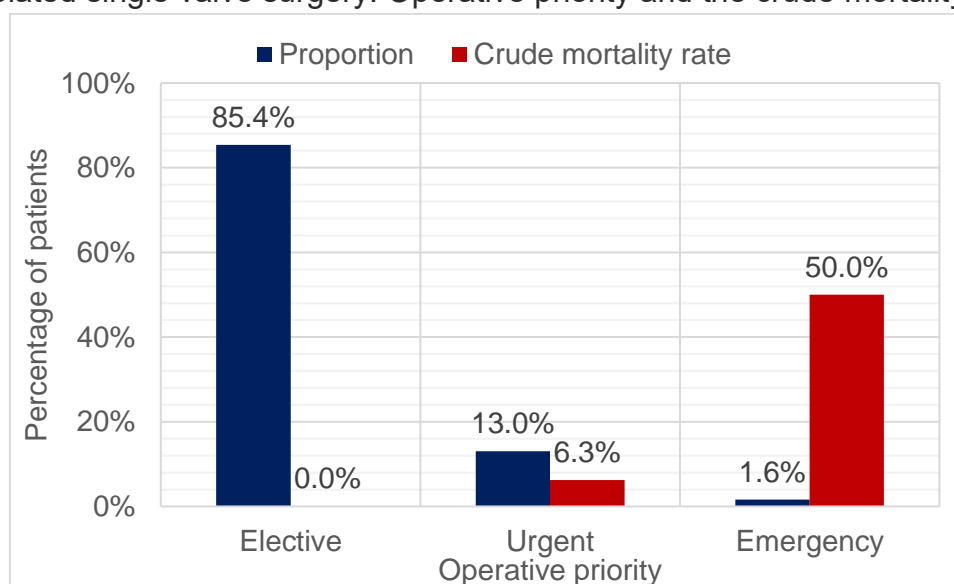


Fig 3.03 Isolated single valve surgery: Operative priority

		Valve treated		
		Aortic alone	Mitral alone	Tricuspid alone
Priority	Elective	61	42	2
	Urgent	9	7	0
	Emergency	1	1	0
	All	71	50	2

Previous cardiac surgery

- Repeat (redo) operations contribute a significant workload in the isolated valve operation group.
- Fig 3.04 shows the isolated valve surgical outcomes according to the patient's previous cardiac surgery status in graphical form. Fig 3.05 presents the distribution of isolated aortic valve, mitral valve, and tricuspid valve surgery according to the patient's previous cardiac surgery status in absolute numbers.
- Most (89.4%) isolated single valve procedures were first-time operations at the PWH between 2021 and 2022.
- Among all isolated single valve operations, 13 (10.6%) had previous cardiac operations between 2021 and 2022 at the PWH, which implied that the proportion of patients who had previous cardiac surgery was significantly small.
- Among those redo cardiac operations, most of them had re-do cardiac operations once only.

Fig 3.04 Isolated single valve surgery: Previous cardiac surgery and the crude mortality rate

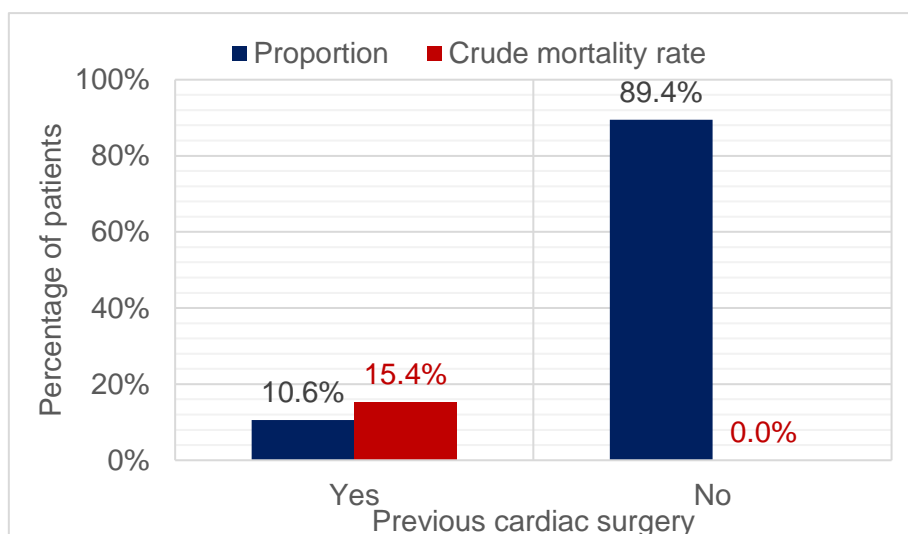


Fig 3.05 Isolated single valve surgery: Previous cardiac surgery

		Valve treated		
		Aortic alone	Mitral alone	Tricuspid alone
Previous cardiac surgery	Yes	7	5	1
	No	64	45	1
	All	71	50	2

Haemodynamic pathology

- Fig 3.06 shows the isolated valve surgical outcomes according to the three common haemodynamic pathologies. Fig 3.07 presents the distribution of isolated aortic valve, mitral valve, and tricuspid valve surgery according to the haemodynamic pathology in absolute numbers.
- More than half of the isolated aortic valve operations, 52% of our case load was for aortic stenosis between 2021 and 2022 at the PWH.
- Among all patients who had isolated mitral valve surgery at the PWH, 82% had mitral regurgitation between 2021 and 2022.
- The dominant types of haemodynamic pathologies were stenosis and regurgitation in the isolated aortic and mitral valve groups respectively.

Fig 3.06 Isolated single valve surgery: Haemodynamic pathology and crude mortality rate

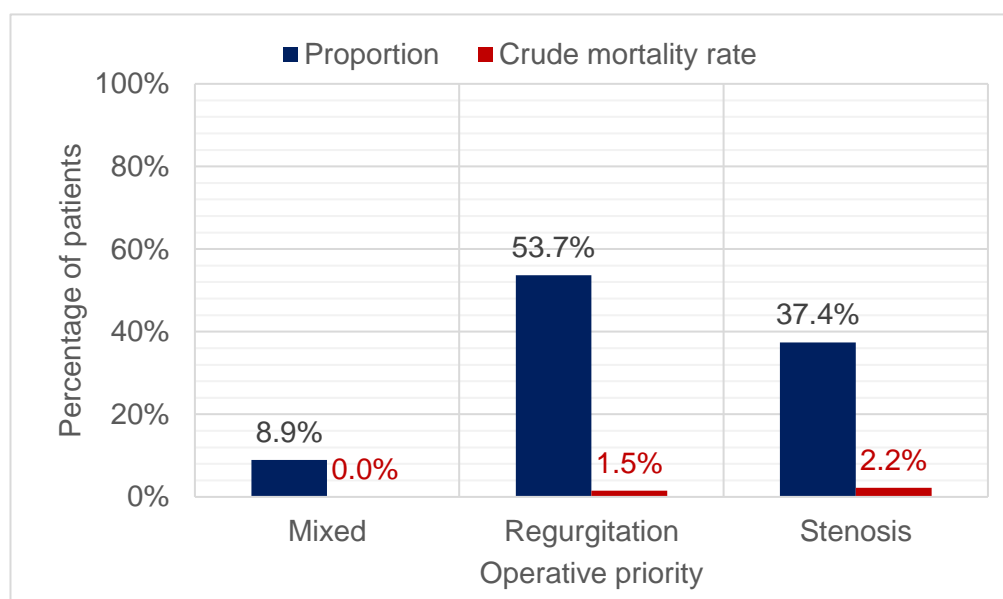


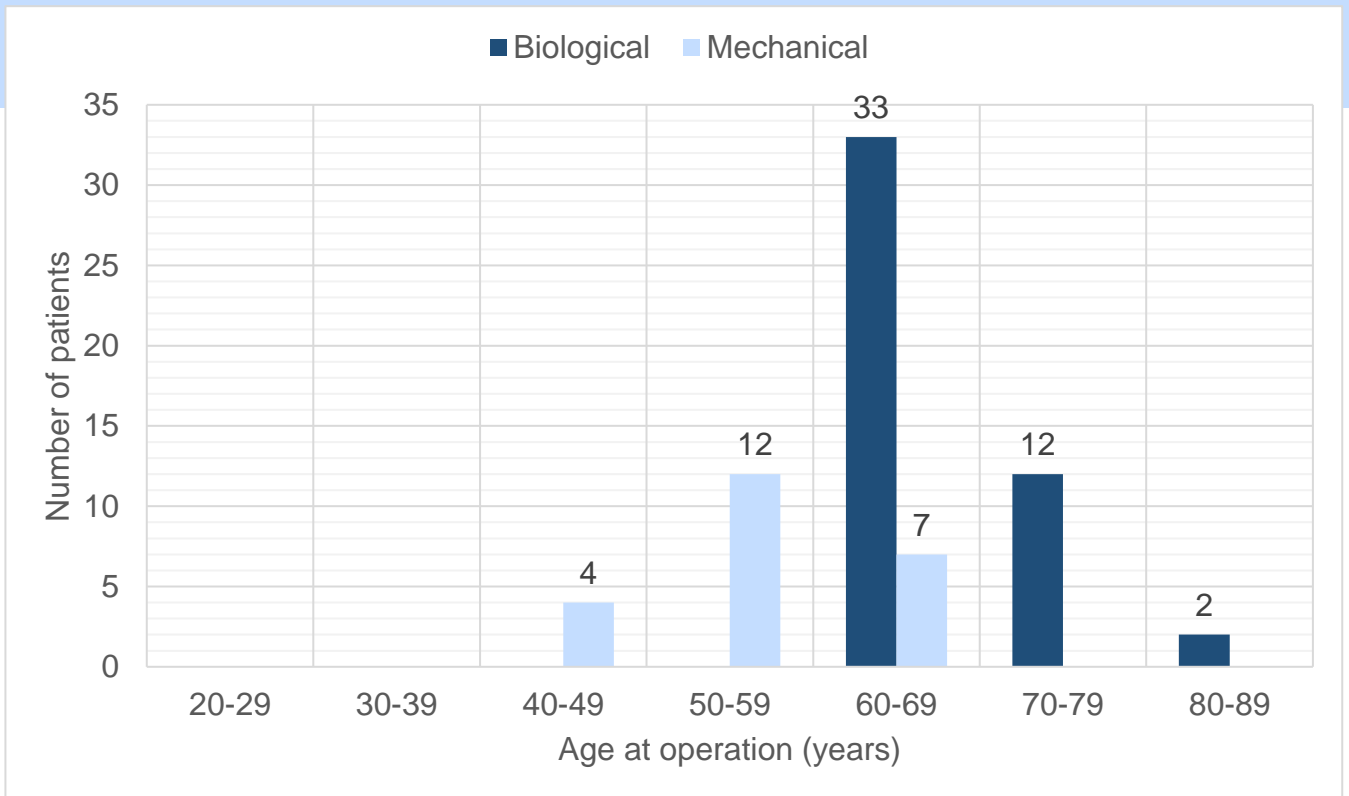
Fig 3.07 Isolated single valve surgery: Haemodynamic pathology

		Valve treated		
		Aortic alone	Mitral alone	Tricuspid alone
Haemodynamic pathology	Mixed	11	0	0
	Regurgitation	23	41	2
	Stenosis	37	9	0
	All	71	50	2

Aortic valve surgery

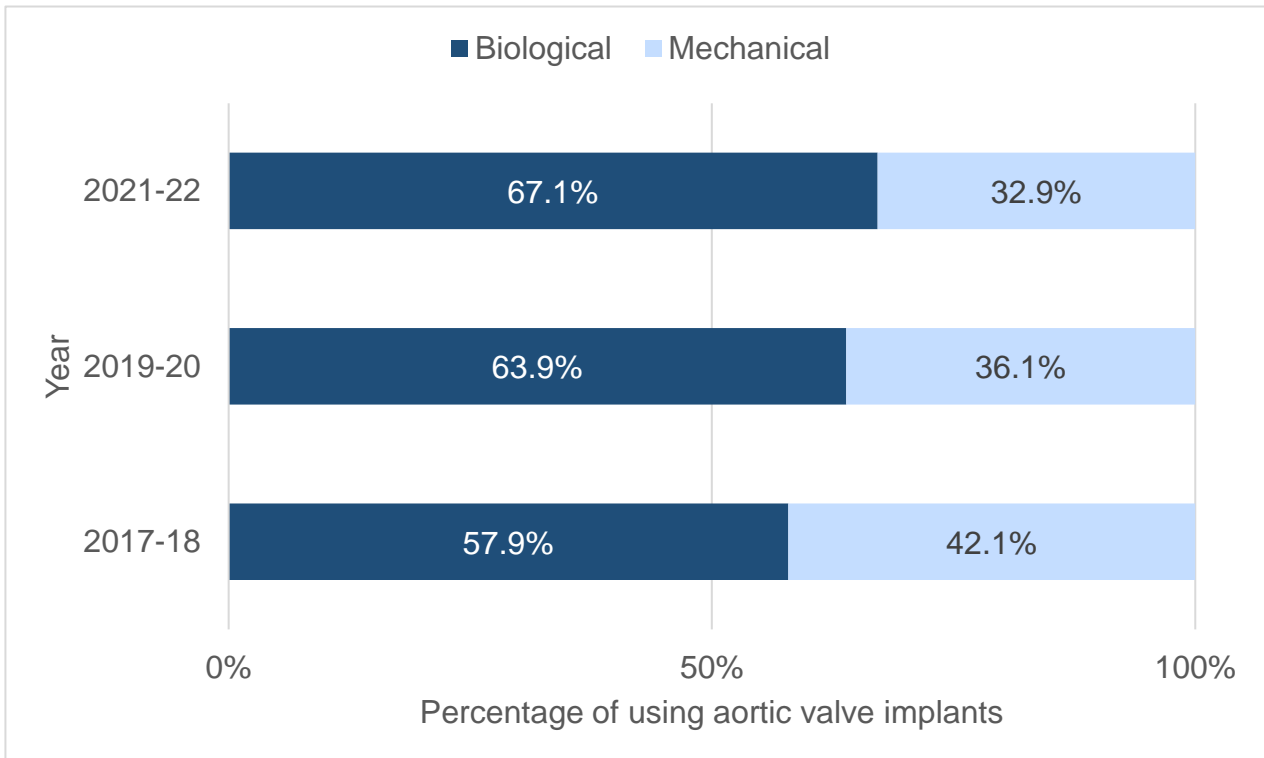
- The number of patients affected by aortic valve disease, in particular aortic stenosis (AS), is constantly rising owing to demographic changes. The incidence of AS is around 52% and this trend will therefore continue for some time.
- Fig 3.08 shows the usages of biological and mechanical aortic valve implants according to patient age during the calendar years 2021 and 2022.
- Overall, there were 70 aortic valve replacements (AVR) and 1 aortic valve repair performed during 2021-2022.
- Most (87.0%) of the biological prostheses were implanted in patients above 60 years of age at the PWH. A trend towards increasing implantation of bioprosthetic valves in patients aged over 60 years has been demonstrated previously in our biennial report.
- Among isolated AVR procedures performed between 2021 and 2022, 67.1% used a bioprosthetic valve, and 32.9% a mechanical valve at the PWH. The result is close to the figure in the US STS ACSD that bioprosthetic valves made up 80.9% of aortic valve implants in 2021. (PWH: 67.1%, 2021-2022 vs the US STS ACSD: 80.9%³, 2021)
- The ratio of aortic valve replacements with bioprosthesis procedures performed in Japan was 83.9% during 2017-2018.
- Fig 3.09 shows the two types of aortic valve implant distribution during 2017-2022. As expected, we have seen an increasing number of biological valves being implanted over time. This is a common international trend and is also consistent with reports of prolonged durability of biological valves resulting in their use in younger patients. This trend has also supported by the figures in the PWH.

