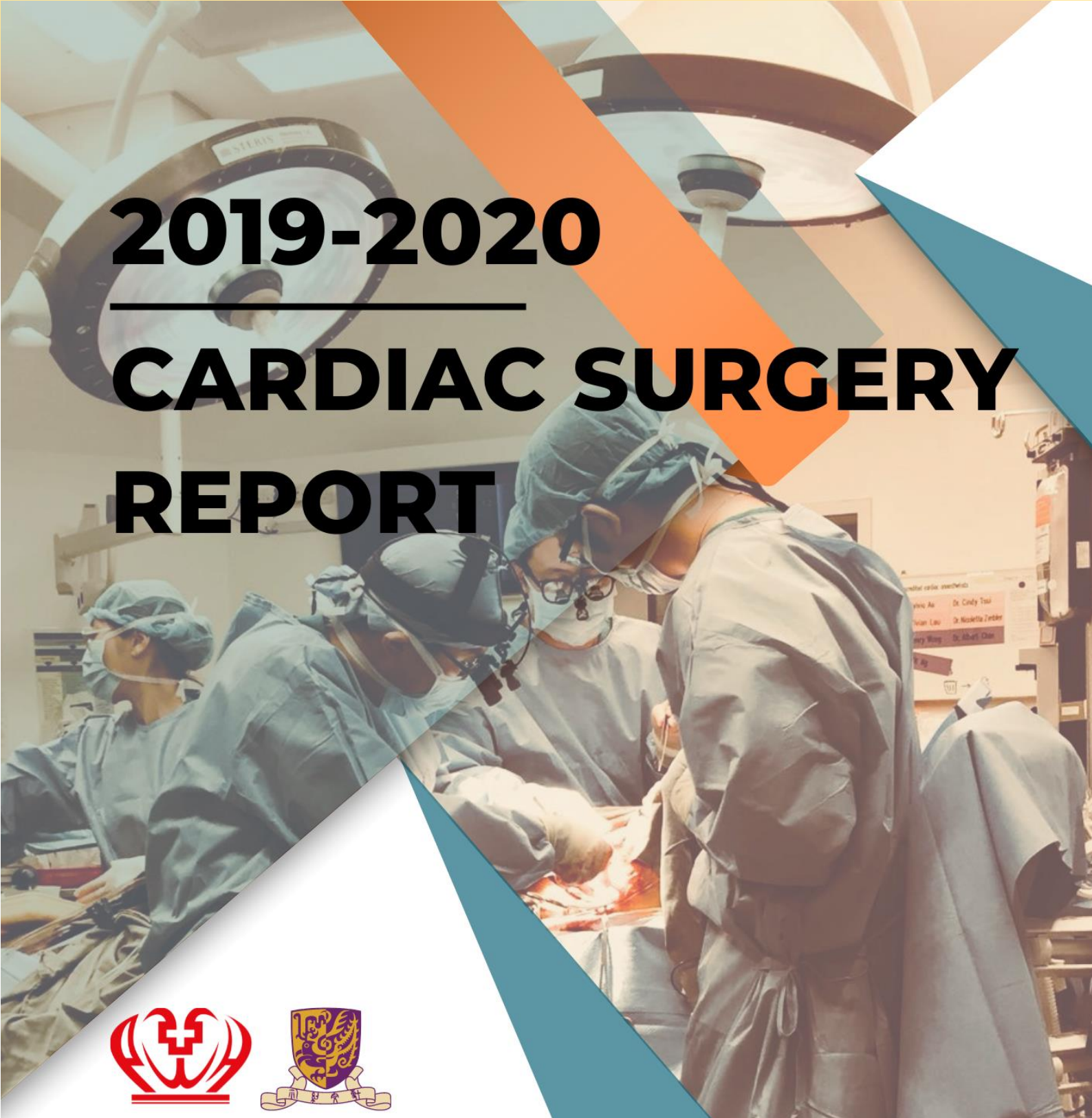
2019-2020

CARDIAC SURGERY REPORT



PREPARED BY

PRINCE OF WALES HOSPITAL
THE CHINESE UNIVERSITY OF HONG KONG

DIVISION OF CARDIOTHORACIC SURGERY
DEPARTMENT OF SURGERY

2019-2020

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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
IABP	Intra-aortic Balloon Pump
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
TEVAR	Thoracic Endovascular Aortic Repair
VAD	Ventricular Assist Device
VLAD	Variable Life-adjusted Display
VSD	Ventricular Septal Defect

EXECUTIVE SUMMARY

1. This report documents the nature of cardiac surgical practice between January 2019 and December 2020 at the PWH to allow a high enough case volume.
2. It demonstrates that overall cardiac surgical outcomes in terms of the crude in-hospital mortality rates for all major operation groups are well within risk prediction despite the increasing risk profiles of the patients, indicating improved quality of in-hospital care.
3. There is a remarkable and statistically significant improvement in the mortality rates in ***major aortic operations*** (from 12.2% to 5.1%) when we compare the current report with 2017-2018 results. We have maintained low crude in-hospital mortality rates for ***isolated CABG*** (1.4%) and ***isolated valve*** (3.9%) surgeries during 2019-2020.
4. The proportion of patients over 75-year-old undergoing cardiac surgery of all types has continued to increase but the in-hospital crude mortality rate in the elderly has continued to decrease.
5. The number of isolated coronary artery bypass surgery activity remained static for PWH.
6. There is a slight decrease in the biannual volume of isolated valve procedures, while there is an absolute increase in the biannual volume of major aortic procedures.
7. 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 complication rates.
8. The differences in case-mix can be attributed to the difference in the percentage of isolated CABG at the PWH (33.6%) vs in the UK (41.7%). Highlighting there is a shift in PWH cardiac surgery workload to become more diversified. We are undertaking proportionally more complex combined operations but fewer redo procedures.
9. The three key outcomes 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 at the PWH.
10. The data completeness in the PWH database has improved over time. In terms of the audit trail, 5% cases of all major operation groups were randomly selected and cross-checked to ensure data accuracy.
11. We continue to drive a number of initiatives to improve both outcomes of care for patients and quality assurance processes.
12. We strive to maintain ‘real-time’ monitoring for the selected outcomes with mechanisms to address divergent practices.

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

FOREWORD

"Hong Kong is our home and it is a great privilege to be able to serve the people of Hong Kong."

The above is my motto and I am very glad to see that this is the core value espoused by our excellent team of Cardiothoracic Surgeons at the Prince of Wales Hospital.

This Report provides a precise, transparent, risk-adjusted, and internationally benchmarked set of outcomes of all major cardiac surgical procedures undertaken by the Cardiothoracic Team of Prince of Wales Hospital Team during the period of 2019 to 2020. With a team of such commendable ability and dedication, patients in the New Territories East and West Clusters and throughout Hong Kong are well-served in their needs and their families can be assured, knowing that their loved ones are in the best hands for their surgical procedures.

I congratulate the Team for their outstanding achievement, including low mortality and morbidities in all aspects of cardiac surgery in the period of 2019-2020. The Team's hard work, innovation, and resolute perseverance in pushing frontiers, collecting and monitoring cardiac surgical patients' clinical outcomes, built over the past 18 years, deserves many commendations. In the past few years, the Team's quest for excellence has extended from surgery for ischaemic heart disease to more complex valvular and aortic surgeries.

I trust that our Cardiothoracic Team will continue to achieve breakthroughs and pursue the highest possible quality care for our patients by applying stage-of-the-art innovations and technologies. Indeed, this can be seen through various milestones which they achieved over the past years which include the introduction of the Dendrite Data collection and analysis system in 2005, the establishment of the Hybrid Cardiovascular Operating Theatre in 2012, and the application of pocket echocardiogram to screen for thoracic aortic aneurysms in 2016. In 2020, for the first time in Asia, the Cardiothoracic Team performed a one-stage hybrid aortic arch surgery on patients with multi-segment aortic diseases using a new device and subsequently achieved zero mortality for their first 25 consecutive patients which led to a successful press conference and raised public awareness.

That Hong Kong people live the longest in the world is not without good reason, which is that healthcare in Hong Kong is of top quality. With our population aging further and the development of the Greater Bay Area and the growing role, Hong Kong plays in our country, maintaining the strength and cutting edge of Hong Kong's stellar healthcare system is especially essential. A good monitoring mechanism and reporting system of clinical

FOREWORD

procedures is the bedrock of a mature healthcare system, on which further innovations and scientific advancements can be developed.

I hope that this Report is insightful to fellow researchers and practitioners and that the spirit of service will be shared by all, so that together, we contribute to Hong Kong, to our country, and ultimately, to humankind.

Ms. Priscilla WONG, SBS, BBS, JP
Chairlady
Hospital Governing Committee
Prince of Wales Hospital

PREFACE

It is with great pleasure and excitement I write this foreword. This Report represents the Prince Wales Hospital's entire cardiac surgical activity in the period of 2019-2020. The road has not always been straight nor without obstacles, especially during the COVID times. I am delighted that our cardiac surgical team at NTEC has come a long way since 2005 and achieved their current outstanding results. This publication not only highlights beautifully the team's accomplishment in clinical practice and improvements in outcomes despite the changing patient demographics and the increasing complexity of treatment options, but also demonstrates the added value of the use of data analysis to deliver quality assurance.

Amid their very demanding clinical duty, the surgeons at the division have sustained their efforts in collecting robust data at the point of clinical care, covering a comprehensive range of key quality indicators. Over years, it is important to recognize that operative mortality continues to decline across the breadth of major aortic surgery despite an increase in the volume and complexity of the patients coming to operation. Although the patient risk profile has increased (from a logistic EuroSCORE of 19.8% to 22.3%), the team at PWH achieved a low crude mortality rate of 5.1% during the assessment period. Apart from major aortic surgery, another remarkable achievement is found in the isolated aortic valve replacement with a zero-mortality rate recorded. None of these achievements would have been possible without a dedicated team of cardiac surgeons, anaesthetists, perfusionists, OT and ward nurses, physiotherapists, and others in the clinical team working closely together, where all roles are valued to achieve a common goal, in which the patient is central.

I understand that the clinical team would not be complacent with the foregoing good performance but would strive to improve further to pursue the highest possible quality care for our patients.

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

A MESSAGE FROM OUR TEAM HEAD

"Information is just a bit of data. Knowledge is putting them together. Wisdom is transcending them."

-Ram Dass (1931-2019)

With the vision of providing our patients, health care administrators, and fellow collaborators visible and transparent cardiac surgical outcomes, the Division of Cardiothoracic Surgery at Prince of Wales Hospital, the Chinese University of Hong Kong commenced data collection for all patients undergoing cardiac surgery in our Institute in November 2005. This is a formidable task, and yet, year after year, with unswerving tenacity and indubitable determination, our group of cardiothoracic surgeons together with the great support from the Specialty Group of Cardiothoracic Surgery of Hong Kong, are seeing information has become knowledge and wisdom is acquired from the lessons learned.

In this latest report, we could see the change in case-mix of our cardiac surgeries skewing from predominantly CABG to more complex surgeries such as aortic arch surgery, thoracoabdominal aortic surgery, surgery for post-infarct complication as well as extracorporeal circulatory supports. Despite the increase in complexity and risk profile of our patients, our team achieved extra-ordinary well in maintaining very low observed mortality which is better than expected in all categories when compared with the international database. Thanks to the dedicated team of Cardiac Anaesthetists under the leadership of Dr. Sylvia Au, Dr. Albert Chan, and Dr. Henry Wong; a team of Perfusionists under the leadership of Ms. Pollina Yung; Cardiac nurses led by Ms. Chiu Ying Ying; Intensivists led by Prof. Gavin Joynt; Cardiologist under the leadership of Dr. Joseph Chan as well as dedicated ward nurses led by Mr. Wilfred Yeung.

In 2019-2020 we were granted extra resources for an additional 1 cardiac operating session via annual plan bidding with the intent of relieving the pressure on the waiting time for cardiac surgery in our institution. With the booster of resources, we performed 839 cases of cardiac operations in 2019-2020, however, we are still struggling to reduce our waiting time for our routine CABG and valve surgeries as we are seeing an increasing referral from our catchment hospitals from both NTEC and NTWC. We are looking forward to seeing the impact of our waiting time after the implementation of 3 additional cardiac operating sessions from the 2021-2022 annual plan bid. Through the annual plan bidding via COC surgery, a Data Manager Ms. Karen Ng was employed centrally starting from December 2021 to support data collection, and data validation, perform audit trials and prepare a biennial integrated report for the three cardiac centers of Hong Kong.

A MESSAGE FROM OUR TEAM HEAD

Overall, the landscape of our cardiac surgery in terms of complexity, volume, and patient risk profile had completely changed compared to 2005. We transformed from a unit that performed 300 cardiac cases to now more than 430 cardiac cases per annum. Wisdom is accumulated during this journey and we are now not only achieving excellent in-hospital outcomes in the areas of CABG and aortic surgeries, but we have also extended the monitoring of our patients and reporting their excellent long-term survival in various international journals.

> *"I am happy to see knowledge has transcended to Wisdom and resulted in excellent clinical outcomes."*

Prof. Randolph Hung-Leung WONG
Professor and Chief
Honorary Consultant (Hospital Authority)
Division of Cardiothoracic Surgery
Department of Surgery
The Chinese University of Hong Kong
Prince of Wales Hospital

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.

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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.

INTRODUCTION

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 *Sixth National Adult Cardiac Surgical Database Report 2008* and the *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*. We recognize that the populations treated may be inherently different but the UK publication remains one of the most authoritative and comprehensive documentations of national cardiac surgical practice available anywhere worldwide.

In our report, we have reported 'observed' versus 'expected' outcomes. We have focused on cumulative activity for the consecutive calendar years 2019 and 2020. We have compared the cumulative data in 2019-2020 with that in 2017-18 in some aspects.

DATABASE OVERVIEW

DATABASE OVERVIEW

An overview of the outcome at the Prince of Wales Hospital, Hong Kong: 2019-2020

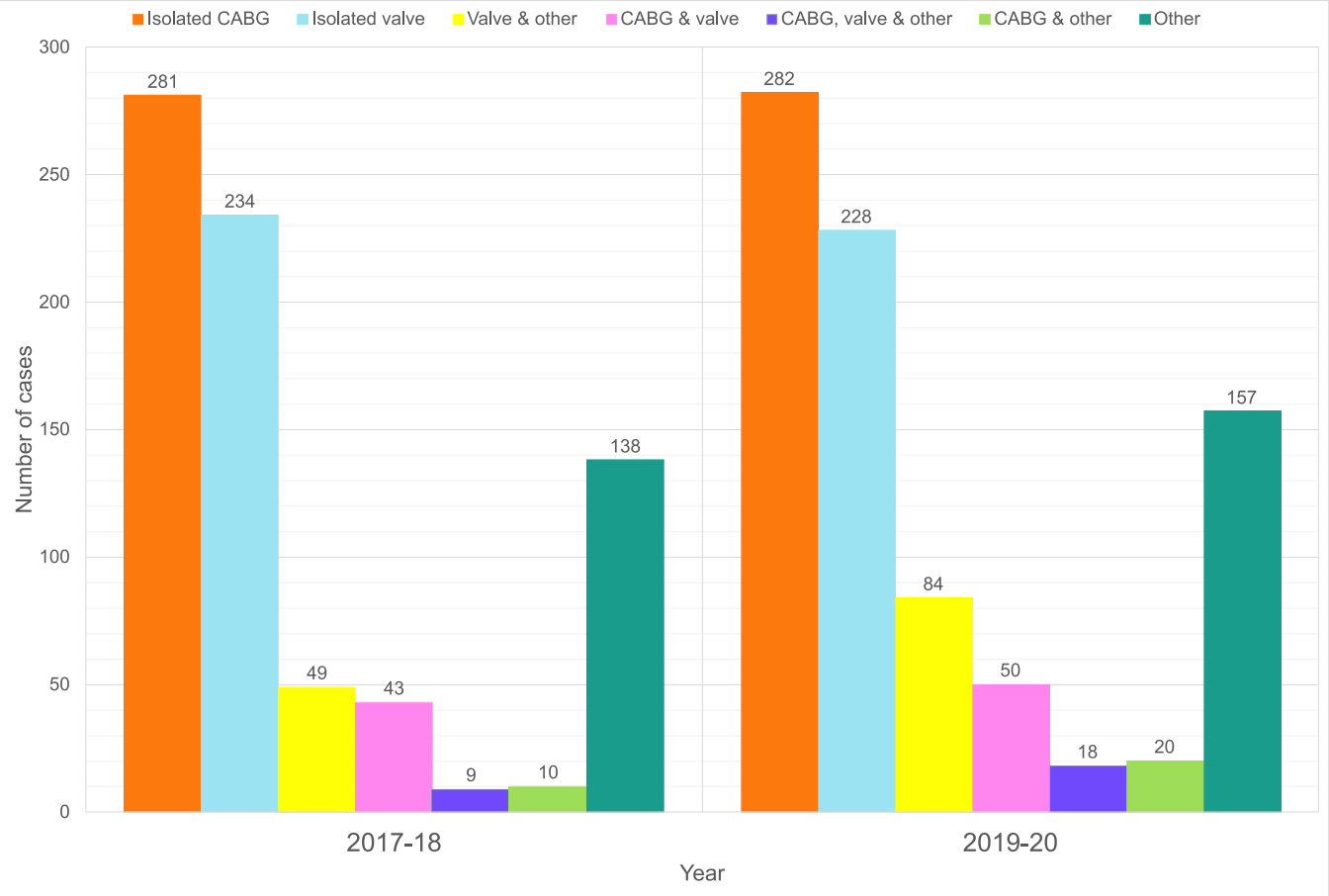
- There were 839 cardiac surgical procedures performed at the PWH during the calendar years 2019 and 2020.
- Fig 1.01 shows the distribution of these procedures by operative category and presented as absolute numbers. The categories are grouped so comparative analysis of the major operative groups can 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 1.02 shows the overall cardiac activities at the PWH from 2017 to 2020.
- 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.