Fig 3.08 Isolated single valve surgery: Biological and mechanical aortic valve implants



VALVE SURGERY

Fig 3.09 Isolated single valve surgery: Aortic valve implants, 2017-2022



Native valve pathology

- Fig 3.10 shows the native valve pathology distributions for isolated single valve surgeries.
- Isolated aortic and mitral valve surgeries are performed for many different pathologies.
- The dominant native valve pathology of isolated aortic, mitral, and tricuspid valve surgeries was degenerative between 2021 and 2022.
- Another common pathology in patients undergoing isolated aortic valve repair and replacement was calcific degeneration in 2021-2022.
- Chronic rheumatic changes of mitral valves also accounted for one of the major causes of valvular heart disease at the PWH.

Fig 3.10 Isolated single valve surgery: Native valve pathology

		Valve treated		
		Aortic alone	Mitral alone	Other singles
Native valve pathology	Degenerative	36	31	2
	Calcific degeneration	18	1	0
	Congenital	11	2	0
	Active infective endocarditis	5	5	0
	Rheumatic	6	7	0
	Other native valve pathology	5	2	0
	Previous infective endocarditis	1	3	0
	Annuloaortic ectasia	0	0	0
	Native valve not present	2	1	0
	Functional regurgitation	0	2	1
	Ischaemic	0	0	0

Mitral valve surgery

Mitral valve repair and replacement in the context of all mitral valve surgeries

- Fig 3.11 shows the total number of mitral valve repairs and replacement and the haemodynamic pathology of mitral valve surgery.
- The whole part about the mitral valve surgery represents all mitral valve operations including those where concomitant procedures such as CABG, multiple valve procedures, major aortic procedures, or other cardiac procedures were performed.
- Mitral valve repair/replacement constituted 55.2% of all valvular operations in PWH (PWH: 55.2%, 2021-2022 vs Japan JCVSD/NCD: $\approx 48.4\%^2$, 2017-2018).
- The vast majority of mitral valve repairs and replacements were performed for mitral regurgitation in PWH (PWH: 71.9%, 2021-2022).
- Among those repaired and replaced, the majority were of degenerative and rheumatic aetiologies respectively.
- Based on The Society for Cardiothoracic Surgery (SCTS) in Great Britain & Ireland, 6th NACSD Report, in 2008, 67% underwent mitral valve repair for degenerative mitral valve disease.

Fig 3.11 Mitral valve surgery: Number of mitral valve repair and replacement & the haemodynamic pathology

		Number of counts
Valve procedure	Replacement	86
	Repair	117
Haemodynamic pathology	Regurgitation	146
	Stenosis	42
	Mixed	15

Elective mitral valve surgery

- Fig 3.12 shows the overall *elective* mitral valve (MV) activity.
- *Elective* procedures make up the vast majority of mitral valve activity in PWH. Hence, a comprehensive update on the status of *elective* mitral valve procedures in PWH is provided to identify whether we have a consistent trend with that in the UK.
- There has been similar proportion of MV repair (PWH: 60.6%, 2021-2022 vs the UK: 60.0%, 2015-2016) and replacement (PWH: 39.4%, 2021-2022 vs the UK: 40.0%, 2015-2016) in patients undergoing *elective* surgery in PWH and the UK.
- With the similar logistic EuroSCORE found in PWH and the UK (PWH: 6.0%, 2021-2022 vs the UK: 6.0-8.0%, 2015-2016), a general trend can be seen towards lower crude mortality for *elective MV repair* with a mortality rate less than 1.0% in PWH (PWH: 0.9%, 2021-2022 vs the UK: <2.0%, 2015-2016).
- Mortality for *elective MV replacement* has remained consistently higher than for patients undergoing *elective* MV repair during 2021-2022 in PWH, but it was lower than the UK benchmarking (PWH: 2.8%, 2021-2022 vs the UK: 4.0-6.0%, 2015-2016).
- We had higher observation of the overall level of *elective* MV activity in PWH and the UK, in terms of the proportion of all mitral valve operations performed *electively* (PWH: 88.7%, 2021-2022 vs the UK: 75.0%, 2015-2016), the observed mortality (PWH: 1.7%, 2021-2022 vs the UK: 3.0-4.0%, 2015-2016), and expected mortality (PWH: 6.8%, 2021-2022 vs the UK: 8.0-9.0%, 2015-2016).

Fig 3.12 Mitral valve surgery: Observed and expected mortality rate of *elective* MV surgery

			PWH	The UK 2015-2016 ⁴
Elective MV	Elective MV repair	Count (Proportion)	109 (60.6%)	60%
		Observed mortality rate	0.9%	<2.0%
		Expected mortality rate	6.0%	6.0-8.0%
	Elective MV replacement	Count (Proportion)	71 (39.4%)	40.0%
		Observed mortality rate	2.8%	4.0-6.0%
		Expected mortality rate	8.0%	10.0-12.0%
Elective MV surgery	Count	180 (88.7%)	75.0%	
	Observed mortality rate	1.7%	3.0-4.0%	
	Expected mortality rate	6.8%	8.0-9.0%	

Type of mitral valve repair

- Fig 3.13 shows the type of mitral valve repair in PWH.
- Most (85.5%) of the mitral valve repairs were complex operations, involving two or more repair procedures in PWH.
- Most (96.6%) of mitral valve repairs had ring annuloplasty between 2021 and 2022 in PWH.
- Artificial chordal implantation was the second most popular technique (71.8%) in mitral valve repair surgery following annuloplasty in PWH.

Fig 3.13 Mitral valve surgery: Type of mitral valve repair

		Count	Proportion
Type of mitral valve repair	Annuloplasty (ring)	113	96.6%
	Artificial chord	84	71.8%
	Leaflet resection	9	7.7%
	Other	15	12.8%
	Annuloplasty (suture)	0	0.0%
	Leaflet patch	4	3.4%
	Commissurotomy	7	6.0%

Tricuspid valve surgery

Tricuspid valve repair in the context of all tricuspid valve surgeries

- Fig 3.14 shows the tricuspid valve surgical outcomes.
- This part represents all tricuspid valve operations including those where concomitant procedures such as CABG, multiple valve procedures, major aortic procedures, or other cardiac procedures were performed.
- There were 85 (23.1%) of all valvular surgeries involving tricuspid valve procedures between 2021 and 2022 in PWH (PWH: 23.1%, 2021-2022 vs Japan JCVSD/NCD: $\approx 27.0\%^2$, 2017-2018).
- Repair of the valve was a popular procedure in tricuspid valve positions. Tricuspid valve repair constituted 22.3% of all valvular operations in PWH (PWH: 22.3%, 2021-2022 vs Japan JCVSD/NCD: $\approx 26.0\%^2$, 2017-2018), and 96.5% of all tricuspid valve procedures in Hong Kong (PWH: 96.5%, 2021-2022 vs Japan JCVSD/NCD: $\approx 96.2\%^2$, 2017-2018).
- Of the four cardiac valves, the valve most commonly needing intervention is the *aortic valve* followed by the *mitral valve*. The *tricuspid valve* may occasionally need repair by annuloplasty in conjunction with mitral valve surgery but otherwise, it is extremely rare that the tricuspid valve ever needs intervention in adult patients as an isolated procedure (5, 2021-2022 vs 2, 2019-2020). On average, fewer than 60 cases of isolated tricuspid valve surgery per annum were reported in the UK.
- Tricuspid valve repairs were mainly for regurgitations between 2021 and 2022. The other common pathologies in tricuspid valve surgeries were rheumatic disease, functional regurgitation, and congenital disease.

Fig 3.14 Tricuspid valve surgery: Number of tricuspid valve repair and replacement

		Repair	Replacement
Valve procedure	Tricuspid alone	2	3
	Tricuspid plus another valve	80	0
	All that include tricuspid valve surgery	82	3

Logistic EuroSCORE and the crude mortality rate (Isolated *single* valve surgery)

- In this section, isolated single valve surgeries include all isolated aortic, mitral, and tricuspid valve surgeries at the PWH.
- The overall crude mortality for Hong Kong was 3.8% in 2021-2022 (HK: 4.1%, 2019-2020).
- Fig 3.15 shows the O/E ratios of isolated single valve surgeries at the PWH. Predominant isolated single valve surgery was isolated aortic valve surgery at the PWH between 2021 and 2022.
- Fig 3.16 pinpoints the differences between the observed and expected mortality rates of isolated mitral valve surgeries at the PWH. For the high-risk patient group (logistic EuroSCORE > 9.9) undergoing isolated mitral valve surgeries at the PWH, the observed mortality rate was lower than the expected logistic EuroSCORE, which represents PWH performed better than expected in terms of outcomes in this group.
- According to the 7th Cardiac Surgery Blue book online, in the UK over the period 2015-2016, for *isolated aortic valve replacement*, the observed mortality reported was 1.7% (predicted mortality was 7.9%) and the O/E ratio was 0.22 approximately. Similarly, the observed mortality reported for *elective mitral valve* surgery was around 3.5% (predicted mortality was around 8.4%) and the O/E ratio was 0.42 approximately. Finally, the observed mortality reported for *isolated tricuspid valve* surgery was less than 5% in the UK in 2015-2016 (PWH: 0.0%, 2021-2022 vs the UK: <5%, 2015-2016).

The proportion of patients by logistic EuroSCORE distribution

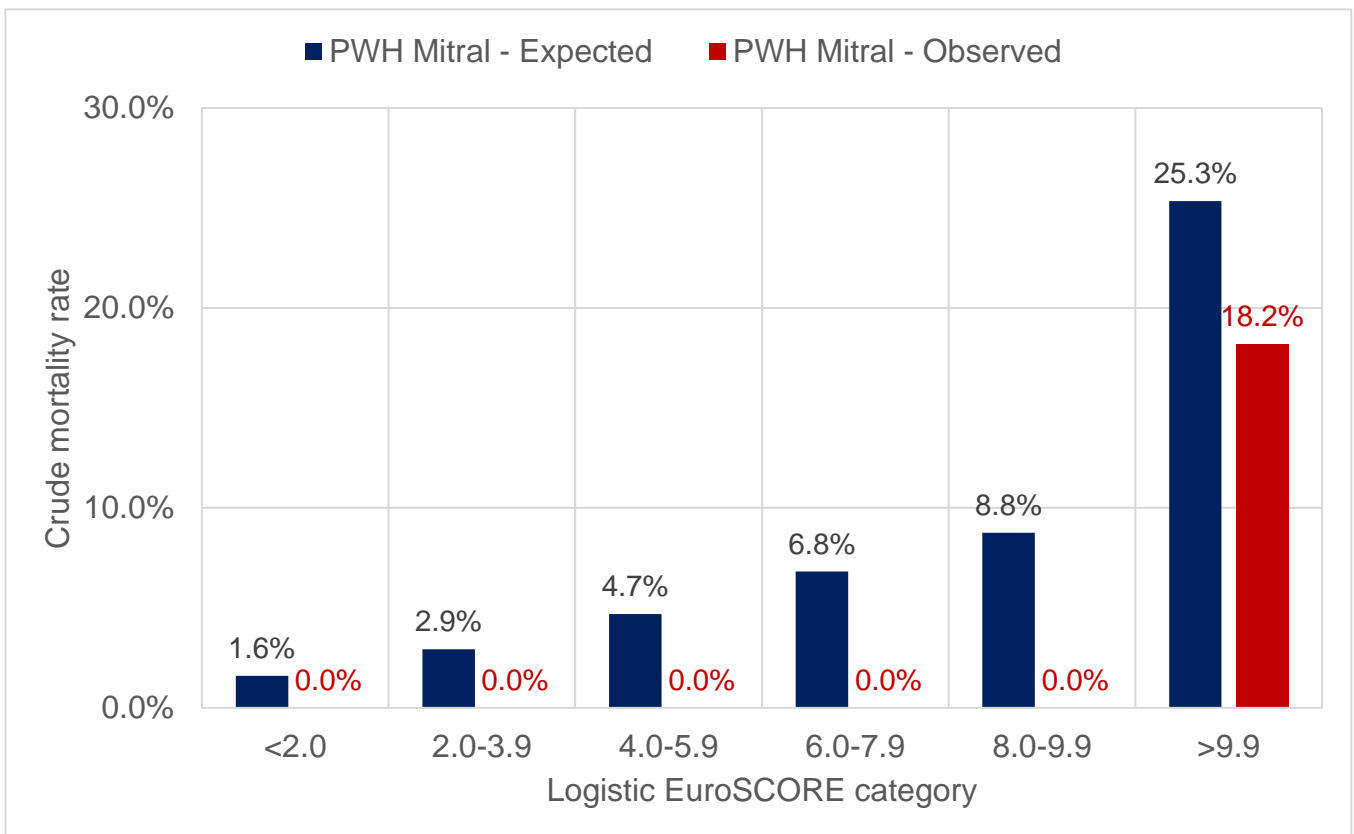
- Fig 3.17 shows the proportions of patients having isolated aortic, mitral, and tricuspid valve surgeries according to their logistic EuroSCORE at the PWH.
- Between 2021 and 2022, most patients who underwent isolated aortic and mitral valve surgeries had logistic EuroSCORE ranging from 2.0 to 3.9 (Aortic valve: 36.6% & Mitral valve: 28.0%).
- Due to the insignificant number of patients undergoing isolated tricuspid valve surgeries at the PWH, no meaningful statistical comparison could be drawn in this group.