Fig 1.01 Makeup of cardiac surgery workload at the PWH, 2019-2020

Cardiac procedures	PWH Count (Proportion)	UK proportion 2008	UK proportion 2015-2016
Isolated CABG	282 (34%)	58.3%	41.7%
Isolated valve	228 (27%)	18.9%	48.4%
Valve & other	84 (10%)	4.5%	
CABG & valve	50 (6%)	11.5%	
CABG, valve & other	18 (2%)	1.6%	
CABG & other	20 (2%)	2.0%	N/A
Other	157 (19%)	3.2%	
Total	839 (100%)	100%	100%

DATABASE OVERVIEW

Fig 1.02 Overall workload at the PWH, 2017-2020

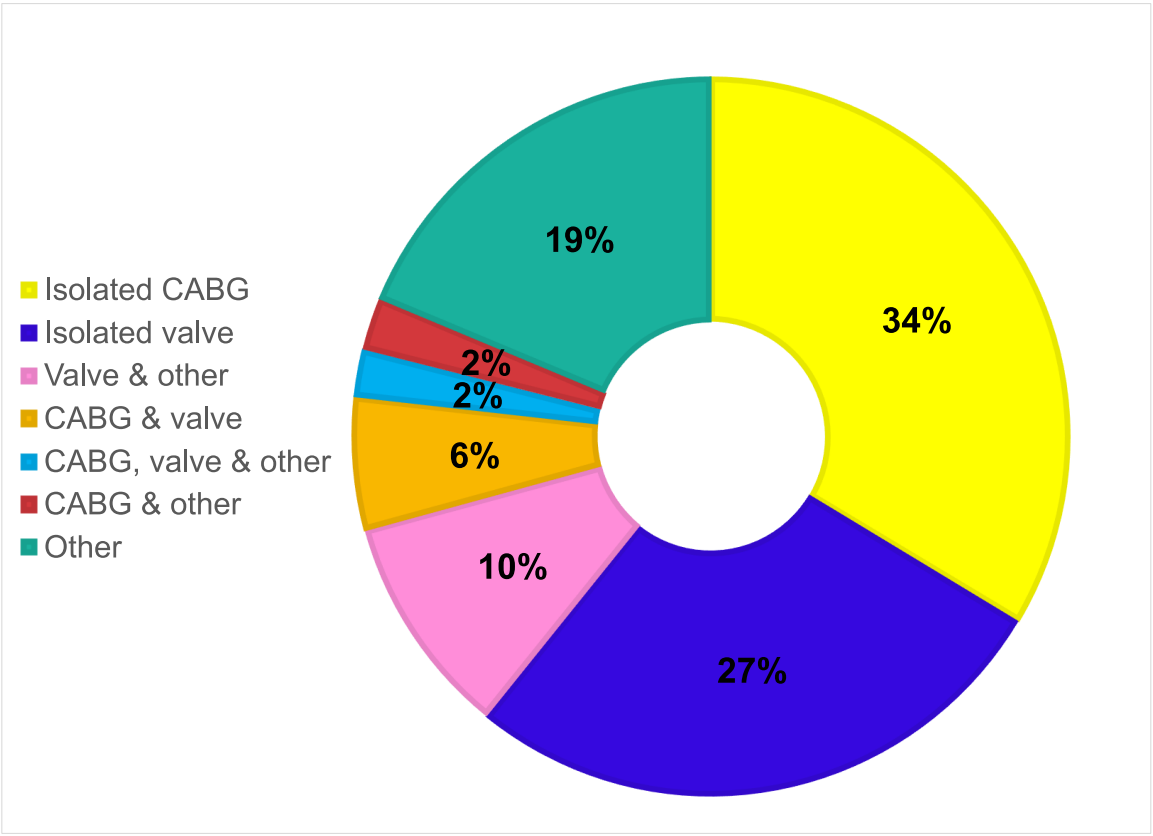


DATABASE OVERVIEW

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 2020.
- The volumes of isolated Coronary Artery Bypass Graft (CABG) as a component of overall activities have remained nearly the same for PWH. Isolated CABG surgeries represented 34% of our workload, which was a lower proportion than those in the UK (PWH: 34%, 2019-2020 vs the UK: 41.7%, 2015-2016).
- The proportion of valvular surgeries has remained steady from 2017 to 2020 at the PWH. Compared with the UK, valve procedures occupied a lower portion at the PWH (PWH: 45%, 2019-2020 vs the UK: 48.4%, 2015-2016).
- Aortic procedures now make up 21% of our activity. We also have a higher workload percentage of major aortic procedures as compared to the UK data under the same category (PWH: 21%, 2019-2020 vs the UK: 3.47%, 2015-2016).

Fig 1.03 Overall workload at the PWH, 2019-2020



DATABASE OVERVIEW

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 (137 in 2017-2018 vs 177 in 2019-2020) as in the last two years there has been an increase in minimally invasive, Thoracic Endovascular Aortic / Aneurysm Repair (TEVAR).
- We are increasingly using newer approaches to left ventricular aneurysm resection, which involves complex procedures for the restoration of the geometry of the left ventricle.
- 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, 2019-2020

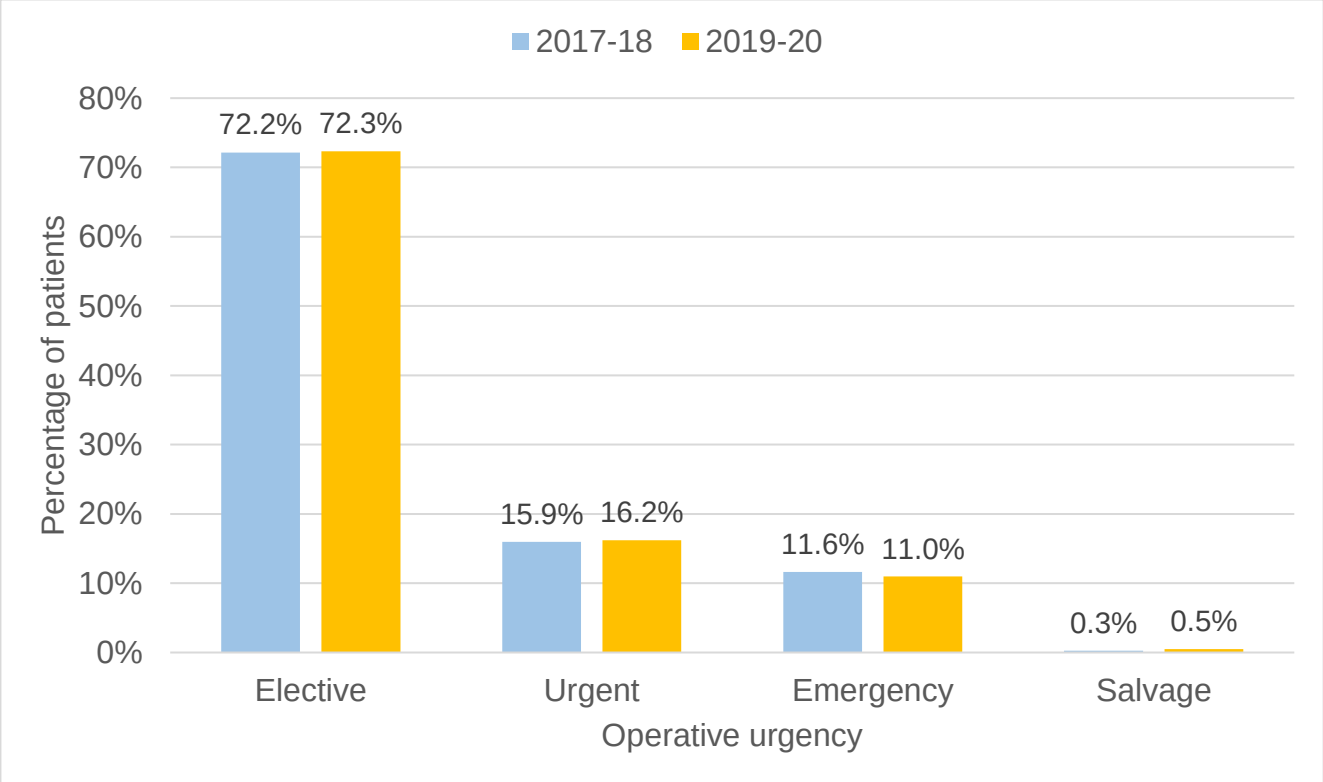
		Data	
		Count	Proportion
Other procedures	No other cardiac procedure performed	560	66.7%
	All operations with other procedure	279	33.3%
	Surgery on the aorta	177	21.1%
	LA appendage occlusion	68	8.1%
	ASD closure	10	1.2%
	Atrial myxoma	9	1.1%
	Peripheral vascular	8	1.0%
	Myomectomy	5	0.6%
	Acquired VSD	4	0.5%
	Pericardiectomy	3	0.4%
	LV aneurysmectomy	2	0.2%
	Other procedures not listed above	27	3.2%

DATABASE OVERVIEW

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. (72.3%, 2019-2020 vs 72.2%, 2017-2018).
- There has been a slight increase in the proportion of urgent patients over time (16.2%, 2019-2020 vs 15.9%, 2017-2018).
- The number of emergency or salvage patients remained small between the calendar years 2019 and 2020, which accounted for 11.5% of our workload. This has had a serious resource and organizational impact on the Division. (11.5%, 2019-2020 vs 11.9%, 2017-2018).

Fig 1.05 Operative priority for all cardiac procedures at the PWH, 2017-2020

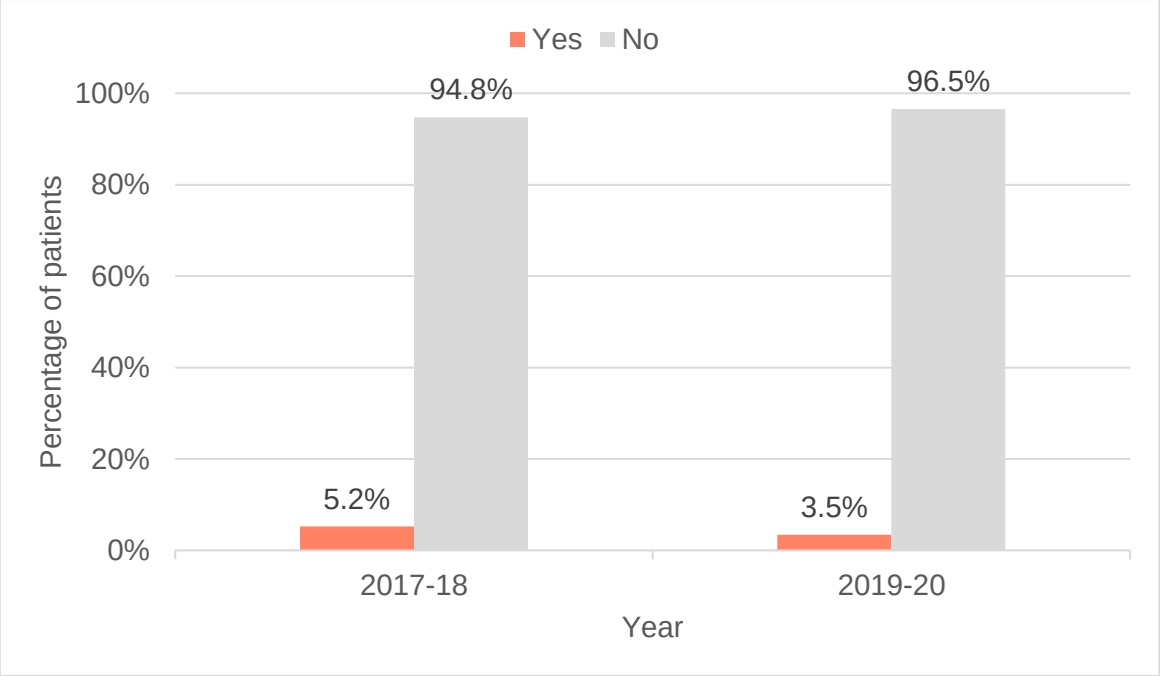


DATABASE OVERVIEW

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 decreased from 5.2% between 2017 and 2018 to 3.5% between 2019 and 2020.

Fig 1.06 Cardiogenic shock at the PWH, 2017-2020



DATABASE OVERVIEW

Referral patterns and the pre-operative patient risk profiles

- Fig 1.07 shows the centers we provide a service for and their contribution to our workload. There was no major change in the pattern of referrals over time taking into account the usual fluctuation of clinical referrals.
- In Fig 1.08, we have also documented some differences in the pre-operative patient risk profiles (logistic EuroSCORE) according to the referral center.

Fig 1.07 Referral patterns, 2017-2020

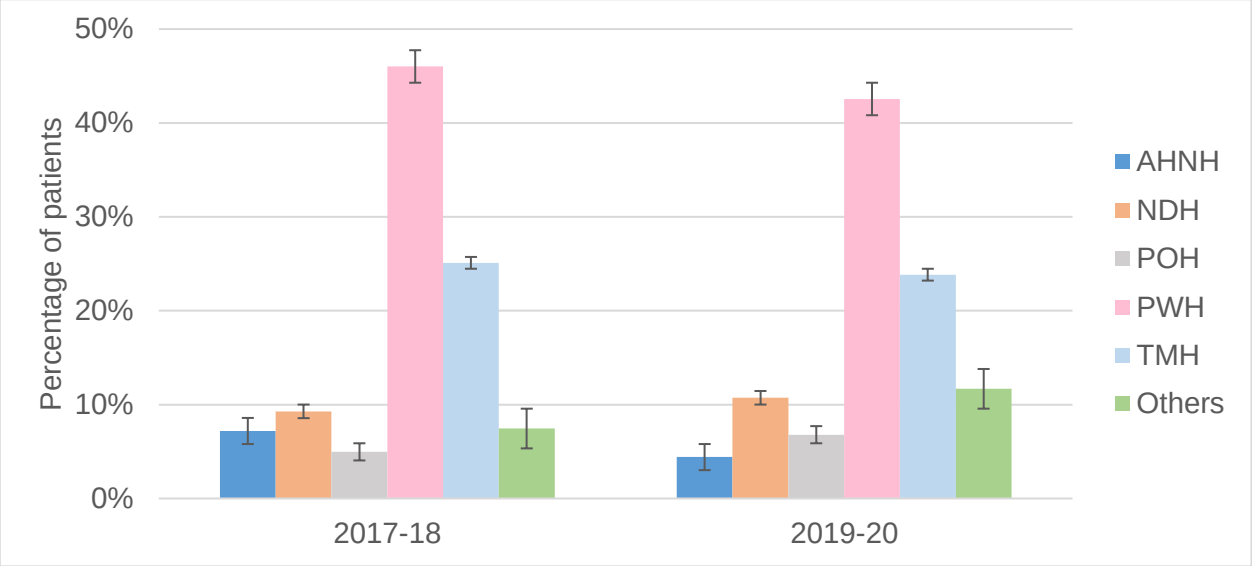
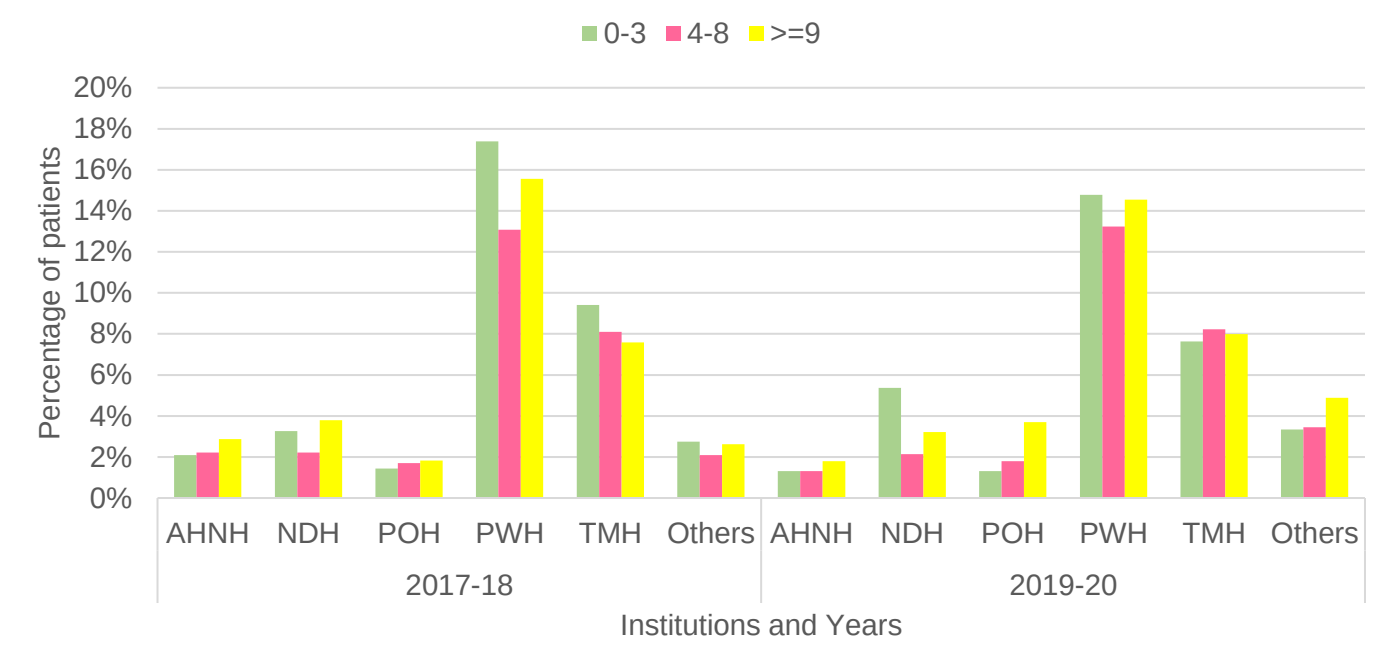