Observed and expected mortality rate at the PWH

Fig 3.15 Isolated *single valve* surgery: Mortality data and O/E ratio

Valve treated	Count		Mortality		
	All	Deaths	Observed (O)	Expected (E)	O/E Ratio
Aortic alone	71	0	0.0%	6.4%	0.00
Mitral alone	50	2	4.0%	8.1%	0.49
Tricuspid alone	2	0	0.0%	24.6%	0.00

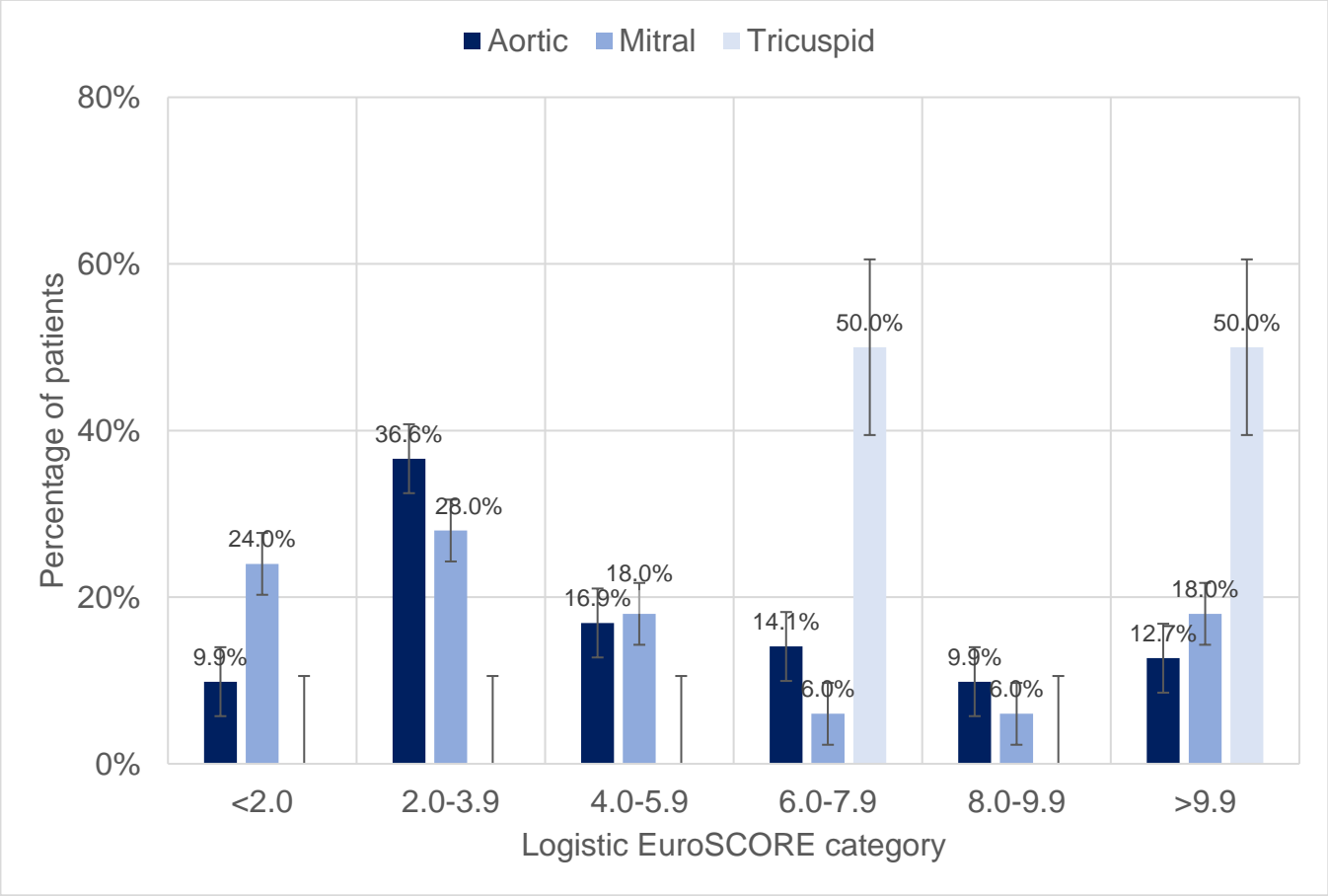
Fig 3.16 Isolated *single & multiple mitral valve* surgery: Observed & Expected mortality



VALVE SURGERY

Proportion of patients

Fig 3.17 Isolated *single valve* surgery: Proportion of patients



VALVE SURGERY

Logistic EuroSCORE and the crude mortality rate (Isolated *multiple* valves surgery)

- In this section, isolated multiple valve surgeries include combined mitral and tricuspid valve surgeries, combined aortic and mitral valve surgeries, combined aortic, mitral, and tricuspid surgeries, and combined aortic and tricuspid valve surgeries.
- Fig 3.18 shows the O/E ratios of isolated multiple valve surgeries at the PWH.
- Predominant multiple valve surgery was combined mitral and tricuspid surgery at the PWH between 2021 and 2022, which remains consistent with our preceding report in 2019-2020.

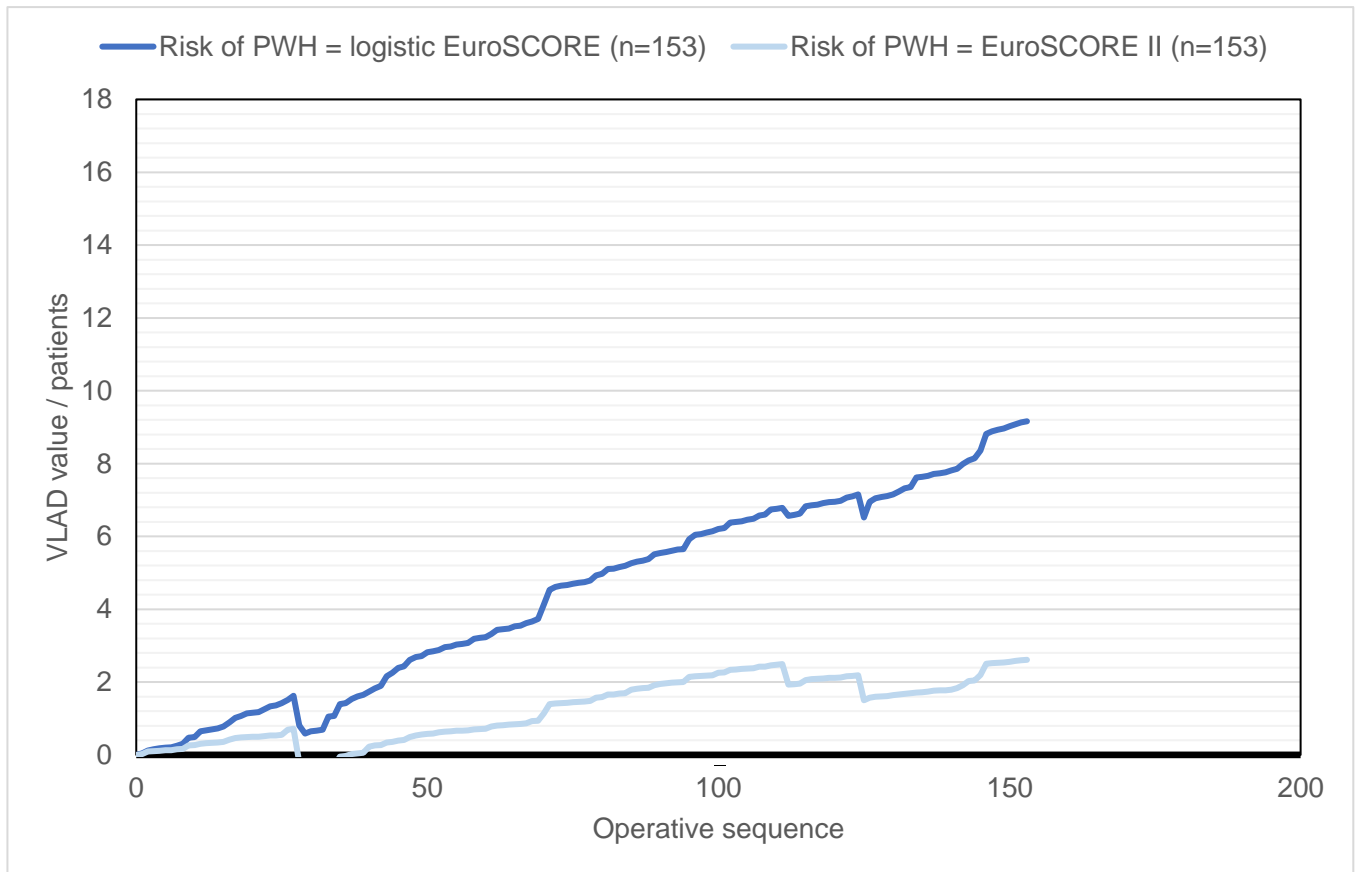
Fig 3.18 Isolated *multiple valves* surgery: Mortality data and O/E ratio

		Count		Mortality		
		All	Deaths	Observed (O)	Expected (E)	O/E Ratio
Valve treated	Mitral & tricuspid	12	1	8.3%	13.8%	0.60
	Aortic & mitral	10	1	10.0%	15.8%	0.63
	Aortic, mitral & tricuspid	7	0	0.0%	8.5%	0.00
	Aortic & tricuspid	1	0	0.0%	26.5%	0.00

VLAD plot of risk-adjusted mortality rate

- Fig 3.19 shows the VLAD plot for isolated valve surgical outcomes using the logistic EuroSCORE and EuroSCORE II respectively. As mentioned before, this provides a good graphical representation of any deviation in outcomes over time.
- We can see that there was an upward deflection for the VLAD curves, which implied that the outcome for the PWH is within the acceptable standard. At the end of the unadjusted VLAD curve derived by the logistic EuroSCORE, a maximum of 9 extra lives had been saved for the isolated valve group at the PWH.

Fig 3.19 Isolated valve surgery: VLAD plot for *all* isolated valve surgeries at the PWH



Other immediate post-operative outcomes

- Fig 3.20 to Fig 3.22 show the post-operative surgical outcomes for patients requiring isolated valve surgeries at the PWH, which are the overall **re-operation for bleeding** rate (Fig 3.20), **post-operative stroke** rate (Fig 3.21), and **new haemofiltration / dialysis** rate (Fig 3.22). Fig 3.23 to Fig 3.25 show the same interpretation using the funnel plots, with alert and alarm lines set at 99.0% and 99.9% respectively. The control limits refer to those generated by the submission of data from all cardiac units in Hong Kong during 2021-2022. The **light purple** horizontal line represents the average data from all cardiac units in Hong Kong during 2021-2022.
- These three key outcomes at the PWH fall comfortably within the control limits, showing satisfactory quality.

Re-operation for bleeding

Fig 3.20 Isolated valve surgery: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	Count	5	148
	Proportion	3.3%	96.7%
	Dead	1	3
	Crude mortality rate	0.7%	2.0%

Post-operative stroke

Fig 3.21 Isolated valve surgery: New post-operative stroke

		Yes	No
New post-operative stroke	Count	2	151
	Proportion	1.3%	98.7%
	Dead	1	3
	Crude mortality rate	0.7%	2.0%

Post-operative HF / dialysis

Fig 3.22 Isolated valve surgery: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	Count	4	149
	Proportion	2.6%	97.4%
	Dead	3	1
	Crude mortality rate	2.0%	0.7%