Fig 1.08 Pre-operative patient risk profiles according to referral center, 2017-2020

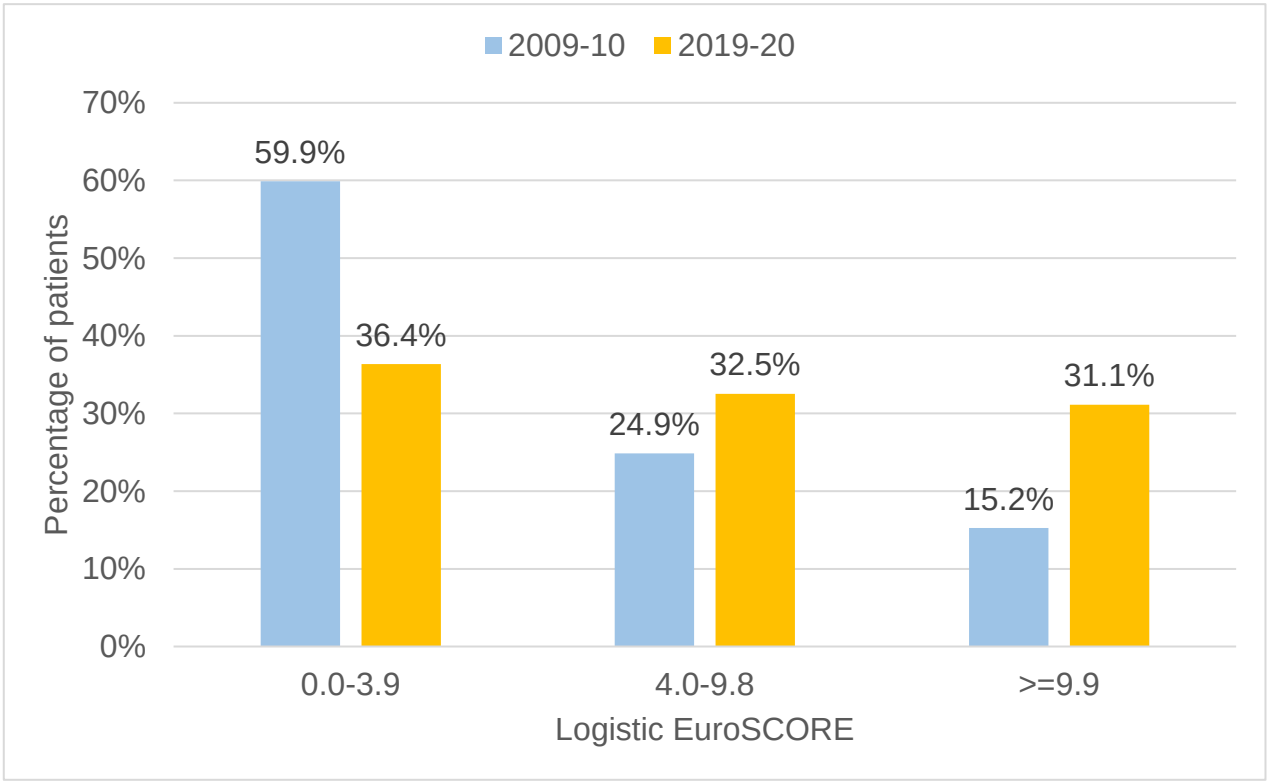


DATABASE OVERVIEW

Risk profiling over time

- Fig 1.09 provides some idea of the 'spread' of patients within the variously designated risk groups.
- The median EuroSCORE for our population was 5.5% during 2019-2020.
- For comparison, we have found the mean logistic EuroSCORE for our population has increased from 6.8% during 2009-2010 to 10.7% during 2019-2020.
- 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 high (4.0-9.8) and 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 1.09 Change in logistic EuroSCORE values over time, 2009-2020

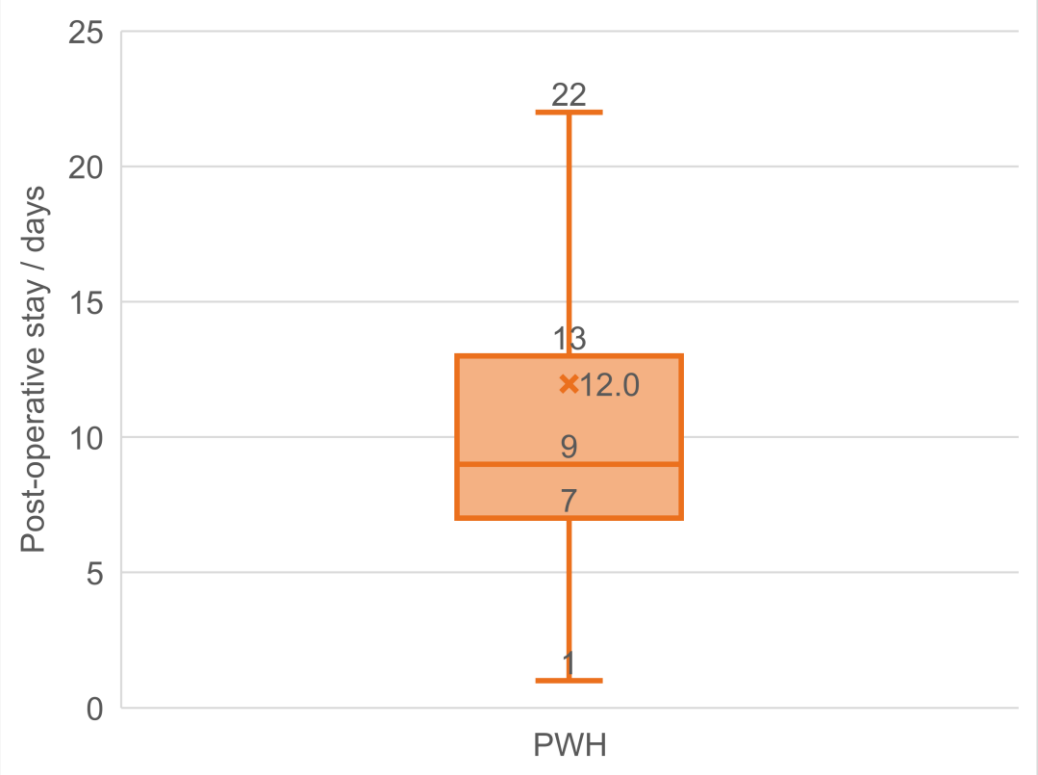


DATABASE OVERVIEW

Post-operative length of hospital stay

- Fig 1.10 shows the box plot of our length of hospital stay during 2019-2020.
- 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 12 and 9 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 that many of these patients are very unwell and develop complications after surgery and almost some will need to stay in the hospital for at least some of the course to be given.

Fig 1.10 Post-operative stay for all cardiac surgeries, 2019-2020

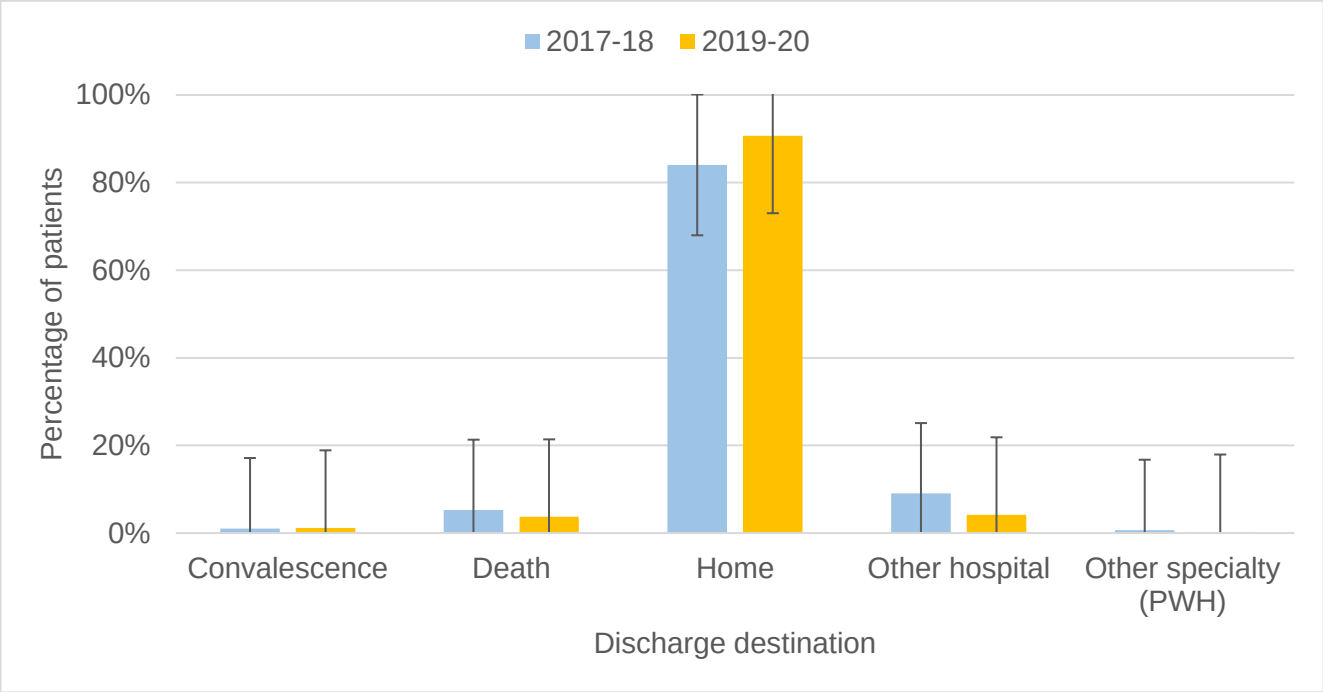


DATABASE OVERVIEW

Discharge destinations

- Fig 1.11 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 (90.7%) stay with us until they are fit for discharge directly home during 2019-20.

Fig 1.11 Discharge destination, 2017-2020



DATABASE OVERVIEW

Previous cardiac surgery

- As shown in Fig 1.12, the proportion of isolated CABG surgery with previous cardiac surgery at the PWH was 1% during 2019-2020, while the proportion of redo CABG operations was 0.2% in the UK over the period 2015-16.
- The complexity and risk associated with re-operations are greater than with primary (first-time) operations.
- Patients with coronary artery disease with 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 at the PWH was 12%.
- Overall, 8% of our adult cardiac surgery patients had previous cardiac surgery performed at the PWH, which remains consistent with our preceding reports (PWH: 8%, 2019-2020 vs the UK: 1%, 2015-2016).

Fig 1.12 Previous cardiac surgery

		Previous cardiac surgery		
		Yes	No	Proportion of prior surgery
Cardiac procedure	Isolated CABG	2	280	0.7%
	Isolated valve	28	200	12.3%
	Valve & other	4	80	4.8%
	CABG & valve	0	50	0.0%
	CABG, valve & other	1	17	5.6%
	CABG & other	3	17	15.0%
	Other	24	133	15.3%
	All	62	777	7.4%

DATABASE OVERVIEW

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 1.13 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 1.13 International comparison of post-operative mortality rates

		Mortality data					
			PWH		United Kingdom NACSD		EACTS database
		Dead	2019-20	2017-18	2008	2015-16	2006-08
Cardiac procedure	Isolated CABG	4	1.4% (282; 0.5%-3.8%)	0.7% (281; 0.1%-2.8%)	1.5% (22808; 1.3%-1.6%)	1.0% (15078; 0.9%-1.2%)	2.2% (219053; 2.2%-2.3%)
	Isolated valve	9	3.9% (228; 1.9%-7.6%)	3.8% (234; 1.9%-7.4%)	3.5% (7379; 3.1%-4.0%)		3.4% (75247; 3.3%-3.5%)
	Valve & other	3	3.6% (84; 0.9%-10.8%)	8.2% (49; 2.6%-20.5%)	5.5% (1780; 4.5%-6.7%)	3.60%	4.9% (12883; 4.5%-5.3%)
	CABG & valve	1	2.0% (50; 0.1%-12.0%)	9.3% (43; 3.0%-23.1%)	6.1% (4508; 5.4%-6.8%)	(17486; 3.3%-3.9%)	6.2% (37721; 6.0%-6.5%)
	CABG, valve & other	3	16.7% (18; 4.4%-42.3%)	55.6% (9; 22.7%-84.7%)	11.5% (617; 9.2%-14.4%)		11.3% (3097; 10.2%-12.5%)
	CABG & other	3	15.0% (20; 4.0%-38.9%)	10.0% (10; 0.5%-45.9%)	7.8% (766; 6.1%-10.0%)	N/A	7.0% (4327; 6.3%-7.8%)
	Other	8	5.1% (157; 2.4%-10.1%)	11.7% (137; 7.0%-18.6%)	7.9% (1271; 6.5%-9.5%)	N/A	7.7% (11562; 7.2%-8.2%)
	All	31	3.7% (839; 2.6%-5.3%)	5.4% (763; 3.9%-7.2%)	3.1% (39129; 2.9%-3.3%)	2.8% (36166; 2.6%-3.0%)	3.3% (363890; 3.2%-3.3%)

DATABASE OVERVIEW

Overall mortality and risk scores at the PWH

- Fig 1.14 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, the status of the heart for that particular patient, and that patient's other associated illnesses. 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 3.7% for all cardiac procedures at the PWH during the calendar years 2019 and 2020 (PWH: 5.4%, 2017-2018). Cardiac surgery outcomes in the UK reported mortality of 2.8% for the period 2015-2016 (PWH: 3.7%, 2019-2020 vs the UK: 2.8%, 2015-2016).
- During 2019 and 2020, logistic EuroSCORE predicted a mortality rate of 10.7% at the PWH. The average logistic EuroSCORE in the UK was 8.5% for the period 2015-2016 (PWH: 10.7%, 2019-2020 vs the UK: 8.5%, 2015-2016).
- During 2019 and 2020, the O/E ratio was 0.35 at the PWH.

Fig 1.14 Overall mortality and risk scores at the PWH, 2019-2020

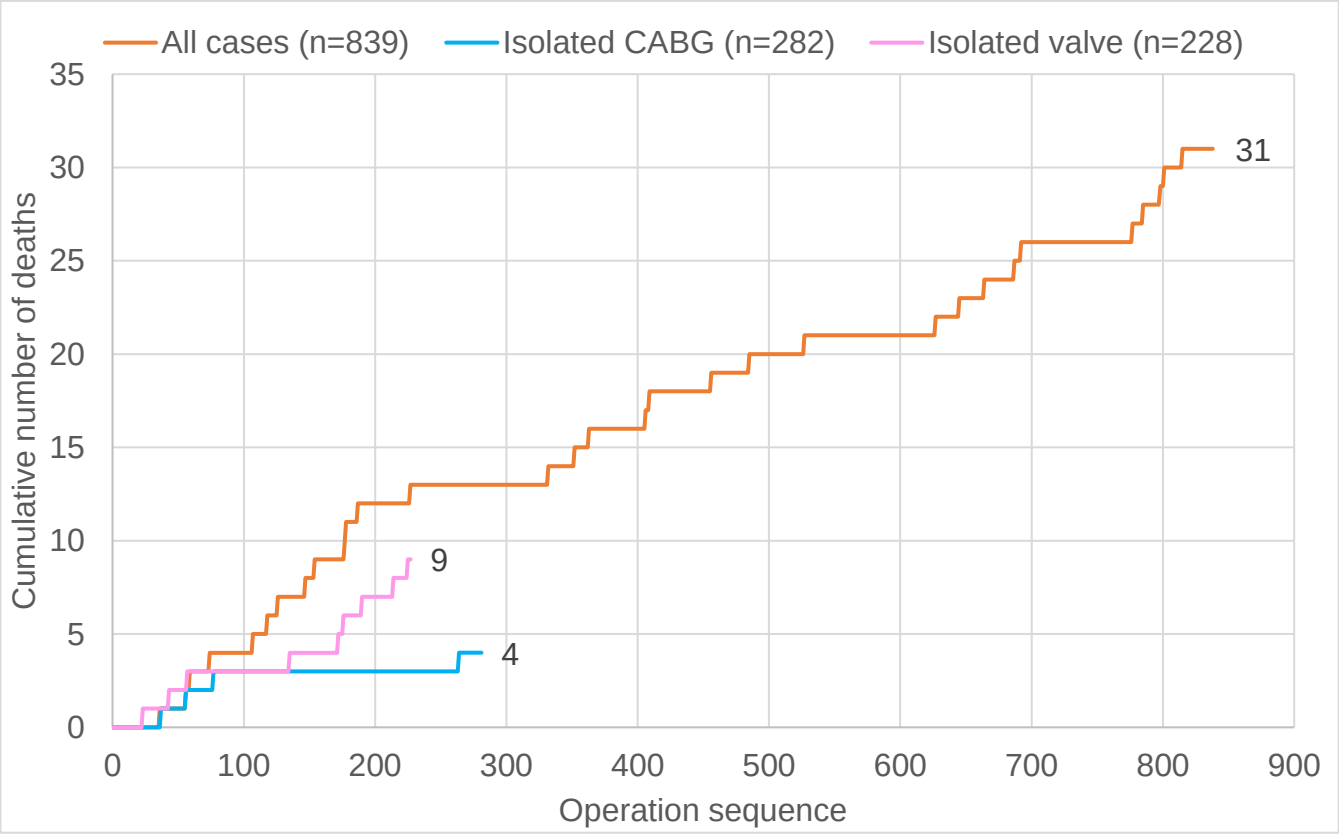
		Observed vs Expected mortality			
		Alive	Dead	Observed risk	Expected risk
Cardiac procedure	Isolated CABG	278	4	1.4%	3.8%
	Isolated valve	219	9	3.9%	10.1%
	Valve & other	81	3	3.6%	11.1%
	CABG & valve	49	1	2.0%	9.3%
	CABG, valve & other	15	3	16.7%	14.3%
	CABG & other	17	3	15.0%	26.2%
	Other	149	8	5.1%	21.7%
	All	808	31	3.7%	10.7%

DATABASE OVERVIEW

CUSUM plots of in-hospital mortality

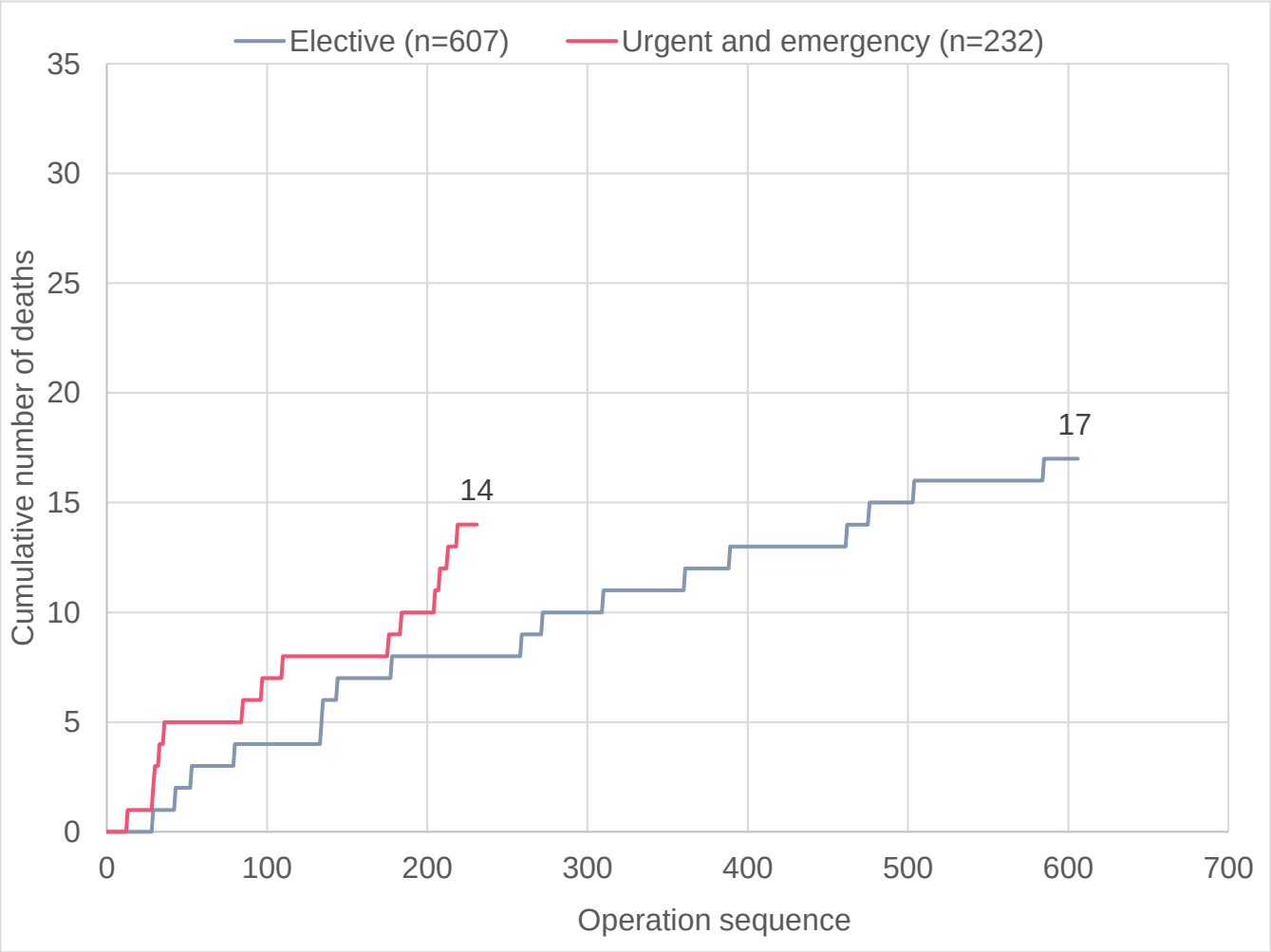
- The cumulative sum (CUSUM) technique is a method of graph plotting an accumulation of events (in-hospital mortality) over time.
- CUSUM charts are based on sequential monitoring of cumulative performance over time.
- Observed CUSUM mortality plot allows the detection of trends and corrective actions 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 2019-2020, the overall number of deaths for all cardiac surgeries was 31 at the PWH as shown in Fig 1.15.
- Fig 1.15 also shows the overall crude mortality rate by surgery type. Between 2019 and 2020, the overall number of deaths for isolated CABG and isolated valve surgeries were 4 and 9 at the PWH respectively.
- Fig 1.16 shows the overall crude mortality rate by operative priority. Between 2019 and 2020, the overall number of deaths for elective, and urgency & emergency (including salvage cases) cardiac surgeries were 17 and 14 at the PWH respectively.

Fig 1.15 CUSUM plot of crude mortality for ***all*** cases, and by ***surgery type*** at the PWH,2019-20



DATABASE OVERVIEW

Fig 1.16 CUSUM plot of crude mortality by ***operative priority*** at the PWH, 2019-2020

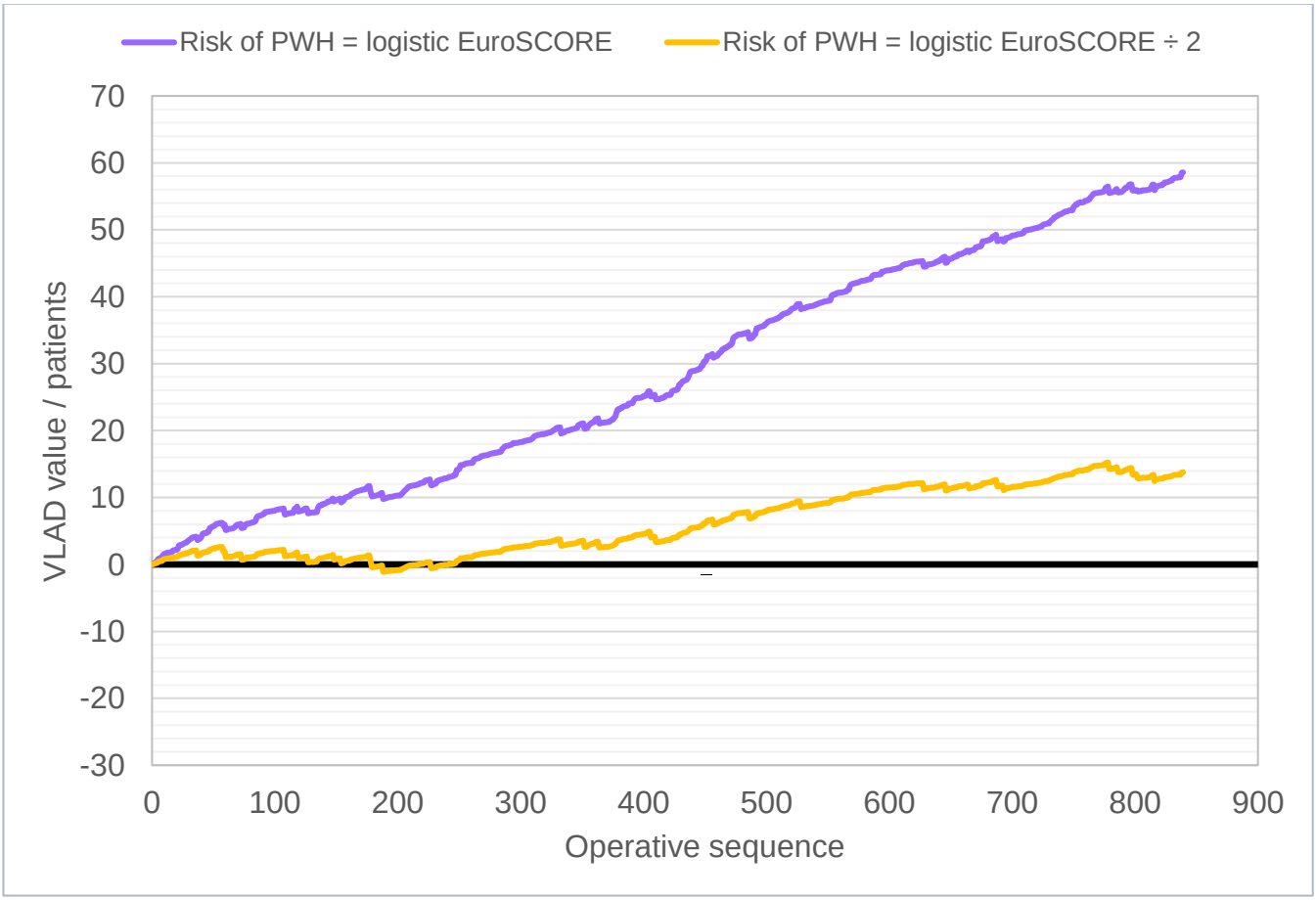


DATABASE OVERVIEW

VLAD plot for all cardiac surgeries at the PWH

- Fig 1.17 shows a Variable Life-Adjusted Display (VLAD) graph that covers all risk-scored procedures performed for the calendar years 2019 and 2020. A logistic EuroSCORE divided by 2 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 2019 and 2020, PWH saved almost 60 extra lives for all cardiac surgeries at the end of the curve as shown in Fig 1.17.

Fig 1.17 VLAD plot of ***all*** cardiac surgeries at the PWH, 2019-2020

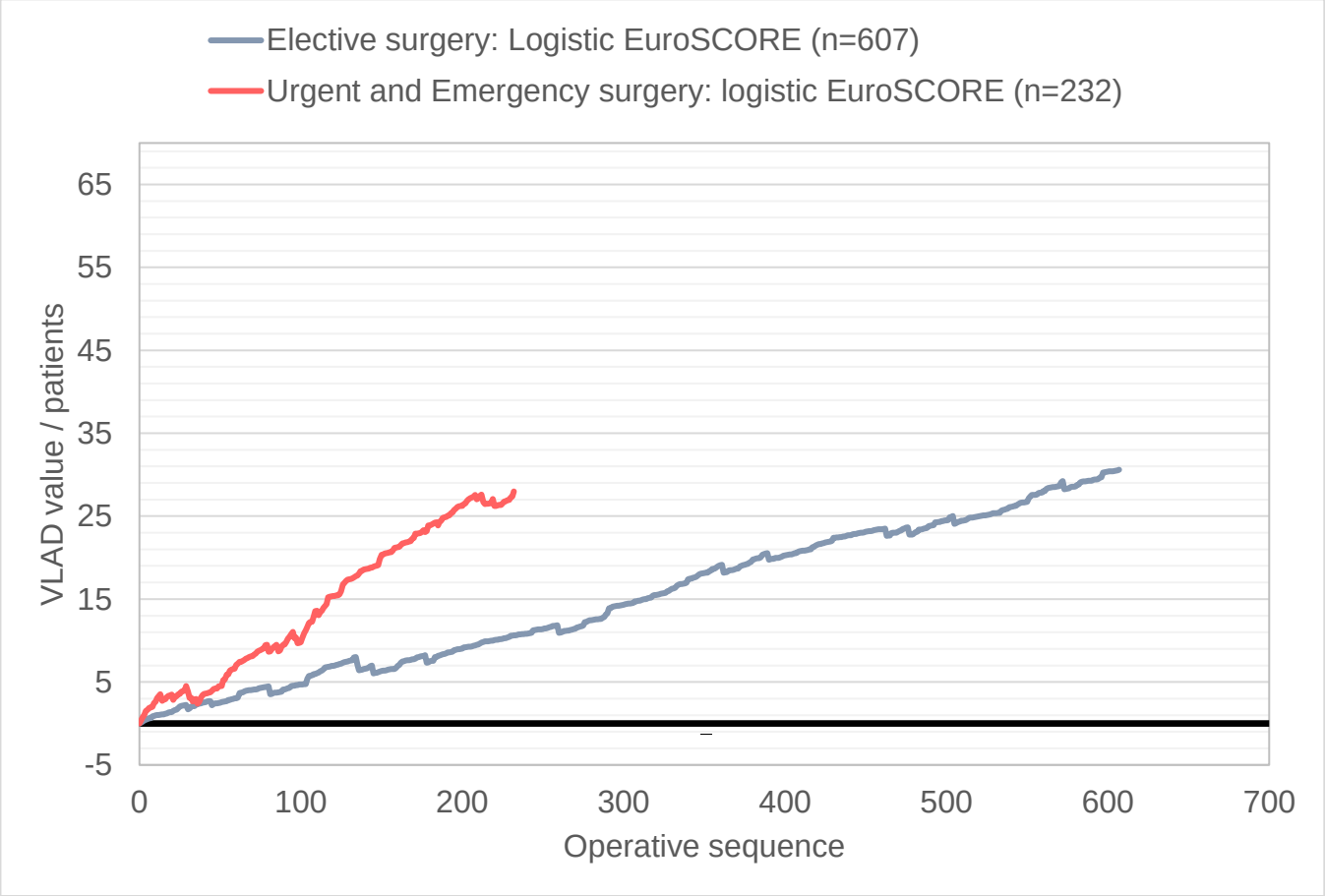


DATABASE OVERVIEW

VLAD plot for all cardiac surgeries by operative priority at the PWH

- Fig 1.18 shows a VLAD graph that covers all risk-scored procedures performed by operative priority for the calendar years 2019 and 2020.
- We can see that around 31 and 28 extra lives had been saved for *elective* and *urgent and emergency* *(including salvage cases)* cardiac surgeries respectively.

Fig 1.18 VLAD plot by ***operative priority*** at the PWH, 2019-2020



DATABASE OVERVIEW

Funnel plot of the overall crude mortality rate for all cardiac surgeries

- A non-risk-adjusted funnel plot for mortality for all cardiac procedures performed in the assessment period is shown in Fig 1.19.
- Two other non-risk-adjusted funnel plots for mortality rates for all cardiac procedures performed by operative priorities in the assessment period are shown in Fig 1.20 and Fig 1.21.
- 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 *urgent and emergency (including salvage cases)* cardiac surgeries was more pronounced at the PWH during the period 2019–2020 than that during 2017-2018.
- 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 higher than the NACSD average, 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 1.19 Funnel plot of crude mortality for ***all*** cardiac surgeries at the PWH, 2019-2020

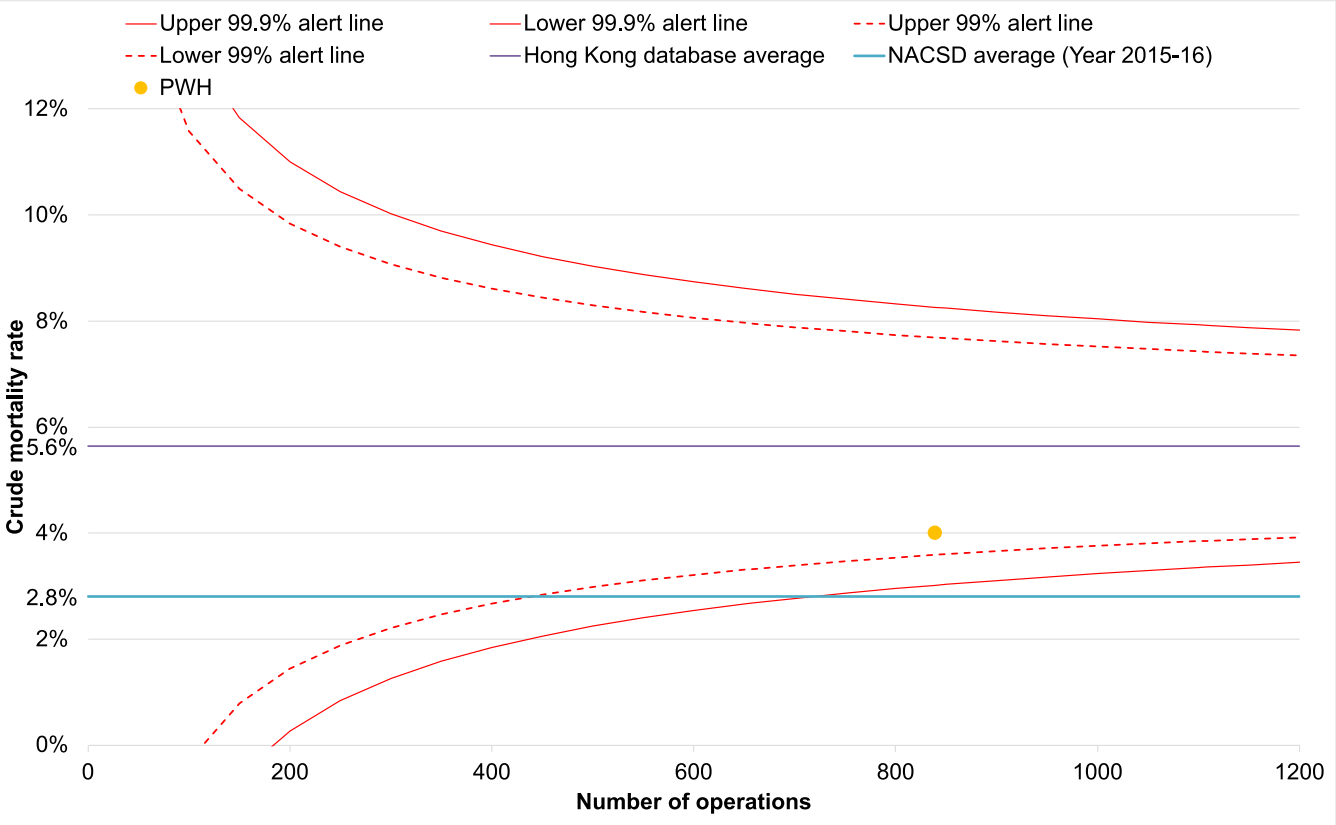


Fig 1.20 Funnel plot of crude mortality for all ***elective*** cardiac surgeries at the PWH, 2019-2020