Funnel plots for other immediate post-operative outcomes

Fig 3.23 Isolated valve surgery: Crude **re-operation** rate **for bleeding**

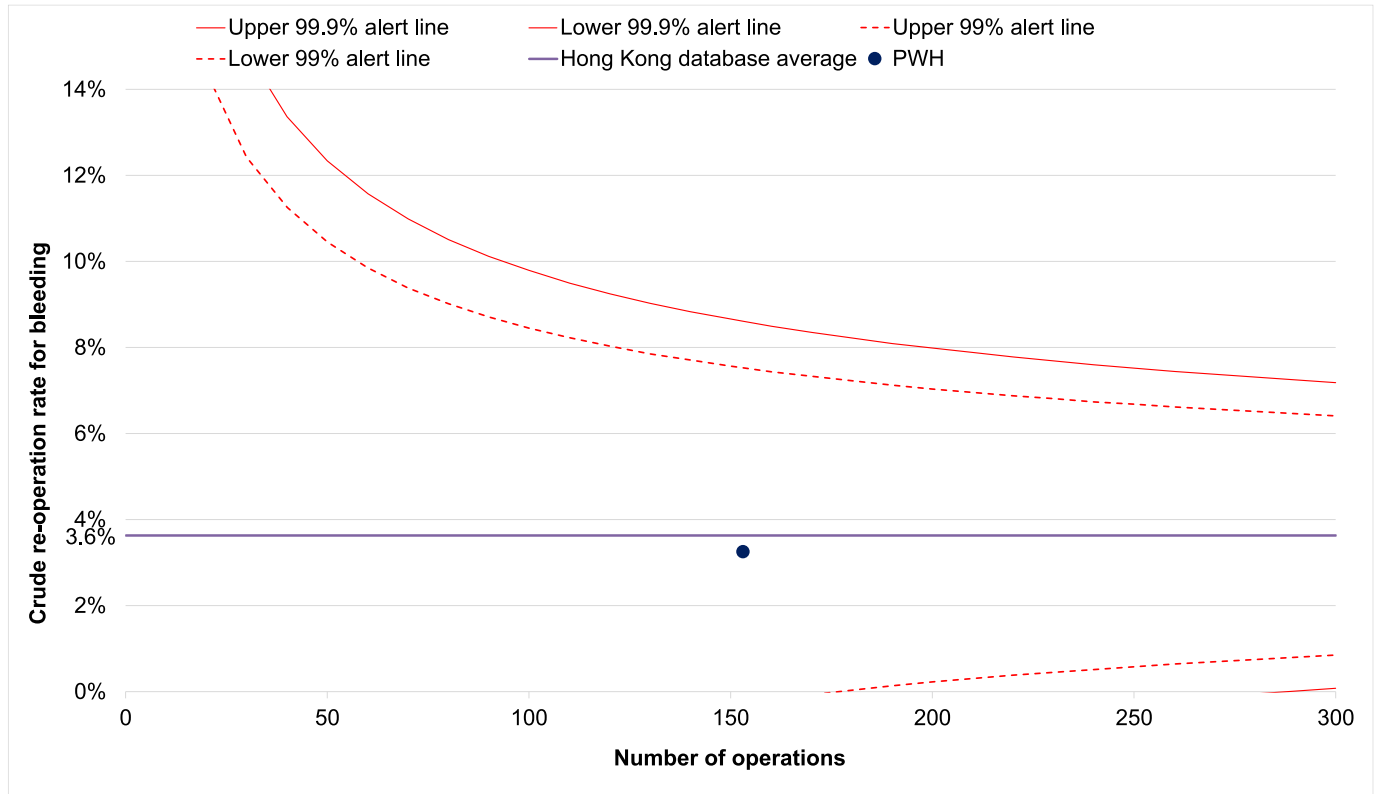


Fig 3.24 Isolated valve surgery: Crude **post-operative stroke** rate

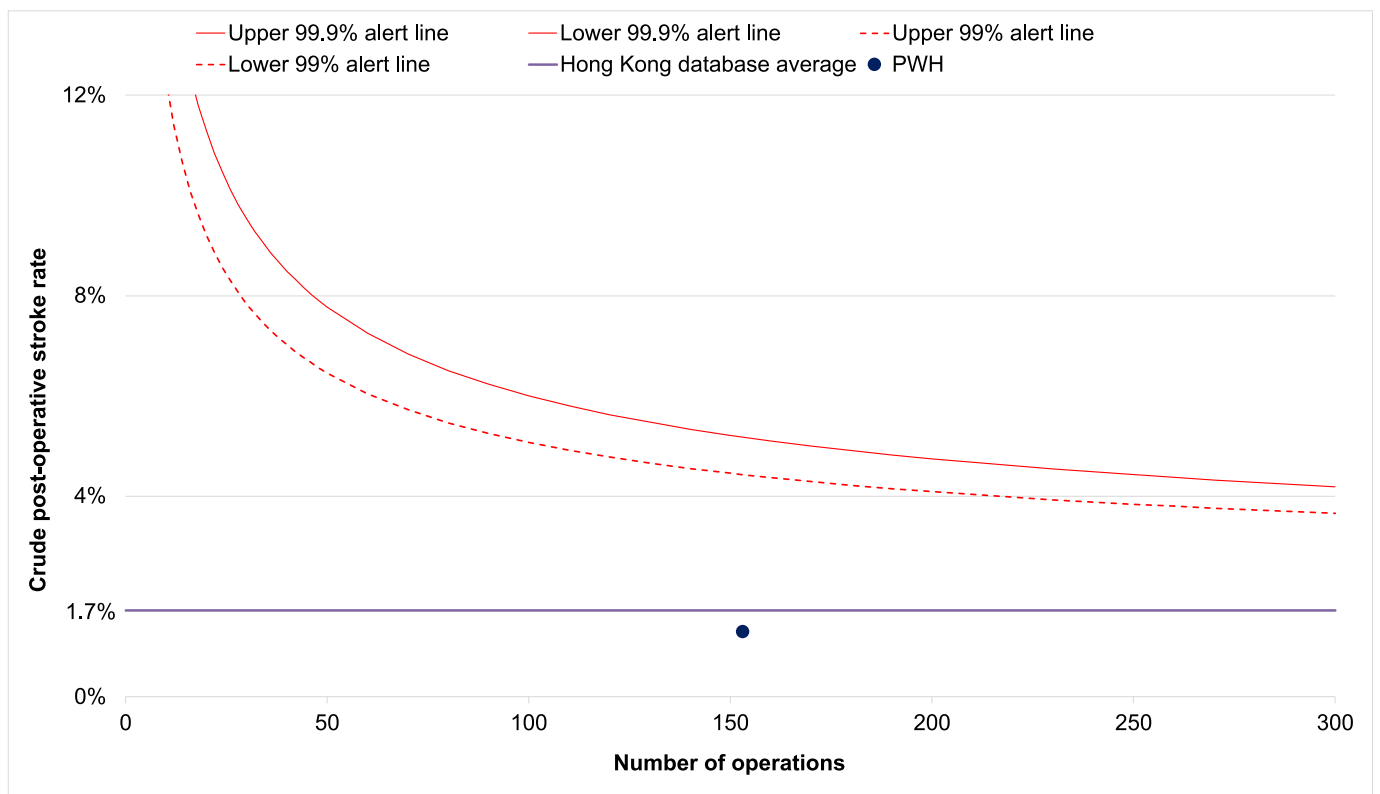
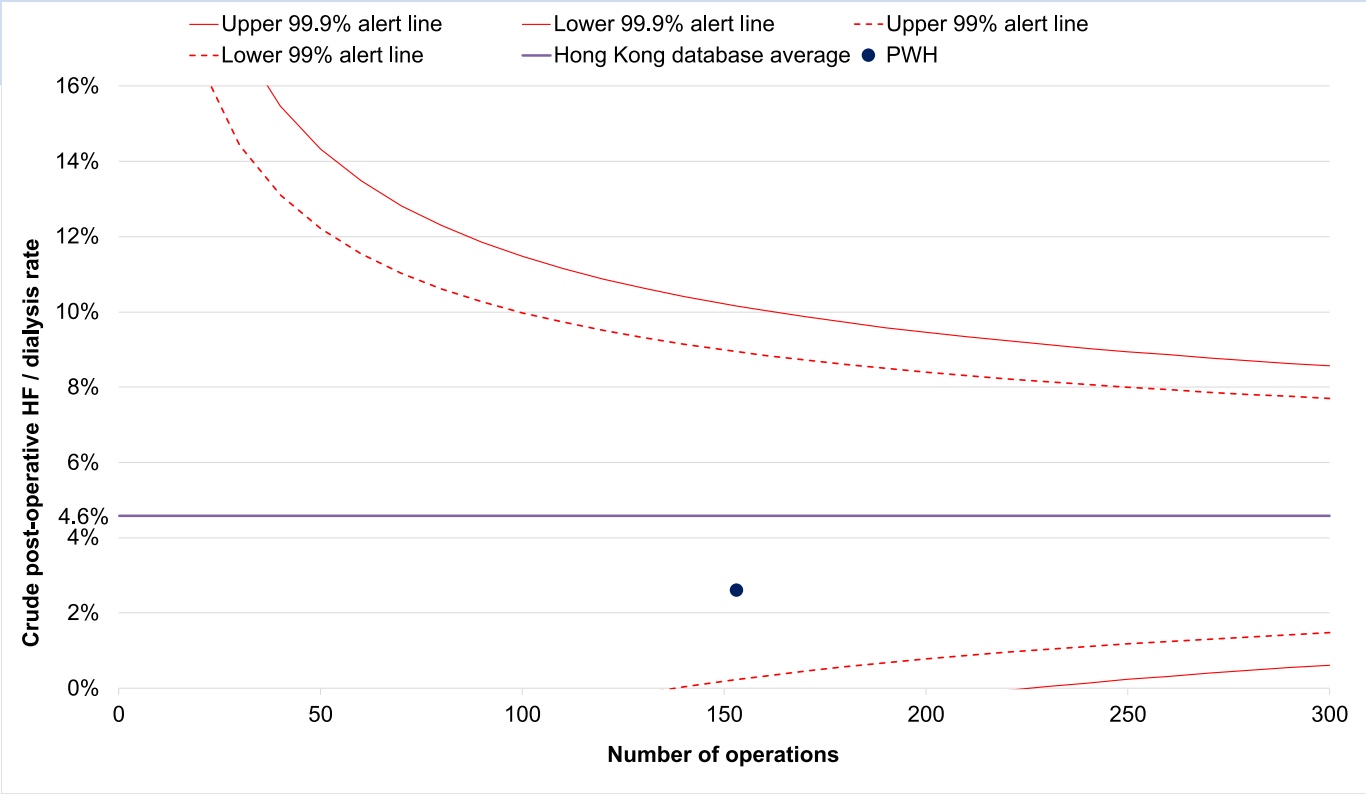


Fig 3.25 Isolated valve surgery: Crude **post-operative HF / Dialysis** rate



VALVE SURGERY

Funnel plot of the crude mortality rate

Isolated valve, isolated aortic valve replacement (AVR), and isolated mitral valve

- Fig 3.26 to Fig 3.28 show the funnel plots for the mortality of the isolated valve, isolated AVR, and isolated mitral valve surgery, with alert and alarm lines set at 99.0% and 99.9% respectively. The **control limits** refer to those generated by the submission of data from all cardiac units in Hong Kong during 2021-2022. The **light purple** horizontal line represents the average data from all cardiac units in Hong Kong during 2021-2022. The **light blue, green, and pink** horizontal lines are served as references on the chart, which represent the in-hospital mortality rate in the United Kingdom NACSD in 2015-2016, the provisional in-hospital mortality rate in the United States STS ACSD in 2020-2021, and approximate in-hospital mortality rate in Japan JCVSD/NCD during 2017-2018 respectively.
- The results of these three funnel plots demonstrated that the crude mortality rate at the PWH fell within the alert lines during 2021-2022, demonstrating no outliers. In other words, PWH performed better than expected over the period reviewed according to the risk profile of the patients operated upon.
- PWH has continued to have excellent surgical outcomes in terms of mortality for isolated aortic valve replacement in 2021-2022. The improvements seen in the UK and US STS ACSD were less pronounced than at the PWH during 2021-2022.

Fig 3.26 **Isolated valve** surgery: Crude **mortality** rate

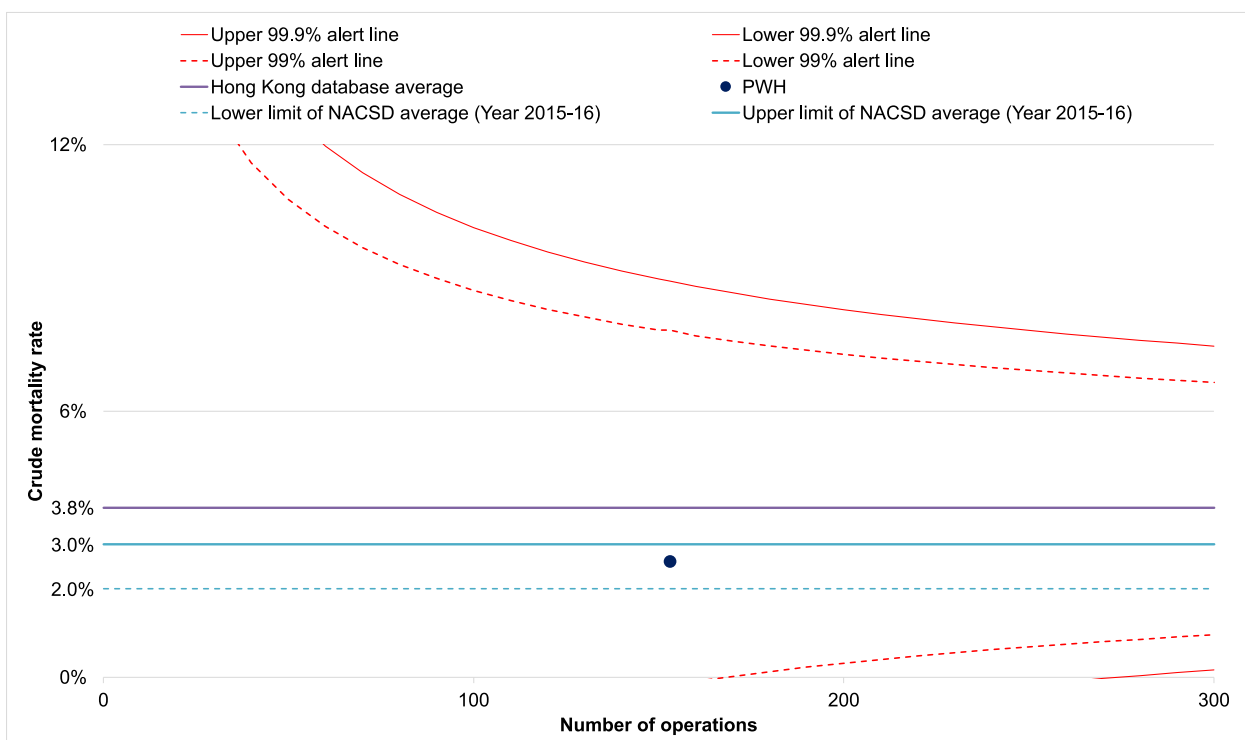
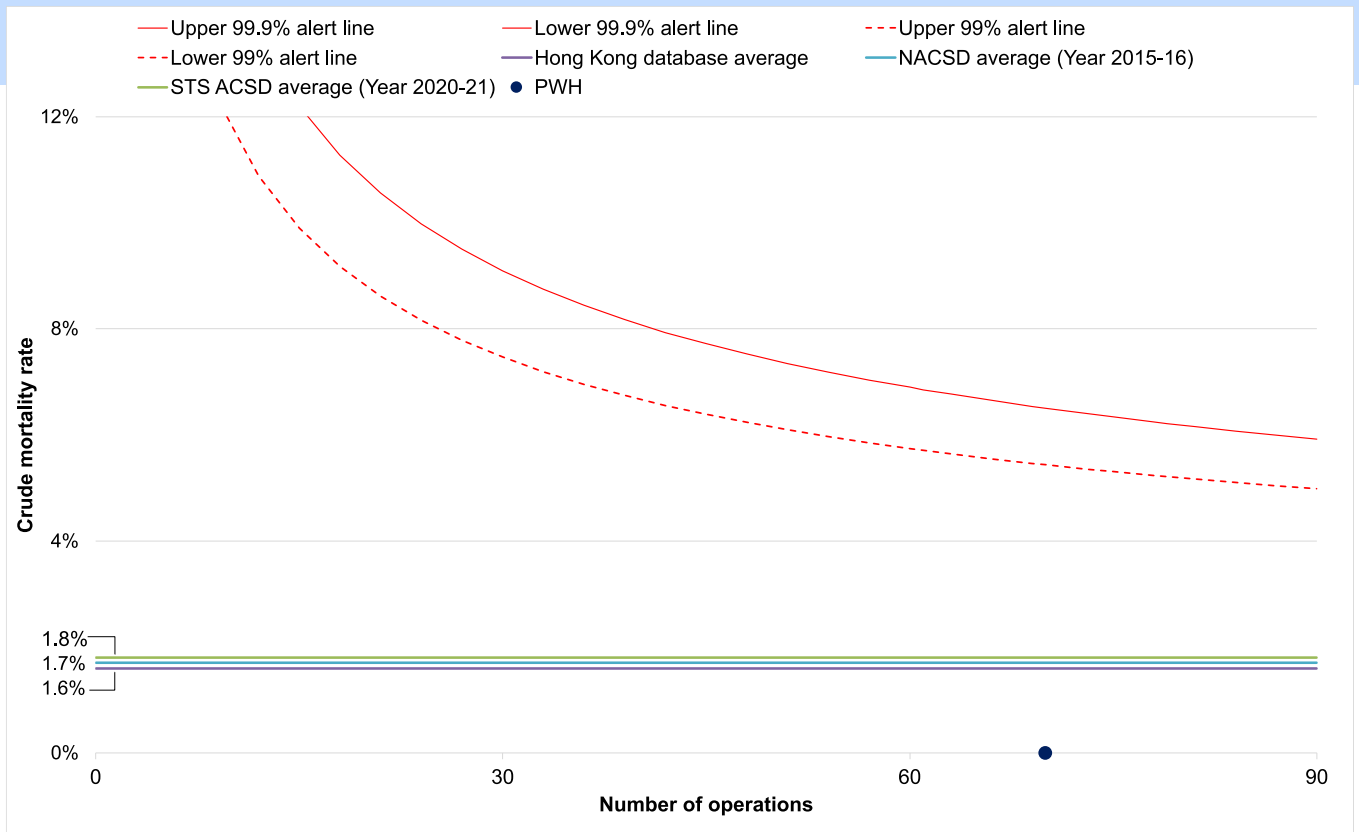
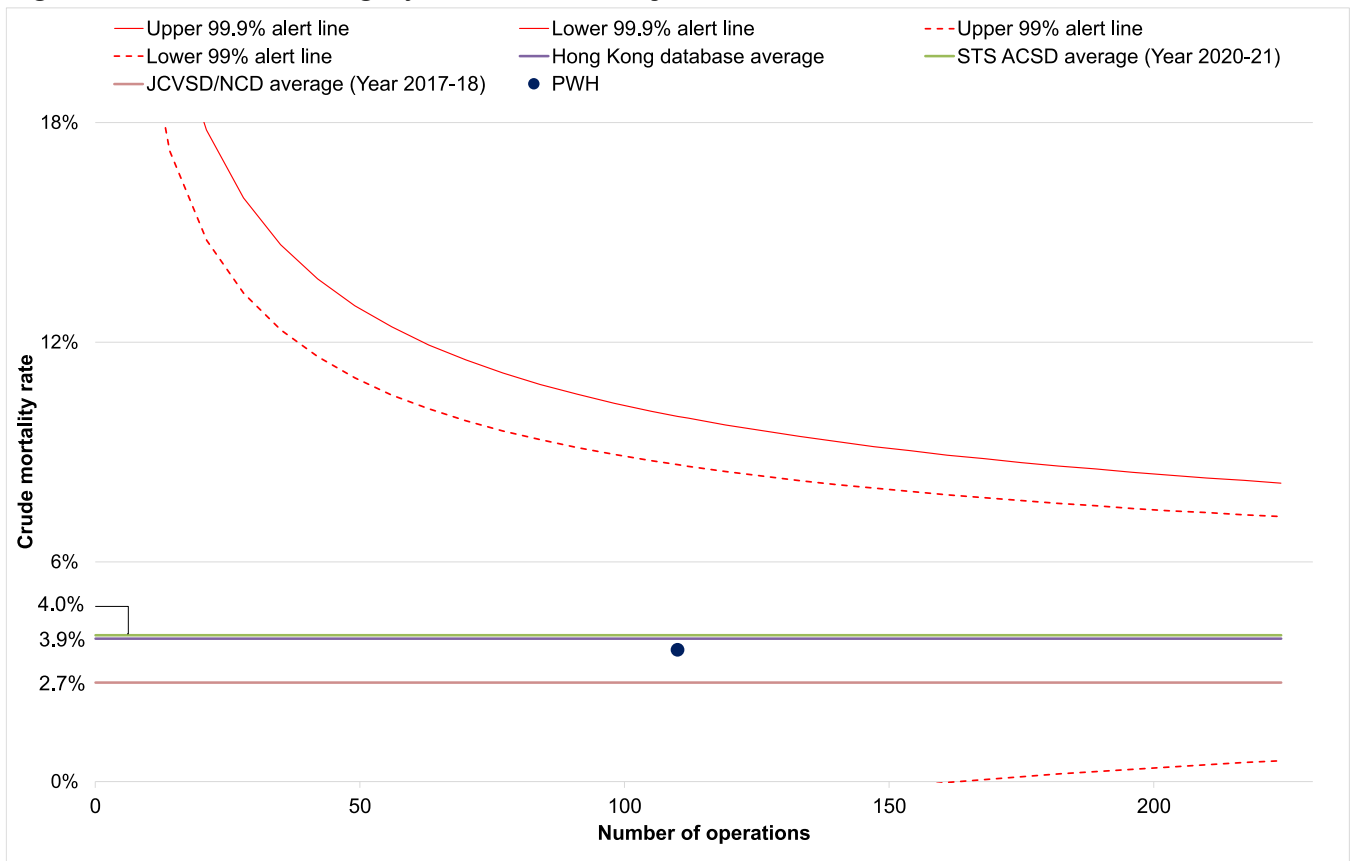


Fig 3.27 *Isolated aortic valve replacement (AVR) surgery: Crude mortality rate*



VALVE SURGERY

Fig 3.28 *Mitral valve surgery: Crude mortality rate*



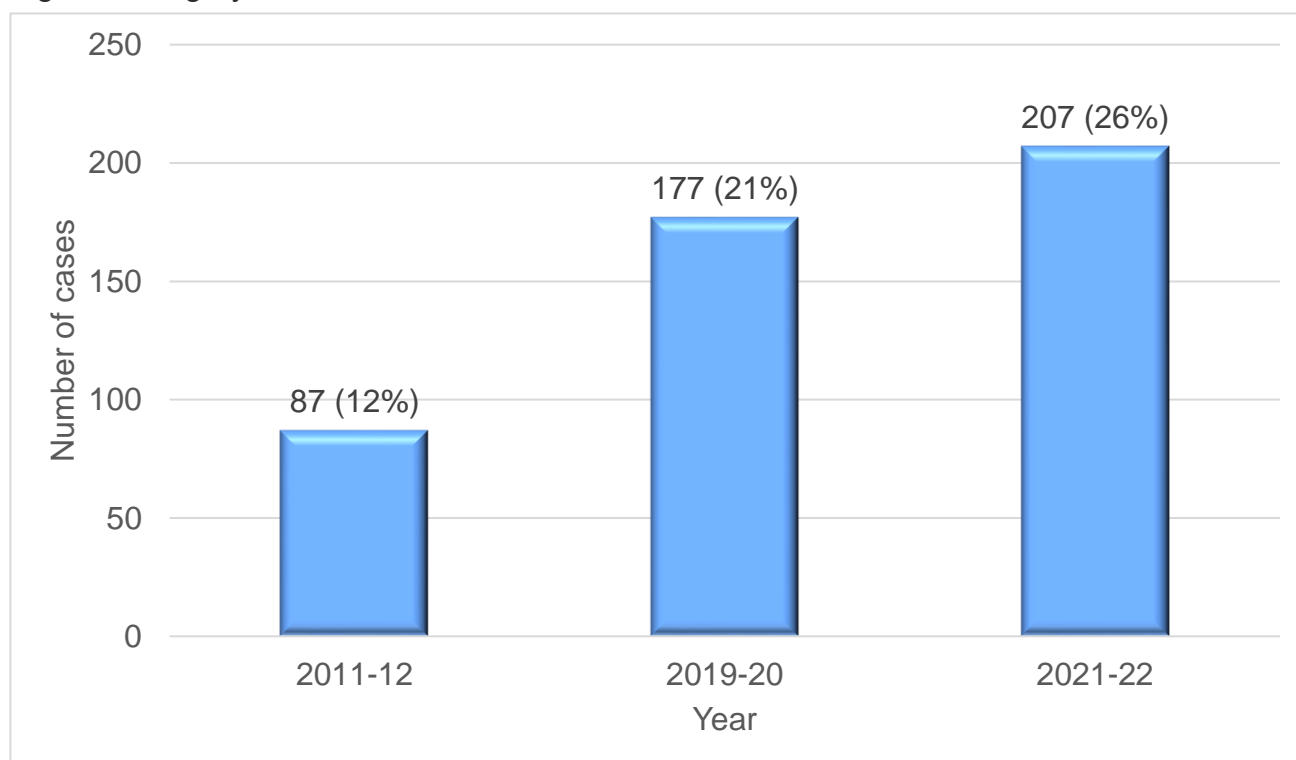
AORTIC SURGERY



Aortic surgery in the context of the overall workload

- The aorta is the major blood vessel leaving the heart and it carries blood to the rest of the body.
- As stated before, this category represents a heterogeneous group often predominated by emergency aortic procedures.
- Fig 4.01 shows the number of surgeries done on the aorta over the years. 207 procedures in total fell into this category during the calendar years 2021 and 2022.
- There has been a doubling in the number of major aortic procedures performed, from 87 in 2011–2012 to 207 in 2021–2022. As a proportion of all adult cardiac operations, major aortic procedures represented 12% in 2011–2012, rising to 26% in 2021–2022. (PWH: 26%, 2021-2022 vs the UK: 3.47%, 2015-2016).
- The doubling of the biennial number of major aortic procedures performed over the period reviewed undoubtedly reflects the increase in recognition and referral of major aortic cases to PWH.

Fig 4.01 Surgery on the aorta at the PWH, 2021-2022 vs 2011-2012



Number and details of segments treated

- Fig 4.02 shows the segment details treated for surgeries on the aorta at the PWH.
- Between 2021 and 2022, there were 66 (31.9%) patients who had aortic surgery at more than one segment at the PWH.
- The isolated ascending aorta was the most common site for aortic surgery during the assessment period (34.8%, 2021-2022 vs 44.1%, 2019-2020).
- The isolated descending aorta was the second most common site for aortic surgeries at the PWH (17.4%, 2021-2022 vs 22.0%, 2019-2020).
- Open repair of the **descending** aorta has become a routine operation over time with crude mortality rate of 8.3%.

Fig 4.02 Surgery on the aorta: Number and details of segments treated at the PWH

		Cardiac procedure group					
		CABG & other	Valve & other	CABG, valve & other	Other	All	
Segments treated	1	Root	0	10	2	3	15
		Ascending	4	19	4	45	72
		Arch	0	1	0	17	18
		Descending	0	0	0	36	36
	2	Root & ascending	2	12	1	0	15
		Root & arch	0	1	0	0	1
		Ascending & arch	0	2	0	14	16
		Descending & abdominal	0	0	0	5	5
		Descending & arch	0	0	0	3	3
	3	Root, ascending & arch	0	1	0	0	1
		Ascending, arch & descending	3	3	0	18	24
		Arch, descending & abdominal	0	0	0	1	1
	4	Root, ascending, arch & descending	0	0	0	0	0
	All		9	49	7	142	207

Pathology and arterial cannulation

- Fig 4.03 shows the pathophysiology for surgeries on the aorta at the PWH.
- The most common pathology that affected the aorta was dissection at the PWH (44.4%, 2021-2022 vs 44.6%, 2019-2020).
- Fig 4.04 shows the arterial cannulation for surgeries on the aorta at the PWH.
- Femoral cannulation for arterial inflow was the commonest cannulation strategy at the PWH (135/178), which is particularly useful in emergency situations with haemodynamically unstable patients (75.8%, 2021-2022 vs 77.9%, 2019-2020).

Fig 4.03 Surgery on the aorta: Pathophysiology at the PWH

		Count
Pathophysiology	Dissection	92
	Aneurysm	73
	Aneurysm and Dissection	29
	Others	13
	Patient count	207

Fig 4.04 Surgery on the aorta: Arterial cannulation at the PWH

		Count
Arterial cannulation	Femoral	135
	Ascending aorta	35
	Arch	6
	Axillary/subclavian	2
	Patient count	178

Logistic EuroSCORE and the crude mortality rate

Overall expected logistic EuroSCORE distribution for the major aortic surgery

- Between 2021-2022, the overall crude mortality was 8.3% for Hong Kong (HK: 9.8%, 2019-2020 & the UK: 8.9%, 2015-2016 vs Japan JCVSD/NCD: $\approx 6.8\%^2$, 2017-2018) and the predicted mortality (logistic EuroSCORE) as a percentage was 22.4% (HK: 20.7%, 2019-2020).
- Fig 4.05 shows the observed and expected mortality of major aortic surgery by logistic EuroSCORE category. Fig 4.06 pinpoints the differences between the observed and expected mortality rates of major aortic surgeries by operative priority. Fig 4.07 is the respective graphical presentation.
- Overall observed and expected mortality rates were 6.8% and 22.8% at the PWH respectively. The O/E ratio was 0.30 at the PWH.
- As expected, the highest observed and expected mortalities were both found in the high-risk logistic EuroSCORE grouping (>9.9). PWH observed a mortality rate of 8.3% in this high-risk group, which was less than the expected mortality rate of 27.5%. Most surgeries in this group were emergent or salvage procedures.
- Fig 4.06 also shows the total number of Thoracic Endovascular Aortic Repair (TEVAR) cases performed in PWH. There has been a steady increase in TEVAR activity over the years, and this trend might continue in PWH in the future. In 2021-2022, a total of 30 TEVAR procedures were performed in PWH.
- The overall observed and expected mortality rates for TEVAR operations were 0% and 21.6% in PWH during 2021-2022 respectively, showing an impressive surgical outcome.

Fig 4.05 Surgery on the aorta: Logistic EuroSCORE distribution and crude mortality

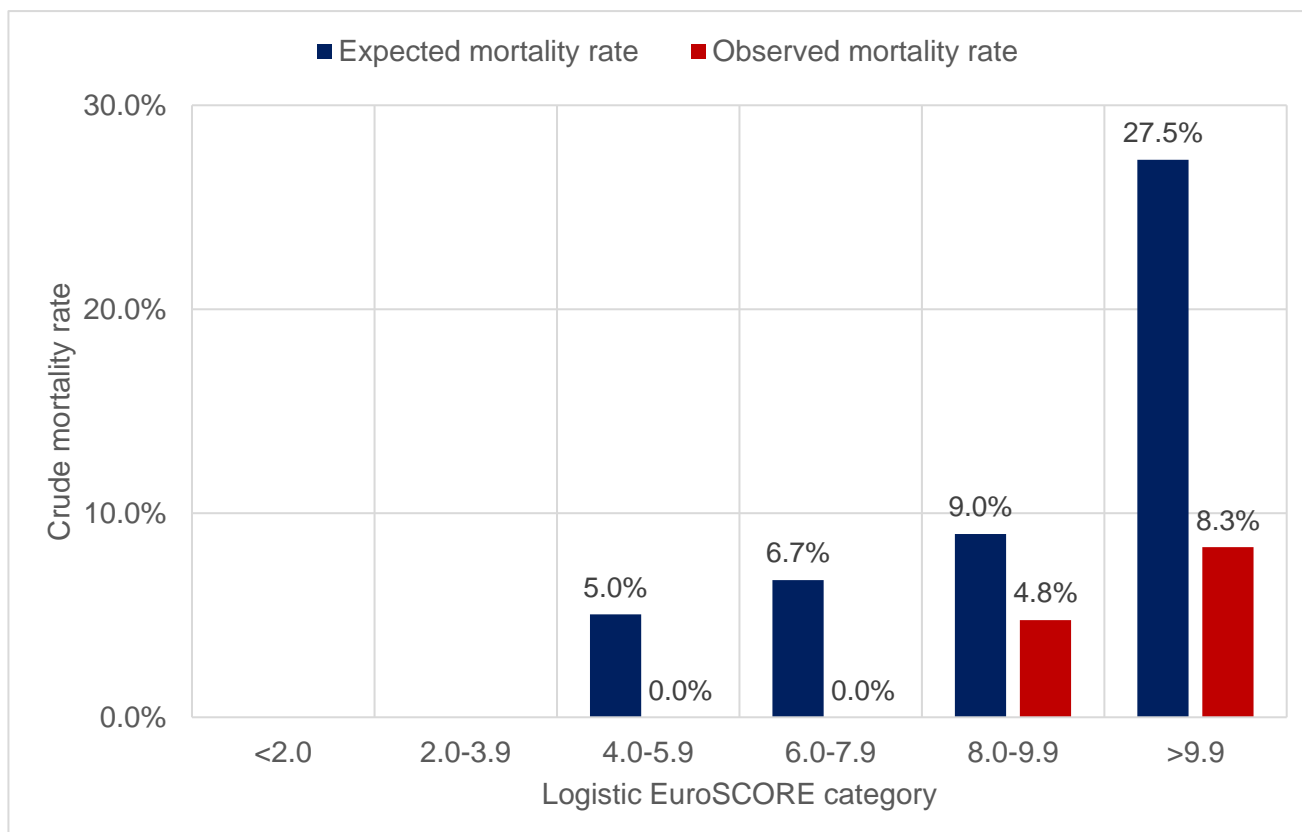
	Logistic EuroSCORE category					
	<2.0	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.9	>9.9
Count	0	0	12	18	21	156
Dead	0	0	0	0	1	13
Observed mortality rate	0.0%	0.0%	0.0%	0.0%	4.8%	8.3%
Expected mortality rate	0.0%	0.0%	5.0%	6.7%	9.0%	27.5%