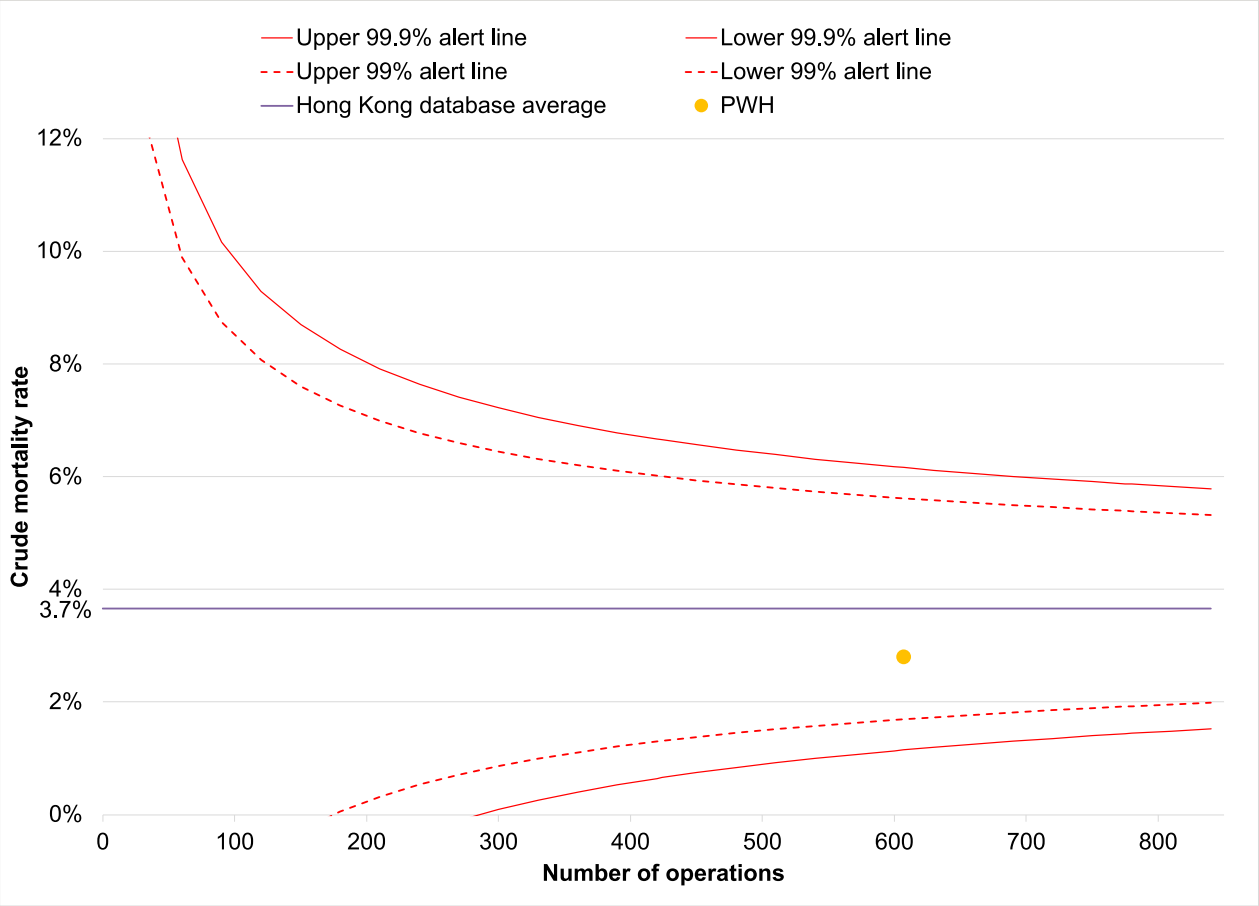
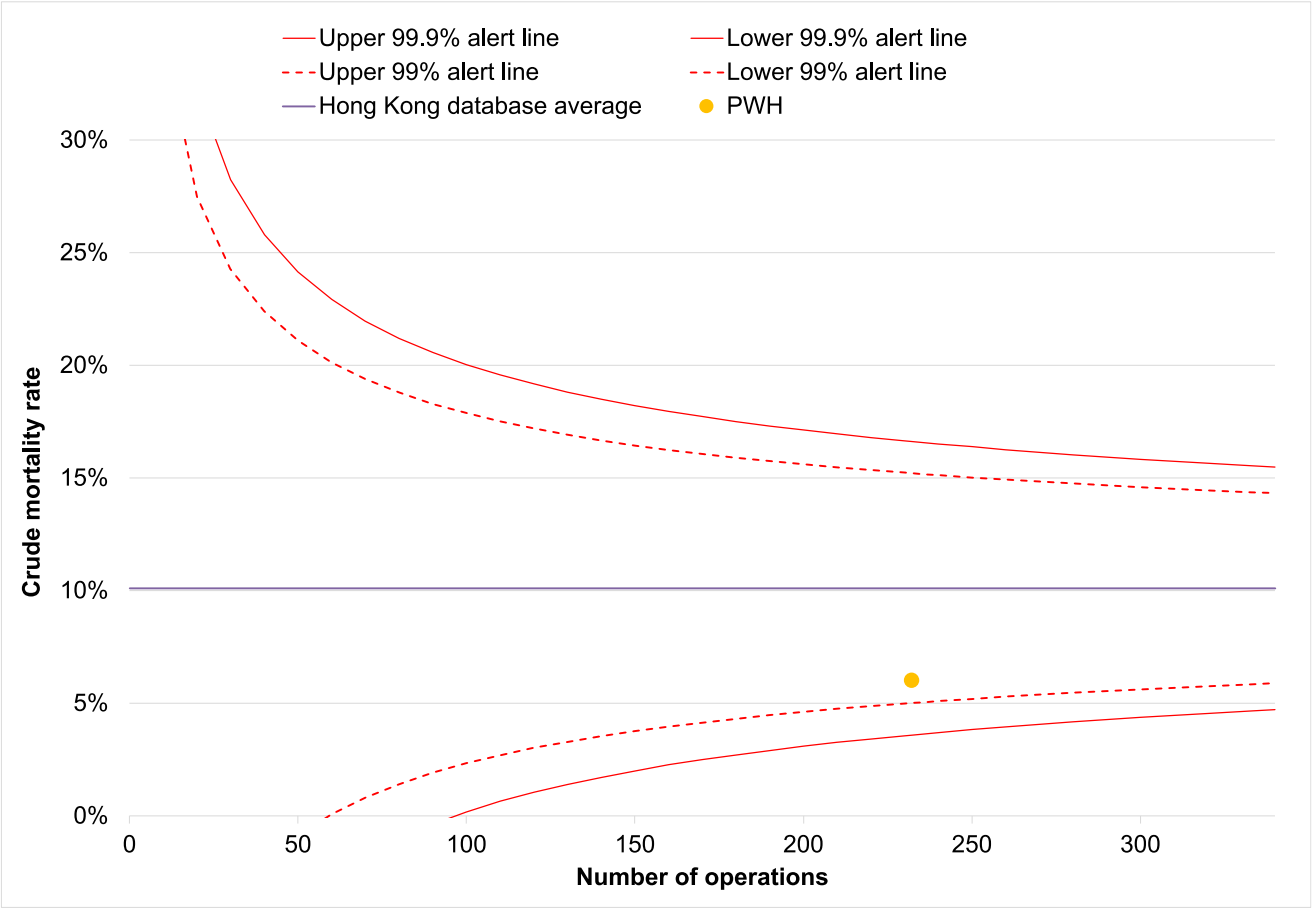


Fig 1.21 Funnel plot of crude mortality for all ***urgent and emergency*** cardiac surgeries at the PWH, 2019-2020



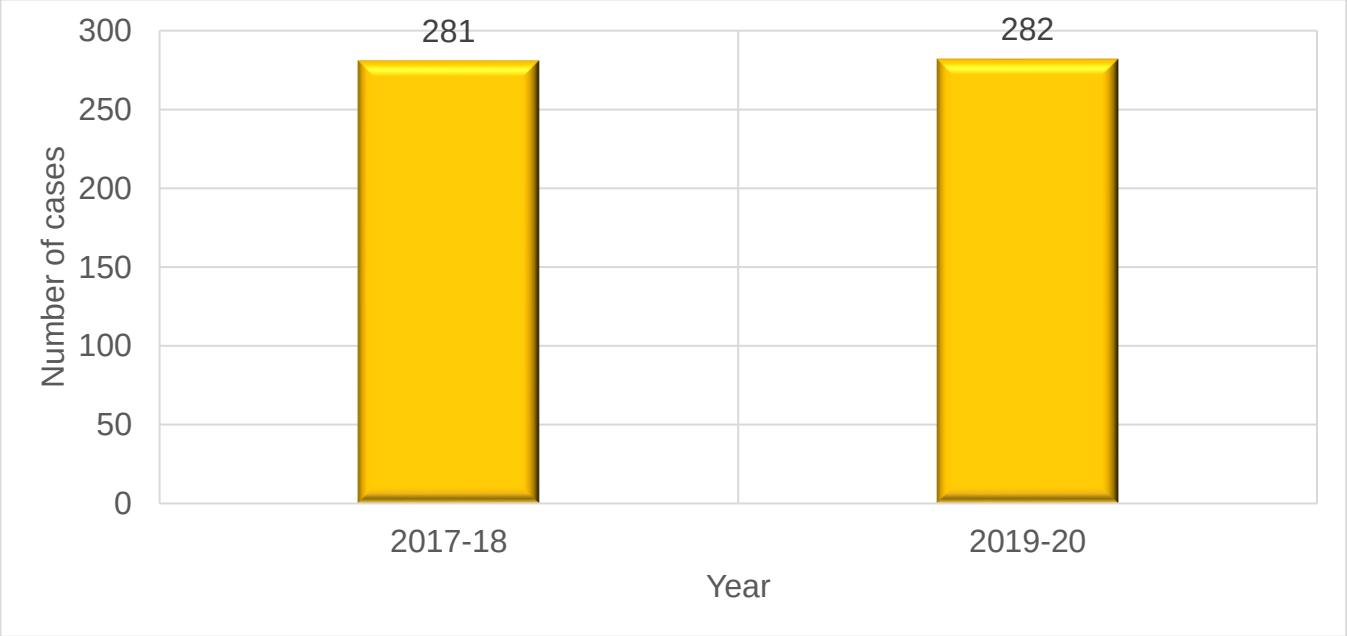
CABG SURGERY

CABG 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.
- We have again looked at this sub-group of patients in detail although as opposed to previous reports this no longer represents the 'main body' of our operative work and the CABG population we deal with has changed in an unprecedented way over the last 10 years which diminishes it as a 'marker' operation. However, despite this our outcomes have been maintained which is a testament to the Team.
- Fig 2.01 shows the number of isolated CABG surgeries done between the calendar years 2017 and 2020. There were 282 isolated CABG surgeries performed in total at the PWH during the calendar years 2019 and 2020.

Fig 2.01 Isolated CABG surgery at the PWH, 2017-2020



CABG SURGERY

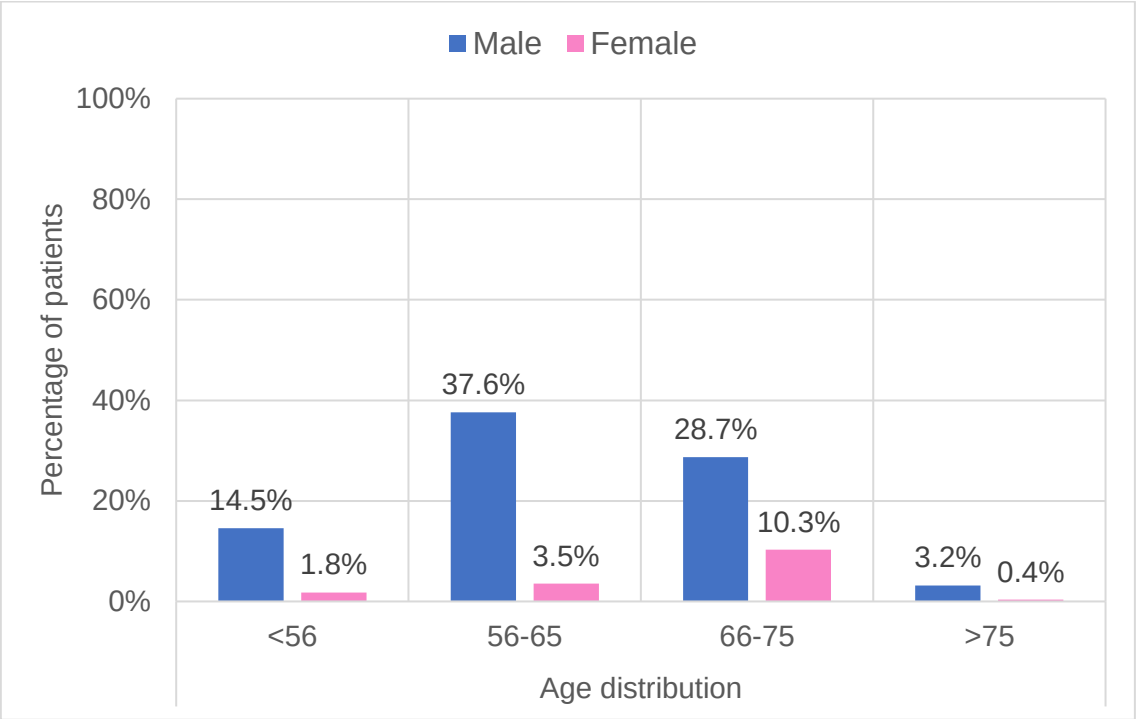
Pre-operative risk factors

Age and gender

- Fig 2.02 shows the patient demographics at the PWH between the calendar years 2019 and 2020. Intuitively age is a well-recognized risk factor for both mortality and morbidity.
- The mean age of patients undergoing isolated CABG was 63 years for PWH between 2019 and 2020. There has been a very slow but steady increase in the mean patient page for isolated CABG procedures at the PWH and the UK over the years (PWH: 63, 2019-2020 vs the UK: 66.1, 2015-2016).
- It does show, however, that on average over 43% of CABG patients were over 66 years of age at the PWH between 2019 and 2020, a significant proportion who have an associated increase in risk profile similar to the 2017-2018 data (PWH: 43%, 2019-2020 vs PWH: 39%, 2017-2018)
- On average, patient demographics remain essentially unchanged. There was a higher proportion of male patients, 84% (237) who underwent CABG compared to female patients, 16% (45) at the PWH. It reflects a widely known gender difference in the prevalence of coronary artery disease.
- 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, 11% of patients were female on average, and in those over the age of 66 it rose to nearly 67% 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.

CABG SURGERY

Fig 2.02 Isolated CABG surgery: Age and gender distribution



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%, 2019-2020 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	46	16.3%	0	0.0%
56-65	116	41.1%	2	1.7%
66-75	110	39.0%	2	1.8%
>75	10	3.5%	0	0.0%

CABG SURGERY

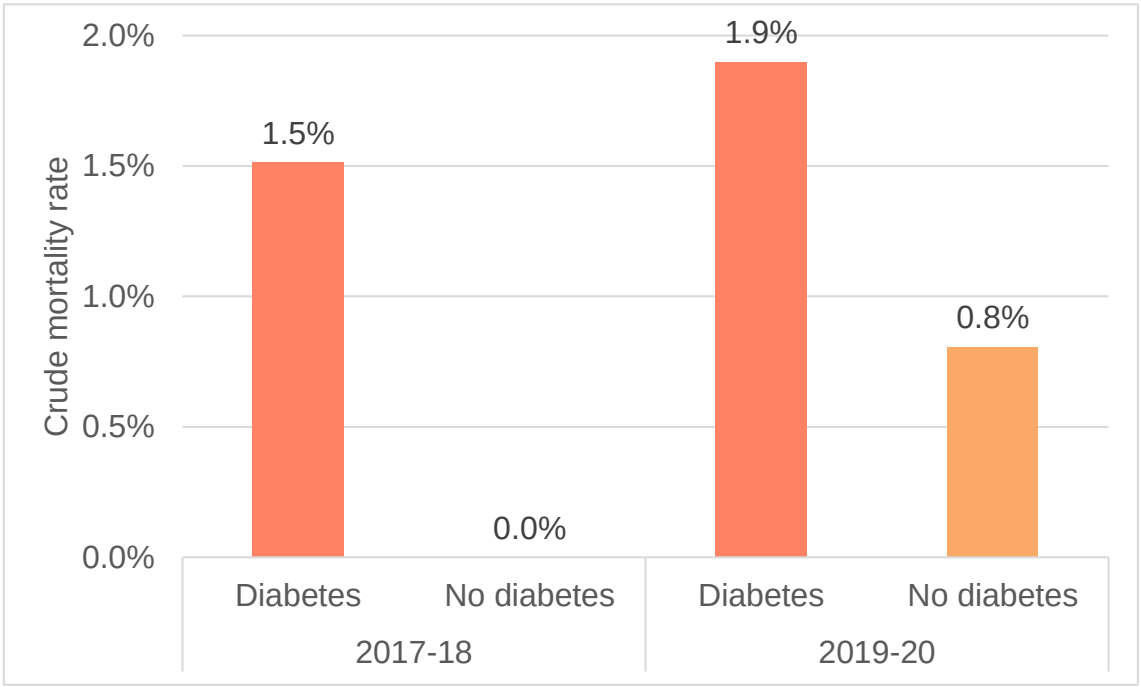
Diabetes

- Individuals with diabetes who undergo CABG have a higher incidence of post-operative complications.
- Fig 2.04 and Fig 2.05 show the patient diabetes distribution and the respective mortality rates at the PWH during the calendar years 2017 and 2020.
- Between 2019 and 2020, this incidence has remained relatively stable over the last 6 years and remains high in comparative terms as over 50% of patients have some form of diabetes.
- Most (64.6%) took oral anti-diabetics, 27.8% were insulin-dependent diabetics, and 7.6% controlled their condition with diets at the PWH.
- As anticipated, the post-operative mortality rate for diabetic patients remains significantly higher than for non-diabetic patients at the PWH.

Fig 2.04 Isolated CABG surgery: Diabetes management

	Diabetes management	
	2017-18	2019-20
	Count (Proportion)	Count (Proportion)
Diabetes	132 (47.0%)	158 (56.0%)
No diabetes	149 (53.0%)	124 (44.0%)

Fig 2.05 Isolated CABG surgery: Diabetes and the crude mortality rate



CABG SURGERY

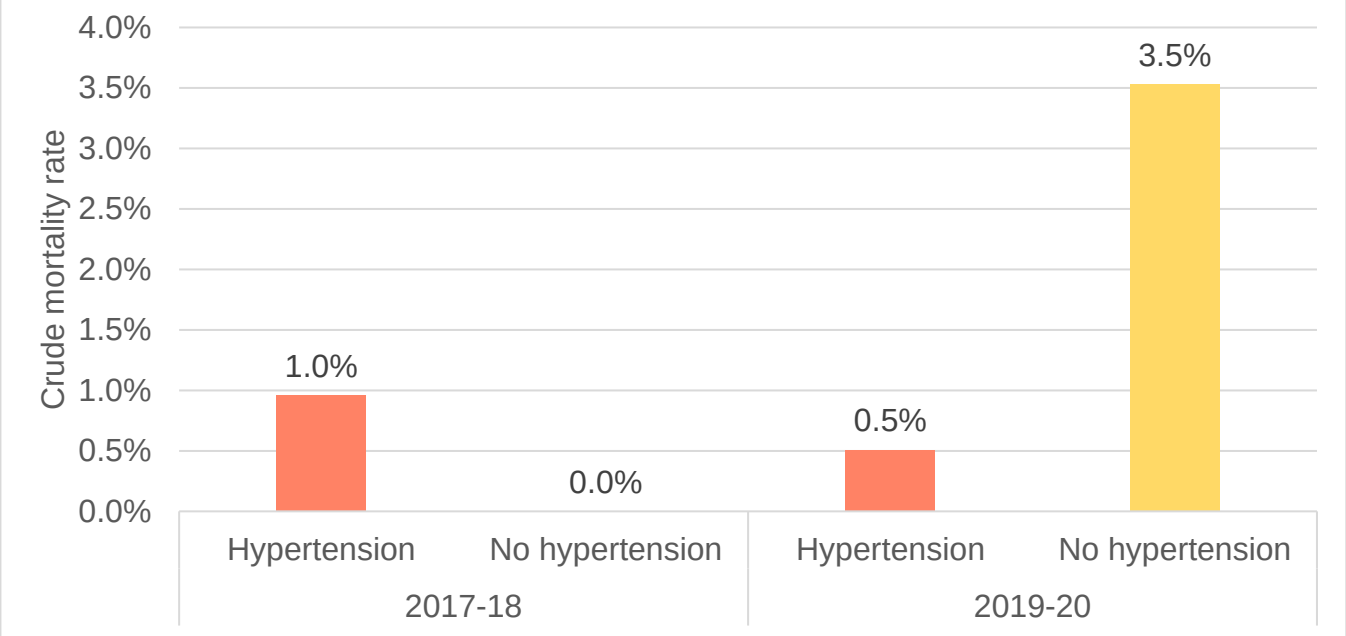
Hypertension

- Hypertension is defined as receiving antihypertensive medications at the time of surgery or BP greater than 140/90 on >1 occasion before admission.
- Pre-operative hypertension influences the overall risk of death and major adverse cardiac, cerebral, and other vascular events after CABG.
- Fig 2.06 and Fig 2.07 show the patient hypertension distribution and the respective mortality rates at the PWH during the calendar years 2017 and 2020.
- Between 2019 and 2020, the proportion of patients undergoing isolated CABG who have a diagnosis of hypertension was 70% at the PWH. (PWH: 74%, 2017-2018).
- There was an obvious decrease in the mortality rate associated with a diagnosis of hypertension at the PWH between 2019 and 2020. However, in the most recent year of study, there is no significant increase in operative mortality in patients with hypertension.

Fig 2.06 Isolated CABG surgery: Hypertension

	Hypertension	
	2017-18	2019-20
	Count (Proportion)	Count (Proportion)
Hypertension	208 (74.0%)	197 (69.9%)
No hypertension	73 (26.0%)	85 (30.1%)

Fig 2.07 Isolated CABG surgery: Hypertension and the crude mortality rate



CABG SURGERY

Left ventricular ejection fraction (LVEF)

- 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 2.08 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 3.2% at the PWH between 2019 and 2020, which is smaller than that of the UK data over the period 2015-2016 (PWH: 3.2%, 2019-2020 vs the UK: 6%, 2015-2016).
- The proportion of patients with a good ejection fraction was 69.5% at the PWH between 2019 and 2020.
- Impaired ejection fraction remains strongly associated with increased mortality. Patients with good left ventricular function had an average mortality rate of 0.5% between 2019 and 2020; for those with poor or very poor function, it was 11.1%.

Fig 2.08 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	195	99.5%	1	0.5%
	Fair	75	97.4%	2	2.6%
	Poor	8	88.9%	1	11.1%
	Very poor	0	0.0%	0	0.0%
	All	278	98.6%	4	1.4%

CABG SURGERY

Operative priority

- This CABG cohort included all cases whether elective, urgent, or emergency and Fig 2.09 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: 79.8%, 2019-2020 vs the UK: ~55.2%, 2015-2016).
- PWH performed an average of 19.1% of CABG surgeries on an urgent basis between 2019 and 2020 compared to 32.4% in the UK over the period 2002-2016 (PWH: 19.1%, 2019-2020 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 1.1% of all coronary operations at the PWH between 2019 and 2020 (PWH: 1.1%, 2019-2020 vs the UK: ~2.2%, 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.
- As expected, the mortality rate for elective cases is very low, but urgent, emergency, and salvage cases have a progressively higher risk. For ***elective*** CABG, the in-hospital mortality rate of 0.9% was recorded at the PWH between 2019 and 2020 respectively (PWH: 0.9%, 2019-2020 vs the UK: 0.6%, 2015-2016). For ***emergency*** CABG, no death for emergency cases was recorded in PWH during the same assessment period (PWH: 0.0%, 2019-2020 vs the UK: 6.6%, 2015-2016).

CABG SURGERY

Fig 2.09 Isolated CABG surgery: Operative priority and the crude mortality rate

		Proportion		Patient status at discharge		
		Overall proportion in HK	Overall proportion in the UK[1]	Dead		
				Count in HK	Proportion in HK	Proportion in the UK[2]
Operative priority	Elective	79.8%	~55.2%	2	0.9%	0.6%
	Urgent	19.1%	42.6%	2	3.7%	1.3%
	Emergency	1.1%	~2.0%	0	0.0%	6.6%
	Salvage		~0.2%			N/A
	All	100%	100%	4	1.4%	1.0%

[1] 2015-2016 approximate figure in the UK derived from *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*

[2] 2015-2016 data in the UK from *Seventh National Cardiac Surgery Activity and Outcomes Report 2002-2016*

CABG SURGERY

Mortality and other risk factors

- Fig 2.10 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 5.3% at the PWH.
- Among all the risk factors, the mortality rate of patients undergoing isolated CABG with pre-op IABP insertions is the highest, around 18.2% on average at the PWH.

Fig 2.10 Isolated CABG surgery: Mortality and other risk factors

			Mortality		
			Alive	Dead	Rate
Risk factor	Gender	Female	44	1	2.2%
		Male	234	3	1.3%
	Body mass index	< 25 kg/m2	136	3	2.2%
		>= 25 kg/m2	142	1	0.7%
	Left main stem disease	Yes	100	2	2.0%
		No	178	2	1.1%
	Previous cardiac surgery	Yes	2	0	0.0%
		No	276	4	1.4%
	Diabetes	Yes	155	3	1.9%
		No	123	1	0.8%
	Hypertension	Yes	196	1	0.5%
		No	82	3	3.5%
	Extra-cardiac arteriopathy	Yes	14	1	6.7%
		No	264	3	1.1%
	Previous CVA	Yes	17	0	0.0%
		No	261	4	1.5%
	Pre-op IABP Insertion	Yes	9	2	18.2%
		No	269	2	0.7%
	Renal failure requiring dialysis	Yes	6	1	14.3%
		No	272	3	1.1%

CABG SURGERY

Angina

- The presence of severe angina remains an important risk factor for operative mortality.
- Angina is graded according to the Canadian Cardiovascular Society (CCS) scale from 0 (no angina) to 4 (severe angina at rest or minimal activity).
- Fig 2.11 and Fig 2.12 show the symptom status of this patient cohort and the crude mortality rates related to the five angina CCS classes. As expected in the modern era of cardiac surgery, there has been a small proportion of patients undergoing CABG with severe and no angina over time.
- There has been the highest proportion of patients who have class 2 symptoms overtime at the PWH. The corresponding figure was 69.1% between 2019 and 2020.
- As expected, severe angina (CCS class 4) is associated with a significant increase in in-hospital mortality rate compared to those with mild symptoms. The crude mortality rate of patients with CCS 4 was the highest at the PWH, which was 14.3% between 2019 and 2020.

Fig 2.11 Isolated CABG surgery: Angina and the crude mortality rate

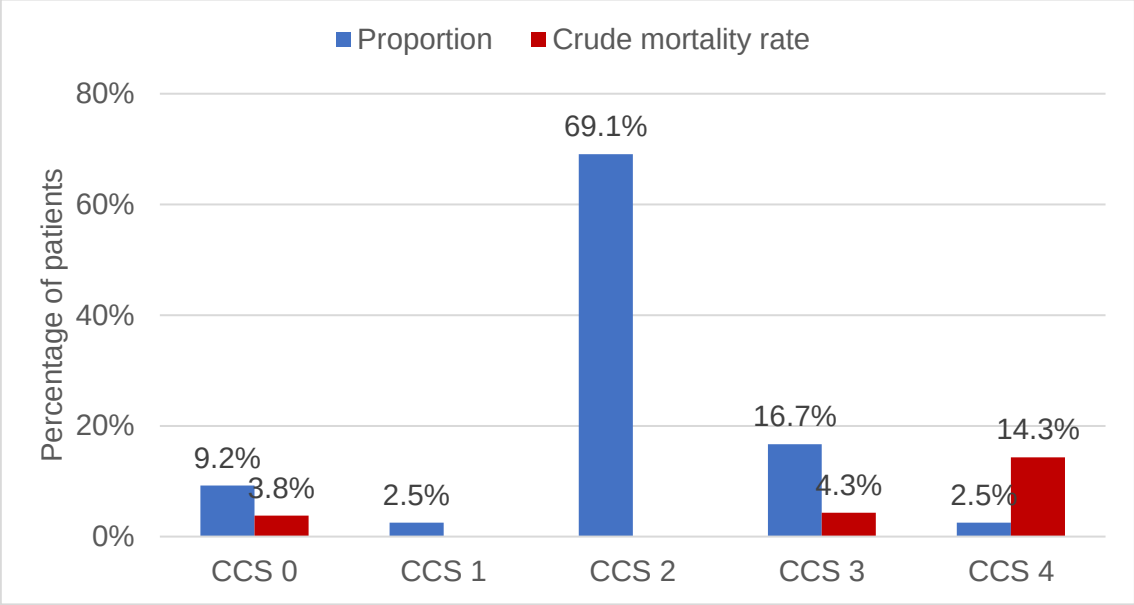


Fig 2.12 Isolated CABG surgery: Angina

	Angina CCS class				
	CCS 0	**CCS 1**	**CCS 2**	**CCS 3**	**CCS 4**
Count	26	7	195	47	7
Proportion	9.2%	2.5%	69.1%	16.7%	2.5%
Dead	1	0	0	2	1
Crude mortality rate	3.8%	0.0%	0.0%	4.3%	14.3%

CABG SURGERY

Number of bypass grafts

- Fig 2.13 shows the number of bypass grafts per patient and the respective mortality rates at the PWH in graphical form, and Fig 2.14 shows this in table form.
- Almost 82% of our population required 3 or more bypass grafts, a reflection of the severity of the coronary disease we are now treating surgically. A higher proportion (82%) of our case load is undertaken with 3 grafts or more during 2019-2020, compared to the UK data (<50%) in 2008 (PWH: 82%, 2019-2020 vs the UK: under 50%, 2008).
- The in-hospital mortality rate for patients who received 2 bypass grafts was the highest at the PWH, which was 2.0% on average between 2019 and 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 2.13 Isolated CABG surgery: Number of bypass grafts and the crude mortality rate

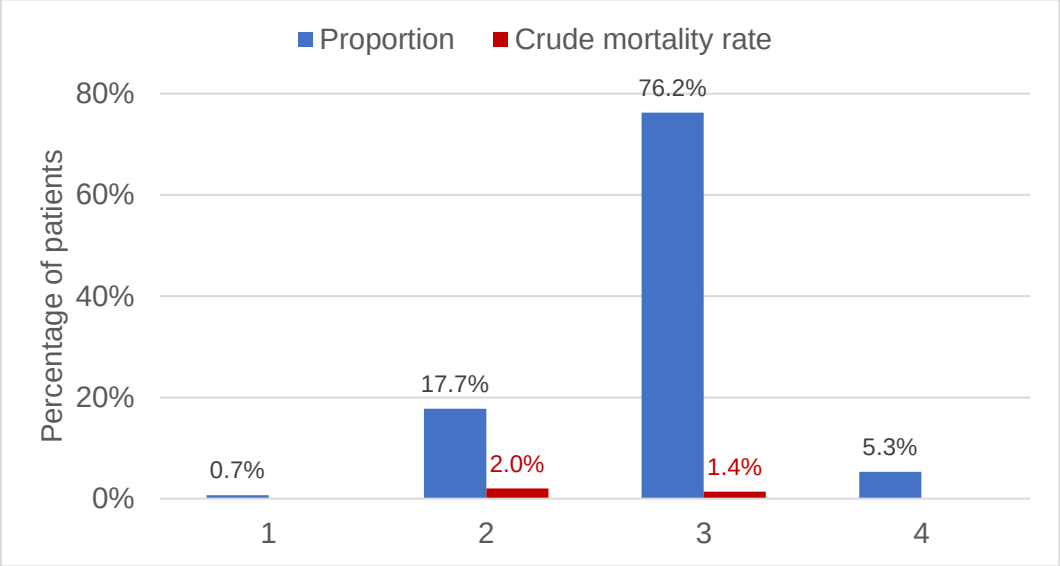


Fig 2.14 Isolated CABG surgery: Number of bypass grafts

	Number of bypass grafts			
	One	**Two**	**Three**	**Four**
Count	2	50	215	15
Proportion	0.7%	17.7%	76.2%	5.3%
Dead	0	1	3	0
Crude mortality rate	0.0%	2.0%	1.4%	0.0%

CABG SURGERY

Left Internal Mammary Artery (LIMA) 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 2.15 shows the percentage and the crude mortality rate of patients in terms of using the LIMA in graphical form, and Fig 2.16 shows this in table form.
- The LIMA usage rate has remained constantly high over the twelve-year period as previously noted and approached 90% at the PWH during the calendar years 2019 and 2020, which is slightly higher than that of 87.5% in our 2017-2018 data.
- The crude mortality rate of patients with LIMA usage was 1.6% on average at the PWH.