Observed and expected mortality rate at the PWH

Fig 4.06 Surgery on the aorta: Observed and expected mortality rate by operative priority

			PWH	The UK 2015-2016 ⁴
Operative priority	Elective	Count (Proportion)	103 (49.8%)	(≈58.0%)
		Dead	2	/
		Observed mortality rate	1.9%	2.0-4.0%
		Expected mortality rate	19.3%	≈18.0-20.0%
	Urgent, emergency, and salvage	Count (Proportion)	104 (50.2%)	(≈42.0%)
		Dead	12	/
		Observed mortality rate	11.5%	15.0-20.0%
		Expected mortality rate	26.3%	≈23.0-40.0%
TEVAR	Count (Proportion)	30	/	
	Dead	0		
	Observed mortality rate	0.0%		
	Expected mortality rate	21.6%		
All	Count	207	1254	
	Dead	14	/	
	Observed mortality rate	6.8%	8.9%	
	Expected mortality rate	22.8%	≈18.0-40.0%	

Fig 4.07 Surgery on the aorta: Observed and expected mortality rate at the PWH



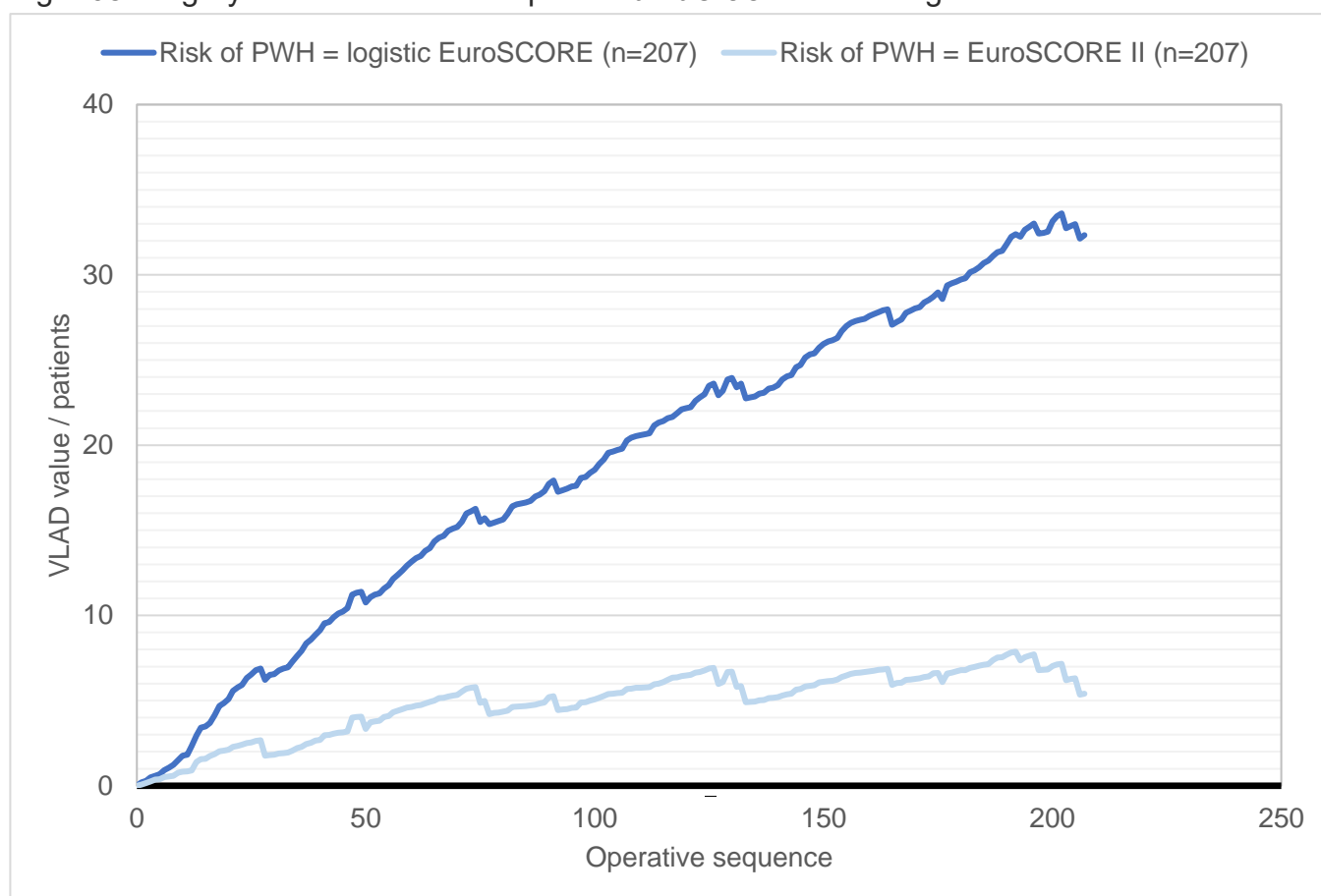
VLAD plot of risk-adjusted mortality rate

All major aortic surgery

- Fig 4.08 shows the VLAD plot for major aortic surgery using the logistic EuroSCORE and EuroSCORE II respectively. As mentioned before, this provides a good graphical representation of any deviation in outcomes over time.
- We can see that there was an upward deflection for the PWH, which implied that PWH performed probably better than expected in terms of outcomes in this complex group.
- At the end of the unadjusted VLAD curve derived by the logistic EuroSCORE, a maximum of 32 extra lives had been saved for the major aortic group at the PWH.

AORTIC SURGERY

Fig 4.08 Surgery on the aorta: VLAD plot for **all aortic** cardiac surgeries at the PWH

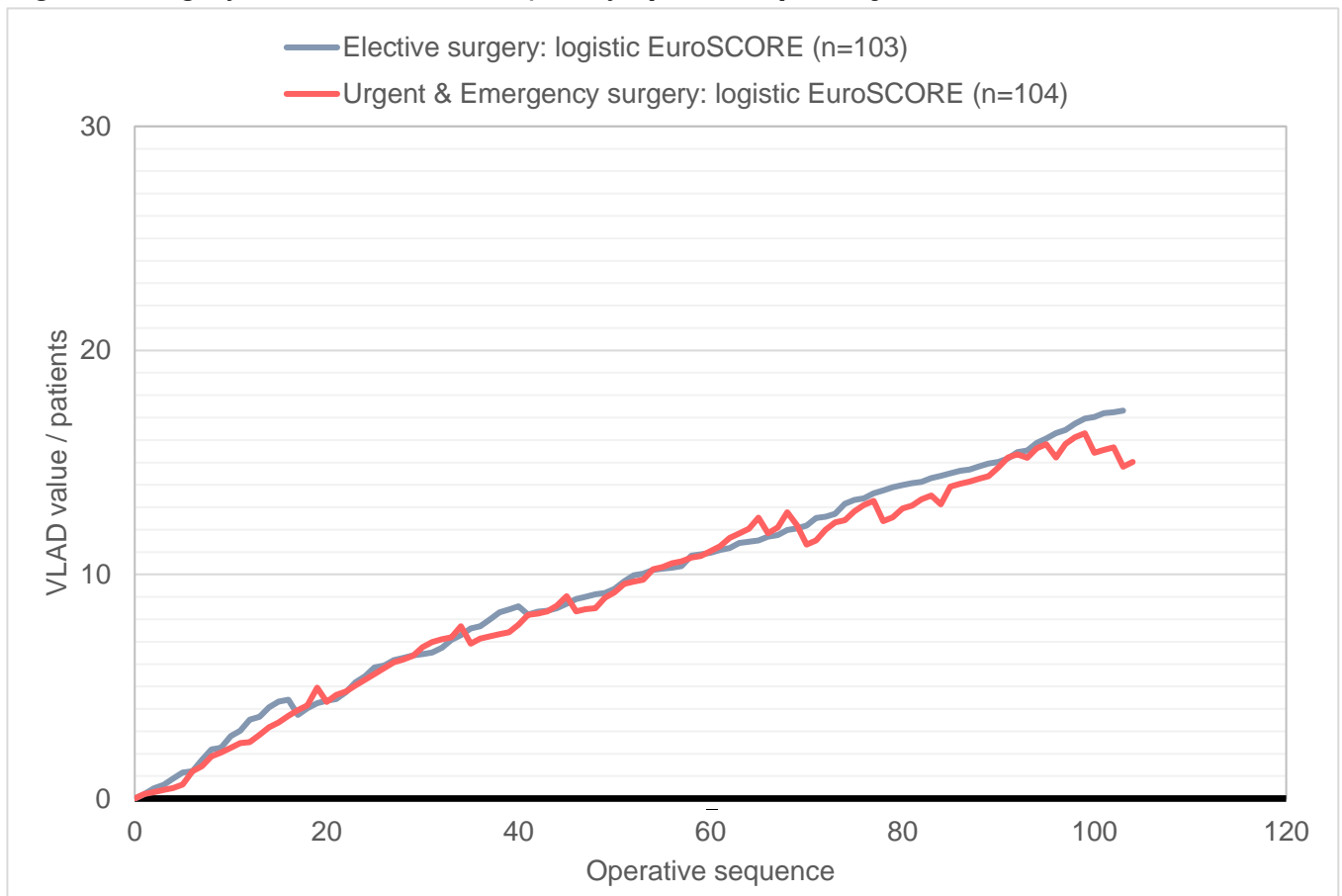


VLAD plot of risk-adjusted mortality rate

Elective, urgent, and emergency major aortic surgery

- Fig 4.09 shows the VLAD plot for elective, urgent, and emergency (including salvage cases) major aortic surgery using the EuroSCORE. As mentioned before, this provides a good graphical representation of any deviation in outcomes over time.
- Emergency cases accounted for 42% of all major aortic operations in the UK during 2015-2016, whereas here, they represented 50.2% during 2021-2022 (PWH:50.2%, 2021-2022 vs the UK: 42%, 2015-2016). This suggests a higher rate of emergency aortic surgery in the PWH in comparison to the UK.
- At the end of the two VLAD curves, almost 17 and 15 extra lives had been saved for the elective, urgent, and emergency major aortic surgery respectively.
- The overall outcome analysis seemed outstanding at the PWH during the assessment period.

Fig 4.09 Surgery on the aorta: VLAD plot by **operative priority** at the PWH



Other immediate post-operative outcomes

- Fig 4.10 to Fig 4.12 show the post-operative surgical outcomes for patients requiring major aortic surgeries at the PWH, which are the overall **re-operation for bleeding** rate (Fig 4.10), **post-operative stroke** rate (Fig 4.11), and **new haemofiltration / dialysis** rate (Fig 4.12). Fig 4.13 to Fig 4.15 show the same interpretation using the funnel plots, with alert and alarm lines set at 99.0% and 99.9% respectively. The control limits refer to those generated by the submission of data from all cardiac units in Hong Kong during 2021-2022. The **light purple** horizontal line represents the average data from all cardiac units in Hong Kong during 2021-2022.
- These three post-operative outcomes at the PWH fall comfortably within the control limits, showing satisfactory quality.

Re-operation for bleeding

Fig 4.10 Surgery on the aorta: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	Count	7	200
	Proportion	3.4%	96.6%
	Dead	2	12
	Crude mortality rate	1.0%	5.8%

Post-operative stroke

Fig 4.11 Surgery on the aorta: New post-operative stroke

		Yes	No
New post-operative stroke	Count	16	191
	Proportion	7.7%	92.3%
	Dead	7	7
	Crude mortality rate	3.4%	3.4%

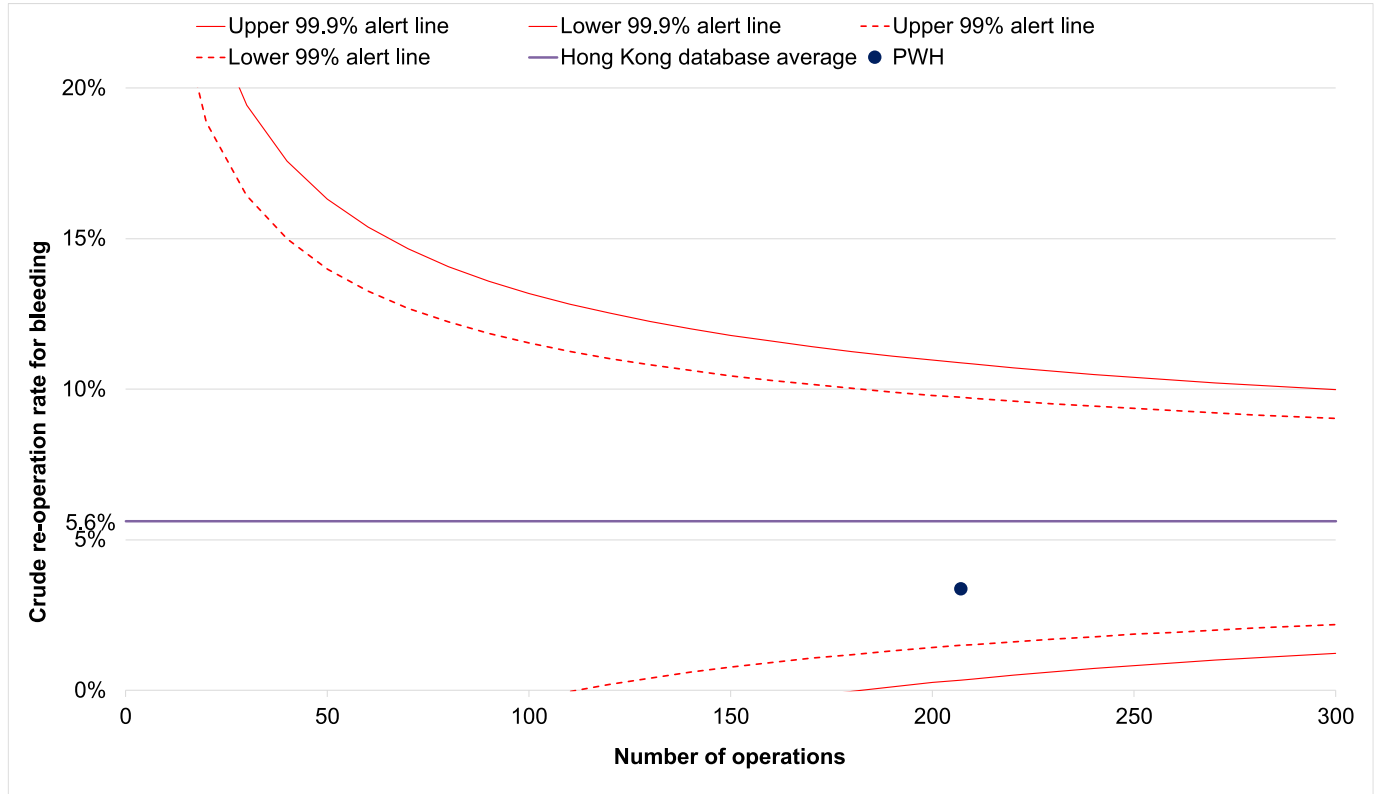
Post-operative HF / dialysis

Fig 4.12 Surgery on the aorta: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	Count	16	191
	Proportion	7.7%	92.3%
	Dead	8	6
	Crude mortality rate	3.9%	2.9%