Fig 2.15 Isolated CABG surgery: LIMA usage and the crude mortality rate

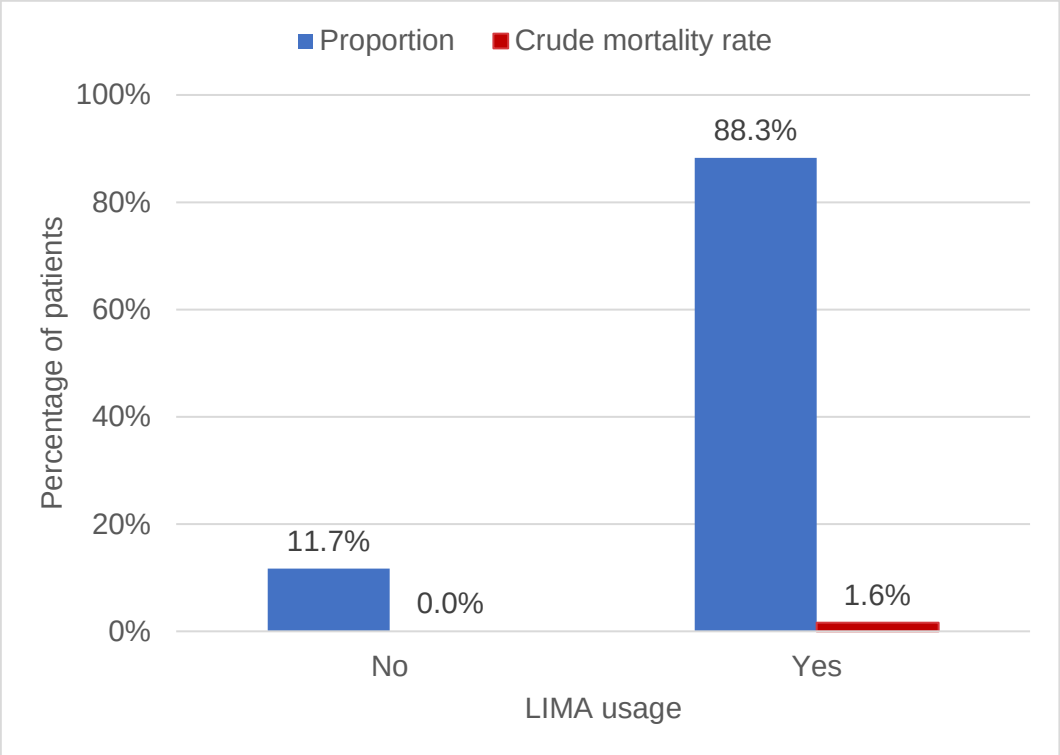


Fig 2.16 Isolated CABG surgery: LIMA usage

	LIMA usage	
	Yes	**No**
Count	249	33
Proportion	88.3%	11.7%
Dead	4	0
Crude mortality rate	1.6%	0.0%

CABG SURGERY

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 2.17 shows that the usage rate of the endoscopic method was 72.0% on average for vein graft harvest at the PWH between 2019 and 2020.

Fig 2.17 Isolated CABG surgery: Endoscopic conduit harvest

		Yes	No	All
Conduit	Endoscopic radial artery harvest	0	14	14
	Endoscopic vein harvesting	203	79	282

CABG SURGERY

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 2.18 and Fig 2.19 show observed and expected mortality and the respective international comparison in table form. Fig 2.20 presents the same interpretations in graphical form.
- Fig 2.21 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%, 2019-2020 vs the UK: 4.6%, 2015-2016).
- The overall **observed** mortality in the isolated CABG group of patients at the PWH was 1.4% (PWH: 1.4%, 2019-2020 vs the UK: 1.0%, 2015-2016).
- The **observed versus expected mortality ratio** for isolated CABG at the PWH was 0.37 (PWH: 0.15, 2017-2018). 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: 0.37, 2019-2020 vs the UK: around 0.22, 2015-2016).
- After risk adjustment, the PWH CABG outcome is better than expected.

Fig 2.18 Isolated CABG surgery: Logistic EuroSCORE distribution and the mortality rate at PWH

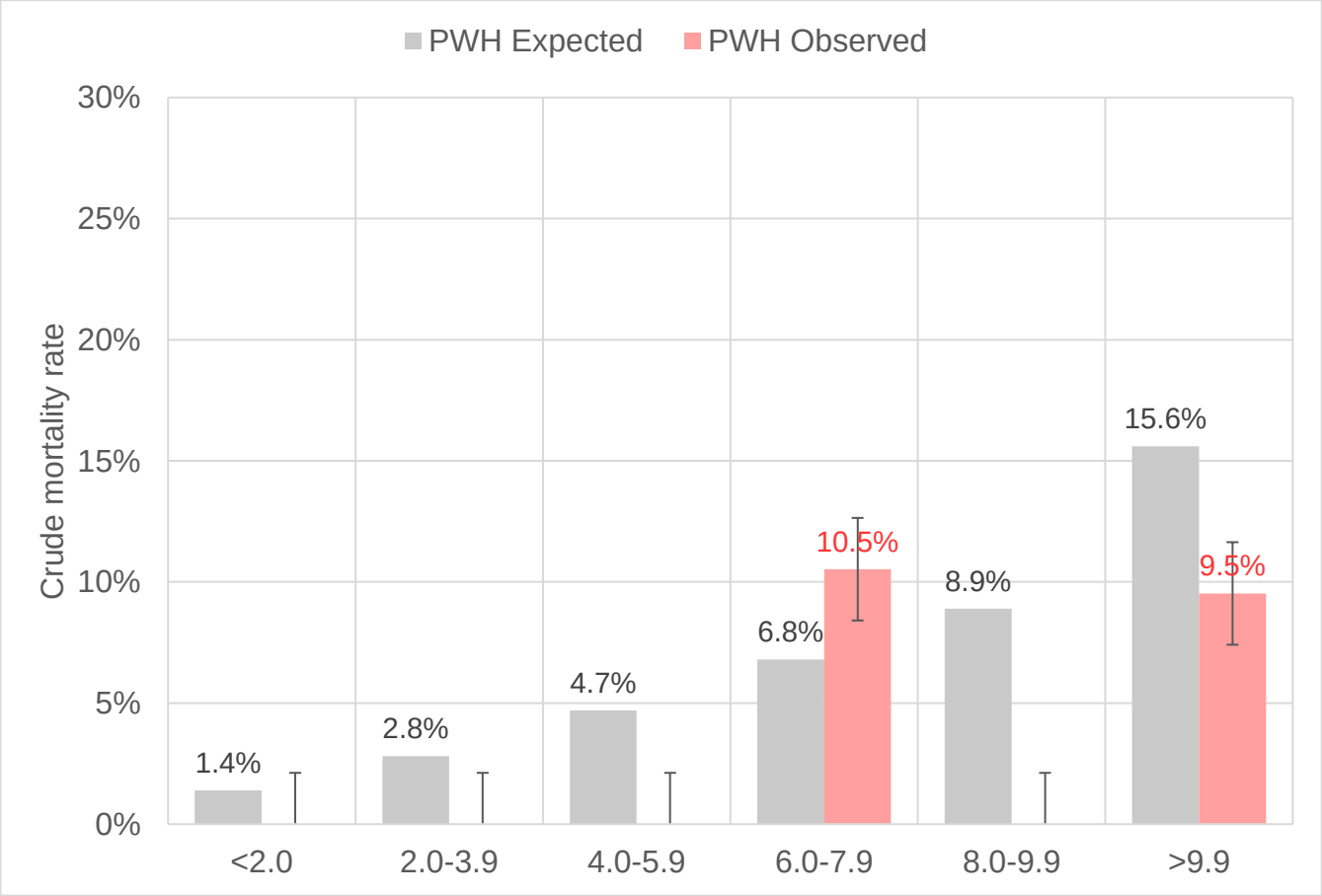
	Logistic EuroSCORE						
	<2.0	**2.0-3.9**	**4.0-5.9**	**6.0-7.9**	**8.0-9.9**	**>9.9**	**All**
Count	124	77	33	19	8	21	282
Dead	0	0	0	2	0	2	4
Observed mortality rate	0.0%	0.0%	0.0%	10.5%	0.0%	9.5%	1.4%
Expected mortality rate	1.4%	2.8%	4.7%	6.8%	8.9%	15.6%	3.8%

CABG SURGERY

Fig 2.19 Isolated CABG surgery: International comparison of observed and expected mortality rate

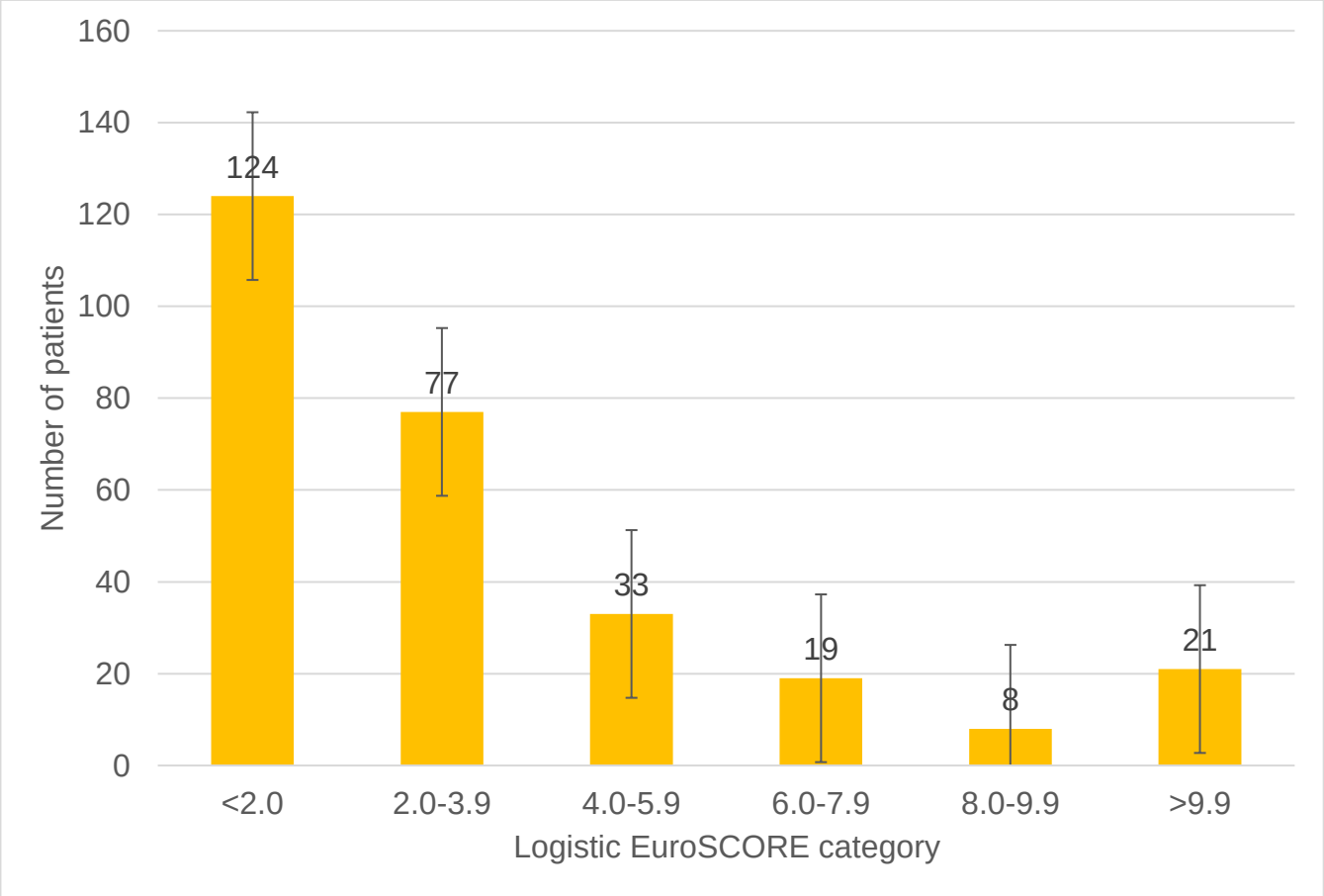
	PWH (2019-2020)		The UK (2015-2016)	
	Observed mortality rate	Expected mortality rate	Observed mortality rate	Expected mortality rate
Elective	0.9%	3.2%	0.6%	2.8%
Urgent	3.5%	5.7%	1.3%	5.5%
Emergency	0.0%	17.4%	6.6%	26.0%
All	1.4%	3.8%	1.0%	4.6%

Fig 2.20 Isolated CABG surgery: Observed and expected mortality rate at the PWH



CABG SURGERY

Fig 2.21 Isolated CABG surgery: Logistic EuroSCORE distribution at the PWH

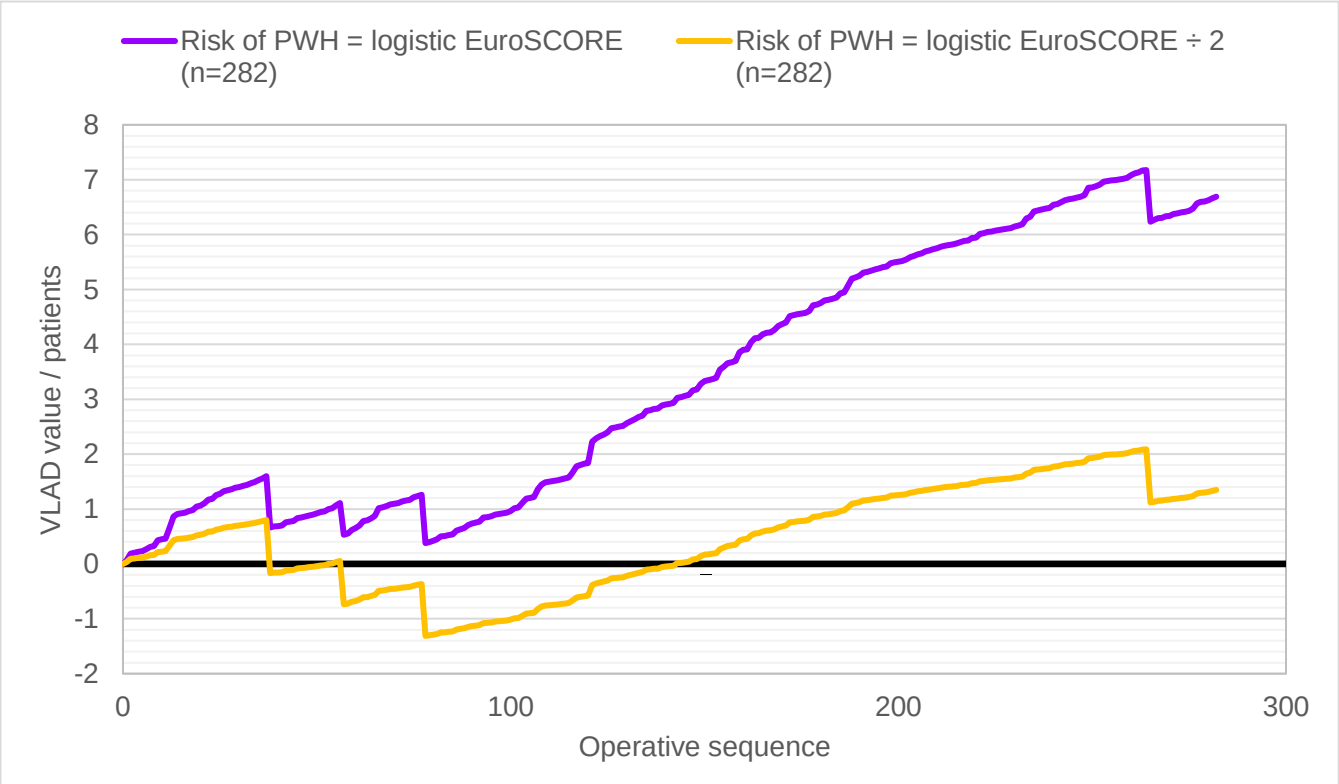


CABG SURGERY

VLAD plot for isolated CABG surgery

- The Variable Life-Adjusted Display (VLAD) graph covers all risk-scored isolated CABG procedures performed during the calendar years 2019 and 2020.
- 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 2.22 shows the VLAD plot for CABG outcomes using the EuroSCORE and EuroSCORE÷2 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, almost 7 extra lives had been saved for the isolated CABG group at the PWH.

Fig 2.22 Isolated CABG surgery: VLAD plot at the PWH



CABG SURGERY

International benchmarking of results

- The focus of this report as stated was on risk-adjusted outcomes in terms of mortality for cardiac surgery at the PWH as part of our journey to real-time monitoring.
- 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 2.23 and Fig 2.26)**:** 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 2.24 and Fig 2.27)**:** 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 2.25 and Fig 2.28)**:** 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 2.29a to Fig 2.29d)**:** 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 2.26 to Fig. 2.29a-d) 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 2019-2020. The ***light purple*** horizontal line represents the average data from all cardiac units in Hong Kong during 2019-2020. The ***light blue*** horizontal line is served as a reference on the charts, which represents the average of the data in the United Kingdom NACSD during the period 2008-2016.
- The crude mortality rates, the re-operation for bleeding rate, the crude stroke rate, and the haemofiltration / dialysis rate for isolated CABG at the PWH fell well within the alert lines during the assessment period.
- The results of these four key outcomes demonstrated that PWH has performed better than expected standards with no outlier.