Funnel plots for other immediate post-operative outcomes

Fig 4.13 Surgery on the aorta: Crude *re-operation* rate for *bleeding*



AORTIC SURGERY

Fig 4.14 Surgery on the aorta: Crude *post-operative stroke* rate

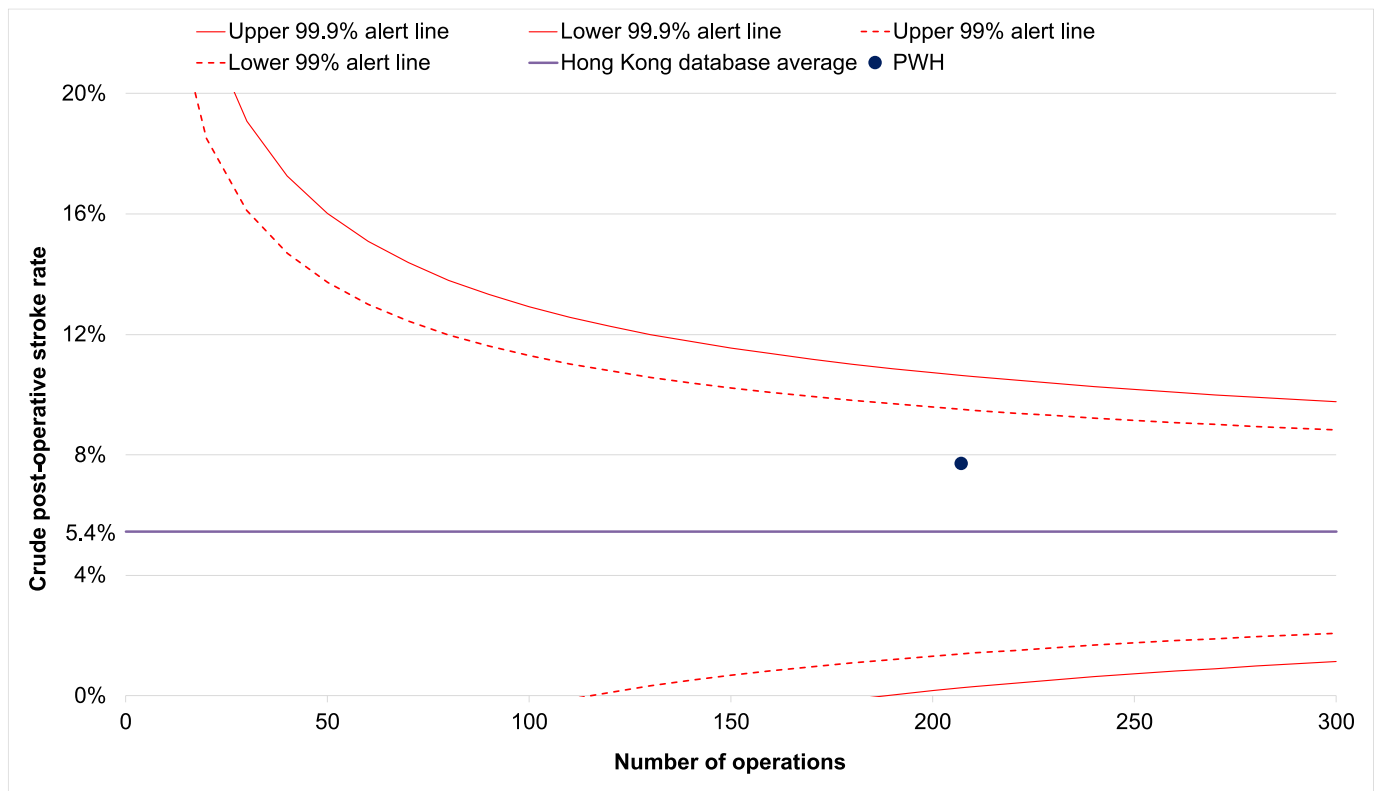
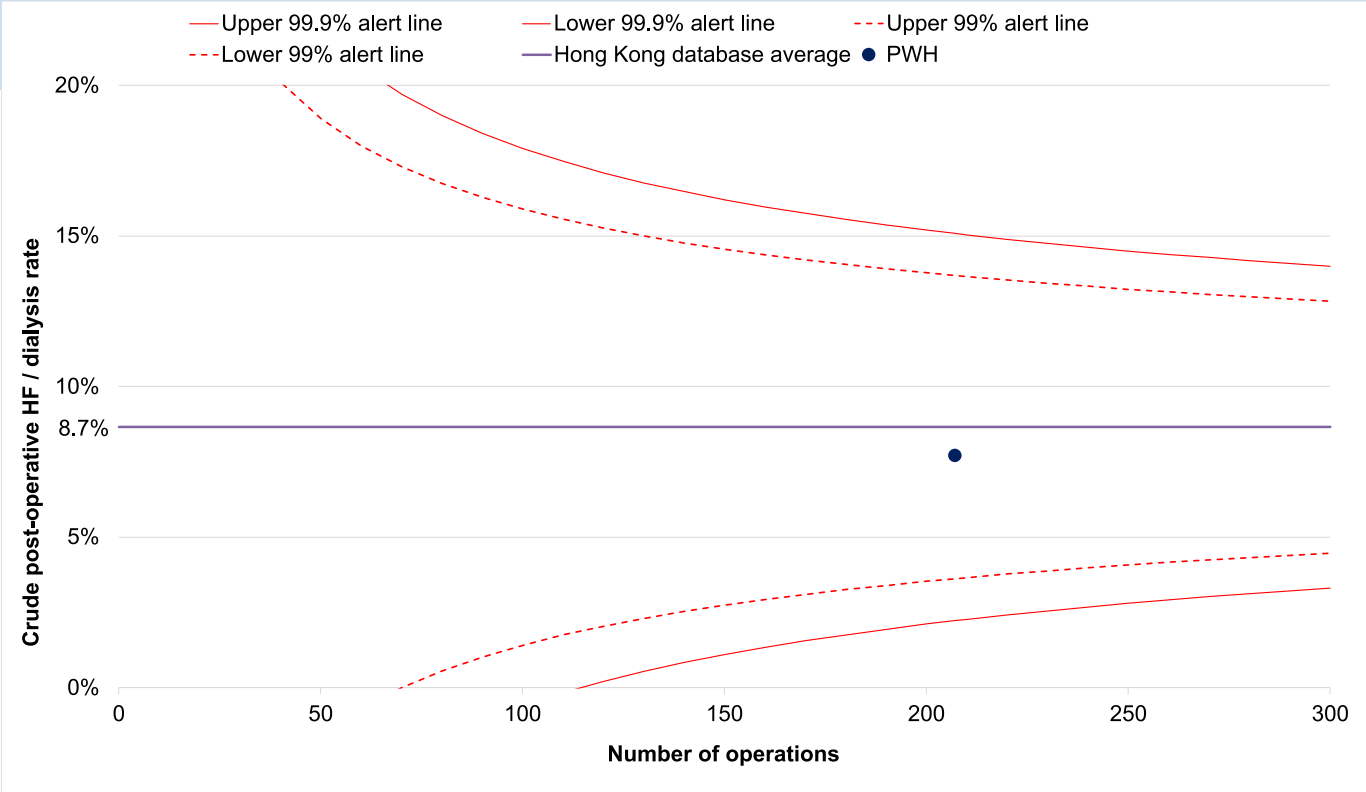


Fig 4.15 Surgery on the aorta: Crude *post-operative HF / Dialysis* rate



AORTIC SURGERY

Funnel plot of the crude mortality rate

- Fig 4.16 and Fig 4.17 show the funnel plots of mortality for elective, urgent, and emergency (including salvage cases) major aortic surgery, with alert and alarm lines set at 99.0% and 99.9% respectively. The **control limits** refer to those generated by the submission of data from all cardiac units in Hong Kong during 2021-2022. The **light purple** horizontal line represents the average data from all cardiac units in Hong Kong during 2021-2022. The **light blue** horizontal lines are served as references on the charts, which represent the approximate upper and lower limit of in-hospital mortality rates in the United Kingdom NACSD during 2015-2016.
- PWH falls within the alert lines for elective, urgent, and emergency major aortic surgery, demonstrating no outliers. We probably performed better than expected during the calendar years 2021 and 2022.
- Between 2021 and 2022, the overall satisfactory outcomes in the funnel plots are consistent with the VLAD analysis.

Fig 4.16 **Elective** surgery on the aorta: Crude **mortality** rate

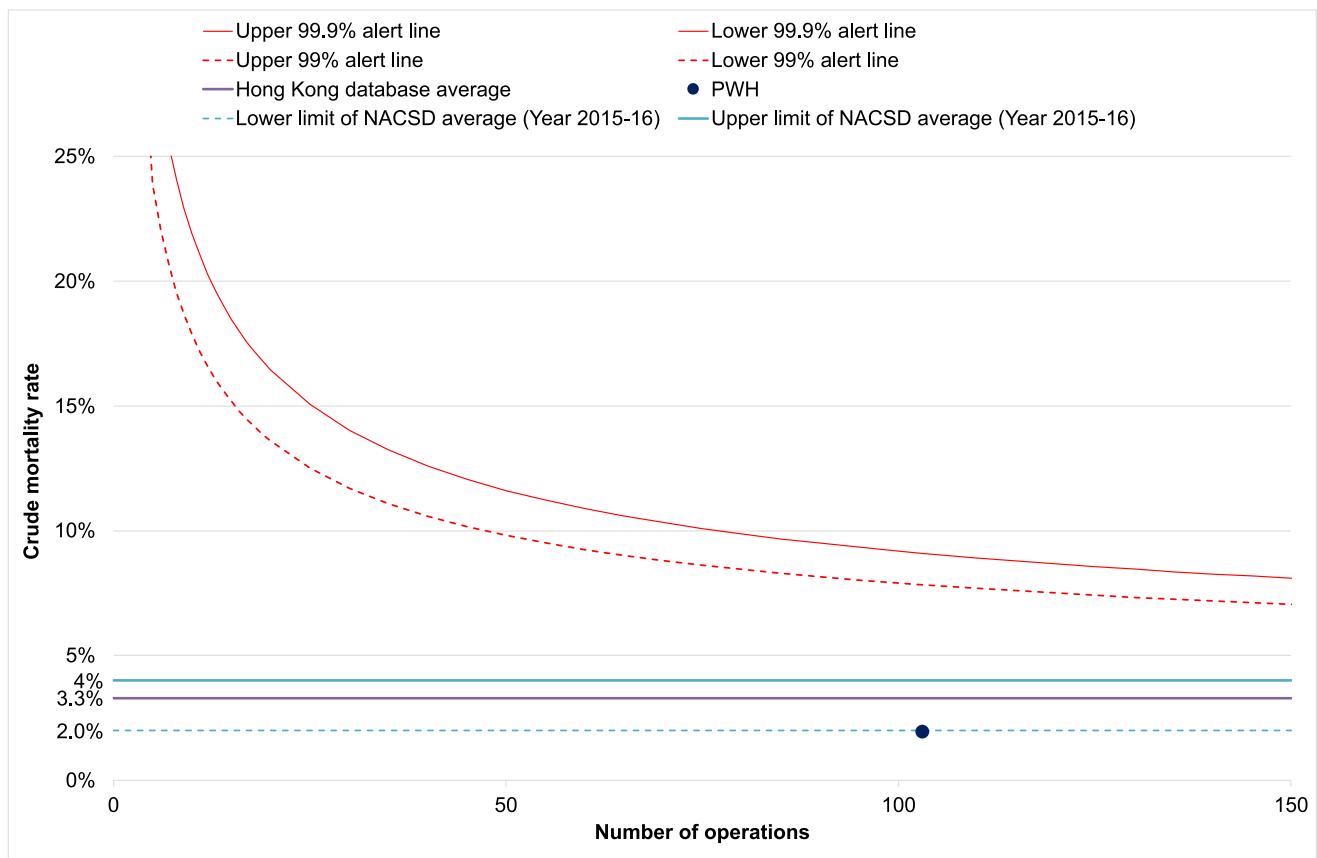
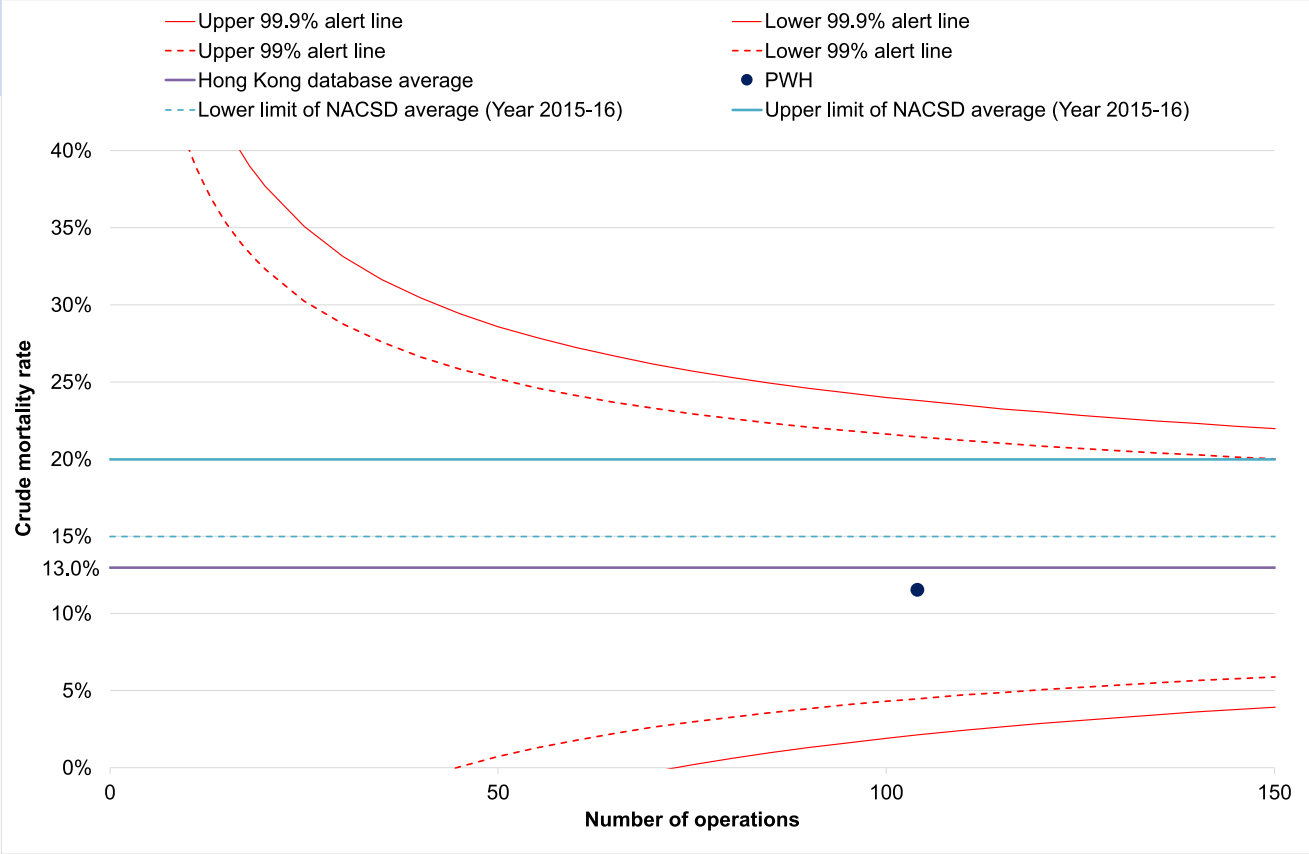


Fig 4.17 **Urgent and emergency** surgery on the aorta: Crude **mortality** rate



AORTIC SURGERY

MINIMALLY INVASIVE CARDIAC SURGERY



Overall workload

- Fig 5.01 and Fig 5.02 show the type of MICS approach and the corresponding procedure grouping for MICS respectively.
- 66/805 (8.2%) of cardiac surgical procedures were performed using a minimally invasive approach in HK.
- The most common MICS approach was endovascular and the majority of MICS approach was found in surgery other than valve in PWH (86.4%).
- Fig 5.03 shows the surgical outcomes in terms of the crude mortality rate and post-operative complication rate for the MICS.
- The observed and expected mortality rates for MICS were 1.5% and 17.9% on average respectively. The O/E ratio was 0.08 in PWH, which represents we performed better than expected in terms of outcomes in the MICS group.
- Due to the improvements in surgical outcomes over time, the post-operative surgical complications rates for patients requiring MICS in PWH were low.

Fig 5.01 MICS: Type of approach

		Count	Prop.
Type of MICS approach	Endovascular	59	89.4%
	Hemi-sternotomy	6	9.1%
	Mini-thoracotomy	1	1.5%
	Robot-assisted surgery	0	0.0%
	Other	0	0.0%
Total		66	/

Fig 5.02 MICS: Procedures performed

		Count	Prop.
Procedure grouping	Valve alone	4	6.0%
	Valve and concomitant surgery	5	7.6%
	Surgery other than valve	57	86.4%
	Total	66	/

Fig 5.03 MICS: Surgical outcome

		Rate
Surgical outcome	Observed mortality	1.5%
	Expected mortality	17.9%
	O/E ratio	0.08
	Re-operation for bleeding or tamponade	1.5%
	New post-operative stroke	4.5%
	New haemofiltration or dialysis post-operatively	1.5%

CONCLUSION

1. Using the cumulative data, we have shown that we are performing in line with international standards for all cardiac surgical activity and all operative sub-groups. More importantly, the publication of these data provides the public with confidence that cardiac surgery at the PWH produces consistently good survival and exceeds expected survival in most of the categories.
2. Significant improvements in survival for most cardiac surgical procedures over these ten years, despite the increasing complexity of case-mix and an increasing patient age and risk profiles.
3. Variations in the types of surgery undertaken marked differences in volumes for the major operation groups, which are CABG, valve, and major aortic surgery.
4. In-hospital crude mortality rates and post-operative complications for most cardiac surgical procedures are reduced, which are in line with international standards.
5. We have seen a continued change in overall surgical practice with a sustained increase in patient risk profiles when assessed using the logistic EuroSCORE for all patients. This has occurred for 12 consecutive years.
6. We have shown that in terms of overall activity, we perform fewer coronary artery bypass grafting operations and more major aortic operations than comparative units in the United Kingdom and Europe although a reduction in coronary surgery is a worldwide phenomenon.
7. We have again seen significant changes in the demographics of our CABG population who are now most likely to require urgent surgery for unstable angina or complex coronary disease as we have noted previously and this trend has continued.
8. Despite the increasing complexity of patient risk profiles, we have shown the outcomes for the subset of patients undergoing CABG are excellent and have been sustained over 12 years.
9. We have continued to record excellent outcomes for isolated aortic valve replacement.
10. We have documented increased activity in surgery for the aorta both conventional and endovascular with again outcomes comparable with the highest international standard.
11. We believe that benefits both to patients and to the profession in the provision of understandable cardiac surgical information are immeasurable. This has played a major role in public confidence and trust in the medical profession. It is hoped that the public and profession have an assurance that cardiac surgical performance is actively monitored at the PWH.

ACKNOWLEDGEMENT

Multi-disciplinary teamwork is required to provide a comprehensive cardiac surgical service. Much attention is naturally given to the surgical arm of this effort, but we must affirm the activity and outcomes presented here demonstrate *par excellence* and the benefits of teamwork. None would have been possible without a wide range of associated personnel, including cardiology, anaesthetic, intensive care colleagues, junior medical colleagues, ward, intensive care, and theatre nurses, perfusionists, physiotherapists, pharmacists, blood bank technicians, laboratory technicians, and many other support personnel. Outcomes and service provision in this and future reports reflect the dedicated effort of all these professionals.

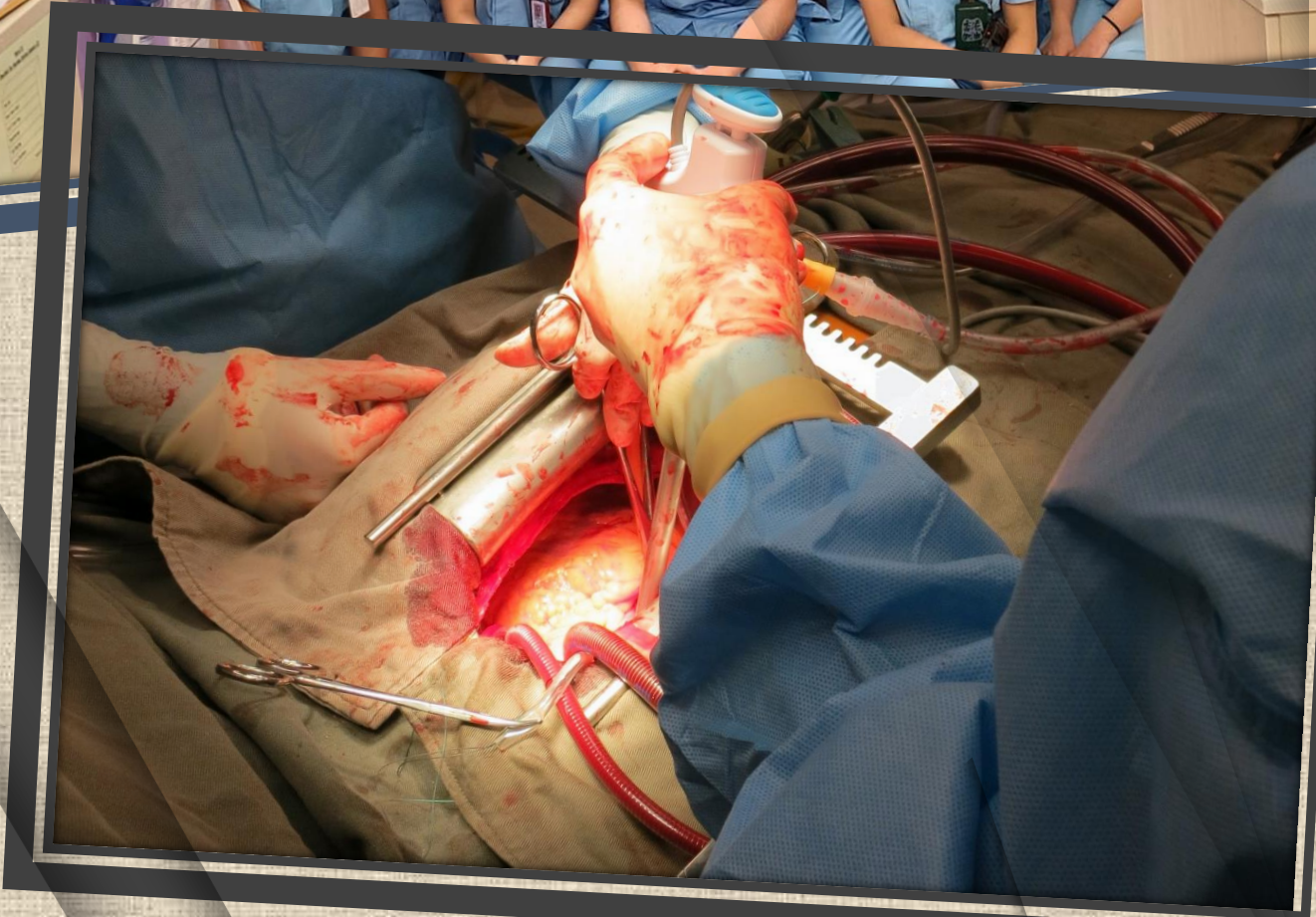
All of their efforts are crucial in maintaining our excellent outcomes, particularly in the face of changing and increasingly high-risk patient profiles. We continue to face many pressures as we seek to deliver even higher quality care for our patients; all of the above-mentioned professional groups have worked and continue to work above and beyond expectations to ensure that standards are consistently maintained. This is particularly pertinent when we are stretching the limits of the current resource.

We continue to acknowledge all of the doctors, nurses, perfusionists, and associated personnel who have spent endless hours inputting these data because without their efforts, we would not have such a comprehensive story to report today. The completeness and accuracy of the source data are critical for future reports, and it remains our responsibility to ensure this. The personnel we employed on the database project contributed more than just validation and data entry. Having lost this support we must be vigilant that we do not lose sight of the principles regarding data collection on which we base our practice.

Our anaesthetists and intensivists have embraced our efforts and actively contribute to the thought processes involved in monitoring outcomes and implementing changes in practice. Our nursing staff have been active as well and have sustained their first project, nurse-led defibrillation whilst embarking on a nurse-led follow-up clinical service for post-operative cardiac patients and they play a pivotal role in organizing our pre-operative assessment clinic.

We thank surgical colleagues and HA administrative staff represented by the Cardiothoracic Specialty Group in Hong Kong for their support and we look forward to collaborative efforts as we extend this process. We are grateful to all the HA IT team who continue to contribute and are now active in helping us integrate our databases and analysis modules so we can move to real-time outcome monitoring.

APPENDIX



APPENDIX

The logistic EuroSCORE: calculation and definition

The EuroSCORE is a system that generates a pre-operative prediction of mortality risk for cardiac surgery patients.

For a given patient, the logistic EuroSCORE is the predicted mortality according to the logistic regression equation, which can be achieved with the following formula:

$$\text{Predicted mortality} = \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}$$

where:

- e is the natural logarithm (2.718281828...)
- β_0 is the constant of the logistic regression equation (-4.789594)
- β_i is the coefficient of the variable X_i in the logistic regression equation provided in the table below (Fig 5.01).
- X_i is set to 1 if a categorical risk factor is present and 0 if it is absent. For the age risk factor, $X_i = 1$ if the patient age is smaller than 60 years and X_i increases by one point per year thereafter: for age 59 years or less, $X_i = 1$; age 60, $X_i = 2$; age 61, $X_i = 3$; and so on.

This score is automatically calculated for each patient after data is input into the Hong Kong Cardiac Surgical Database.

APPENDIX

Fig 5.01 Beta coefficients for the logistic regression model of EuroSCORE

Patient-related factors	β
Age in years	0.0666354
Female gender	0.3304052
Chronic pulmonary disease	0.4931341
	long-term use of bronchodilators or steroids for lung disease
Extra-cardiac arteriopathy	0.6558917
	any one or more of the following: claudication, carotid occlusion or >50% stenosis, previous or planned intervention on the abdominal aorta, limb arteries, or carotids
Neurological dysfunction disease	0.841626
	severely affecting ambulation or day-to-day functioning
Previous cardiac surgery	1.002625
	requiring the opening of the pericardium
Raised serum creatinine	0.6521653
	>200 $\mu\text{mol/L}$ pre-operatively
Active endocarditis	1.101265
	the patient is still under antibiotic treatment for endocarditis at the time of surgery
Critical pre-operative state	0.9058132
	any one or more of the following: ventricular tachycardia or fibrillation or aborted sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the anaesthetic room, preoperative inotropic support, intra-aortic balloon counterpulsation or pre-operative acute renal failure (anuria or oliguria < 10 ml hr ⁻¹)

APPENDIX

Cardiac-related factors		β
Unstable angina	0.5677075	rest angina requiring iv nitrates until arrival in the anaesthetic room
Moderate LV dysfunction	0.4191643	left ventricular ejection fraction 30-50%
Poor LV dysfunction	1.094443	left ventricular ejection fraction <30%
Recent myocardial infarct	0.5460218	<90 days before surgery
Pulmonary hypertension	0.7676924	systolic PA pressure>60 mm Hg
Operation-related factors		β
Emergency	0.7127953	carried out on referral before the beginning of the next working day
Other than isolated CABG	0.5420364	major cardiac procedure other than or in addition to CABG
Surgery on the thoracic aorta	1.159787	for the disorder of ascending, arch, or descending aorta
Post-infarct septal rupture	1.462009	

Hospital Authority
Prince of Wales Hospital
30-32 Ngan Shing Street, Shatin, New Territories, Hong Kong

醫院管理局
威爾斯親王醫院
香港新界沙田銀城街 30-32 號

Copyright©2023 Prince of Wales Hospital. All rights reserved.
©2023 威爾斯親王醫院。版權所有。

No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, or transmitted in any form without the prior written permission of the copyright owner.



Prince of Wales Hospital



The Chinese University of
Hong Kong