CABG SURGERY

Other immediate post-operative outcomes

Re-operation for bleeding

Fig 2.23 Isolated CABG surgery: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	**Count**	5	277
	Proportion	1.8%	98.2%
	Dead	1	3
	Crude mortality rate	0.4%	1.1%

Post-operative stroke

Fig 2.24 Isolated CABG surgery: New post-operative stroke

		Yes	No
New post-operative stroke	**Count**	2	280
	Proportion	0.7%	99.3%
	Dead	0	4
	Crude mortality rate	0.0%	1.4%

Post-operative HF / dialysis

Fig 2.25 Isolated CABG surgery: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	**Count**	5	277
	Proportion	1.8%	98.2%
	Dead	1	3
	Crude mortality rate	0.4%	1.1%

Fig 2.26 Isolated CABG surgery: Crude ***re-operation for bleeding*** rate

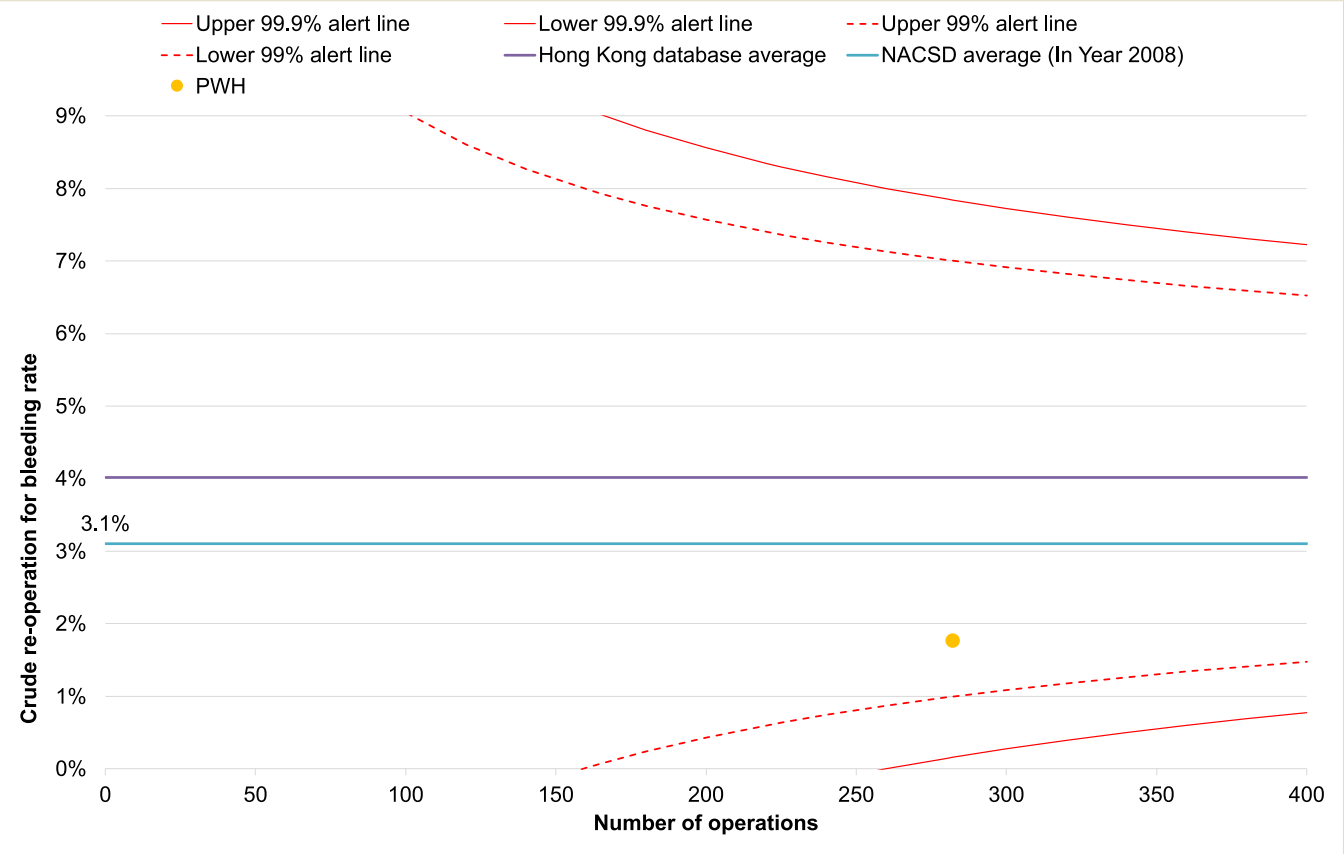


Fig 2.27 Isolated CABG surgery: Crude ***post-operative stroke*** rate

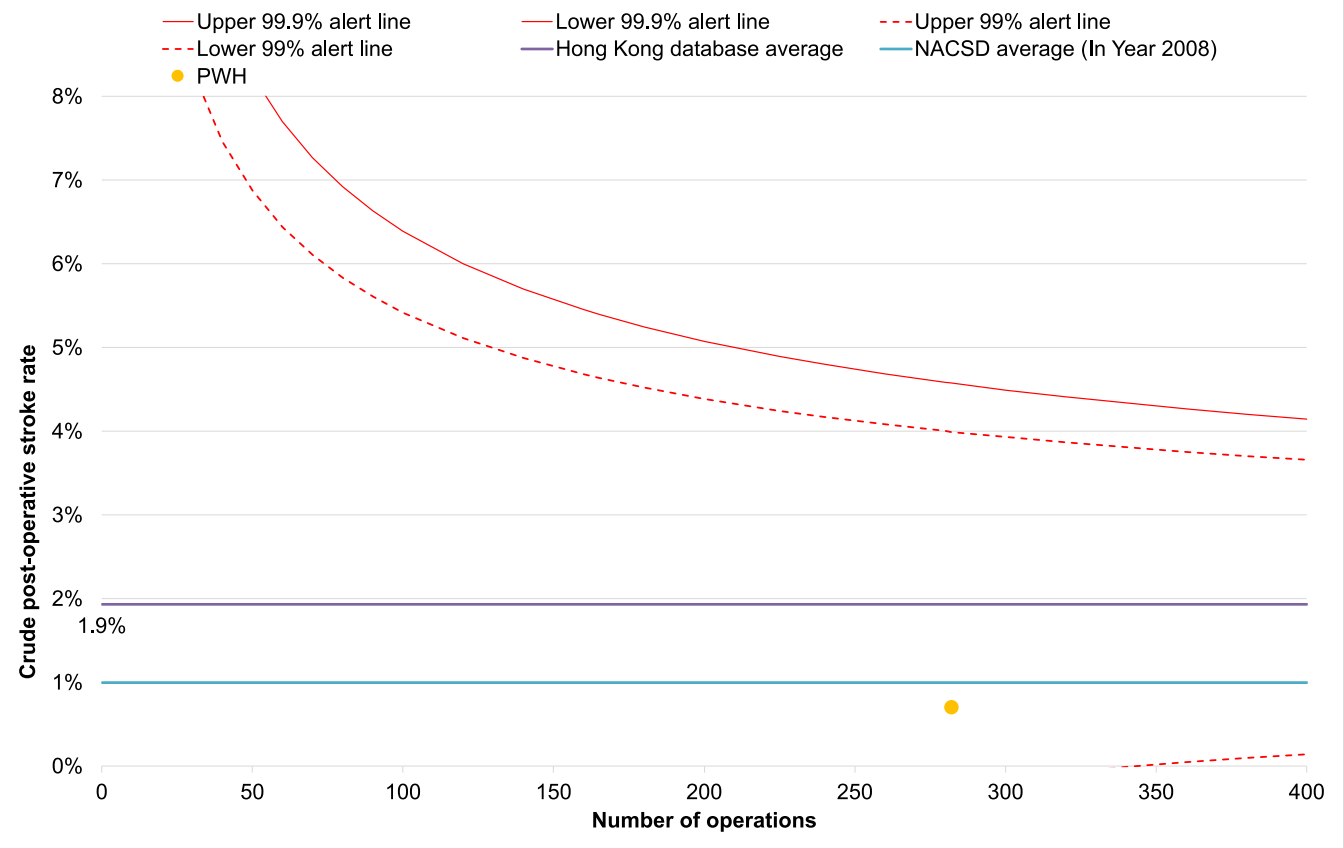
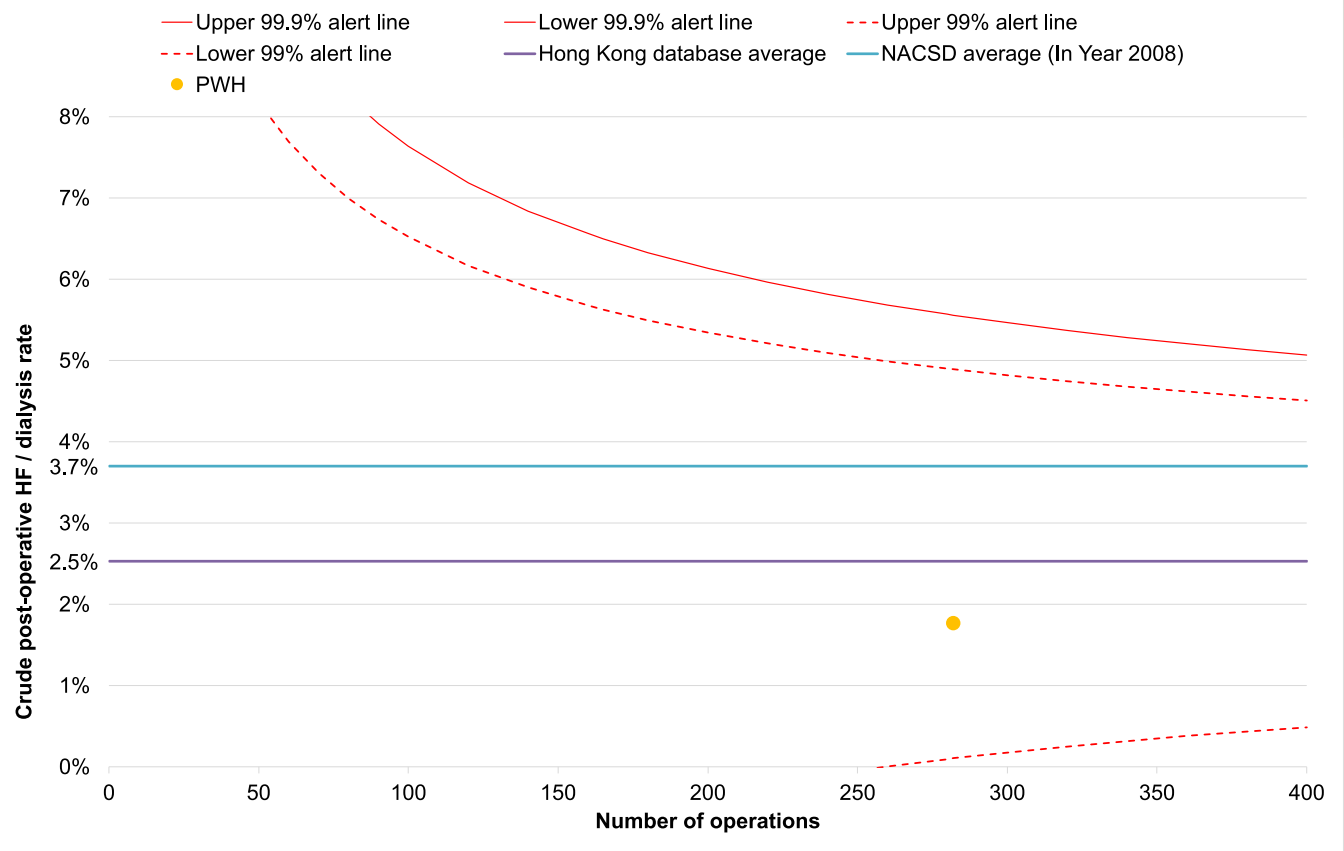


Fig 2.28 Isolated CABG surgery: Crude ***post-operative HF / Dialysis*** rate



Funnel plot of the crude mortality rate for isolated CABG surgery

Fig 2.29a ***Elective*** isolated CABG surgery: Crude ***mortality*** rate

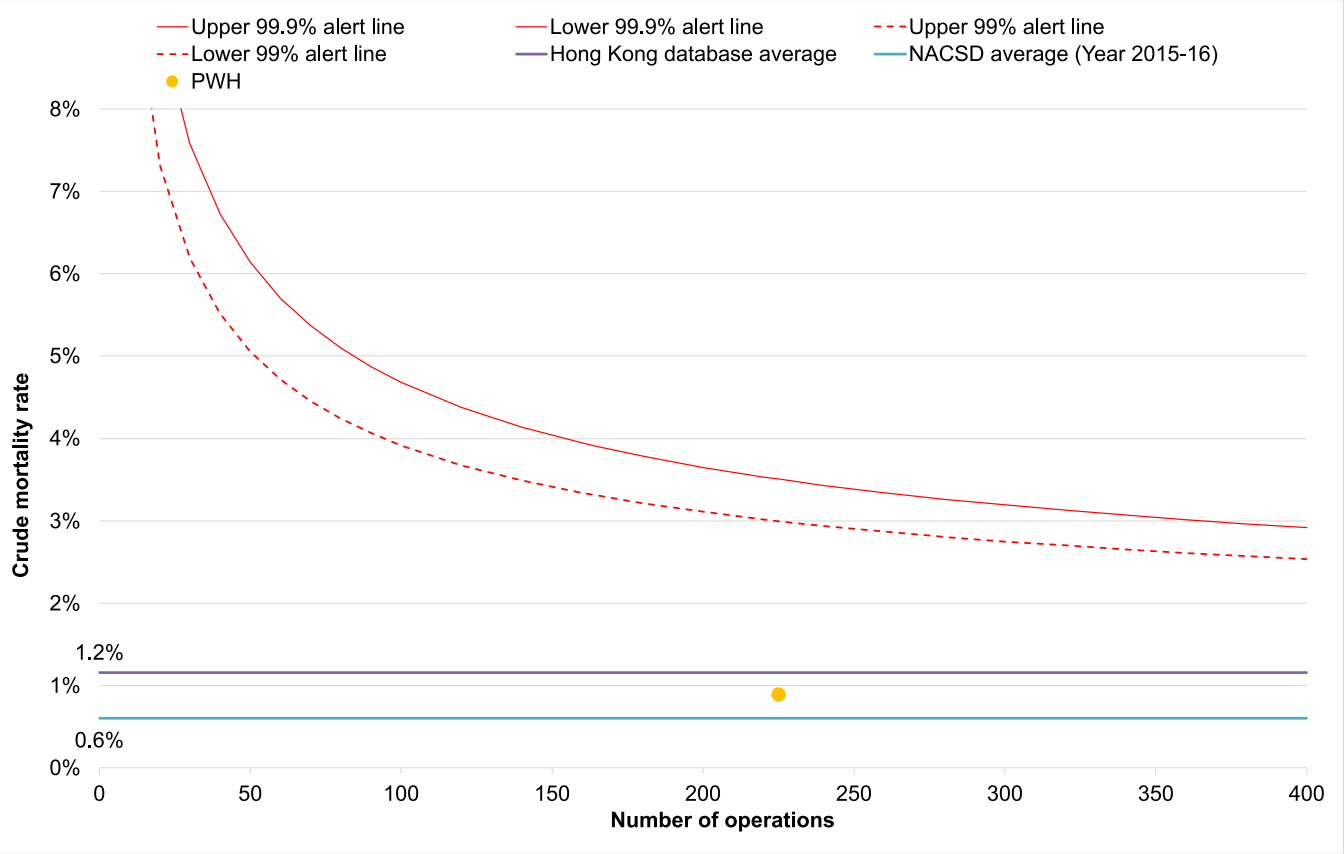


Fig 2.29b ***Urgent*** isolated CABG surgery: Crude ***mortality*** rate

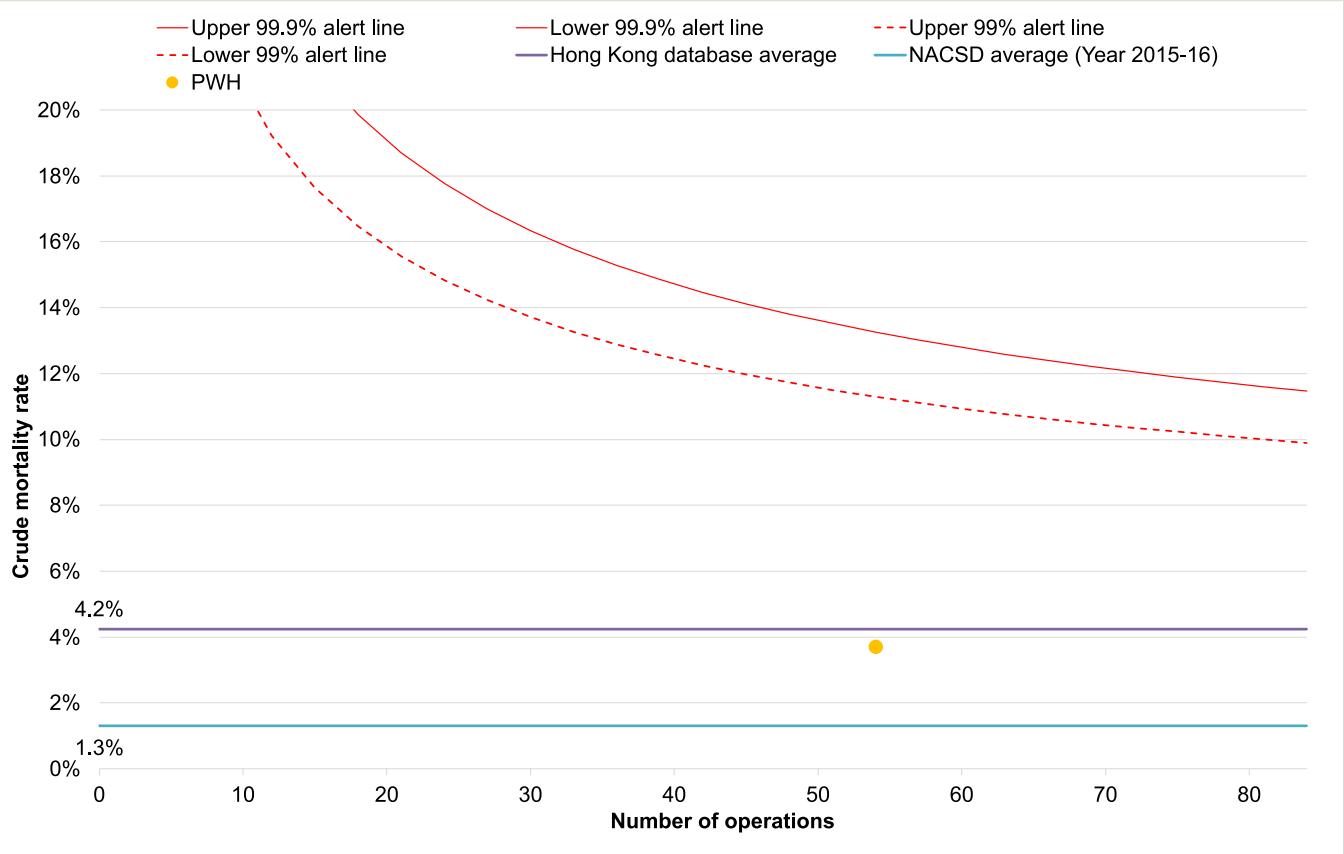
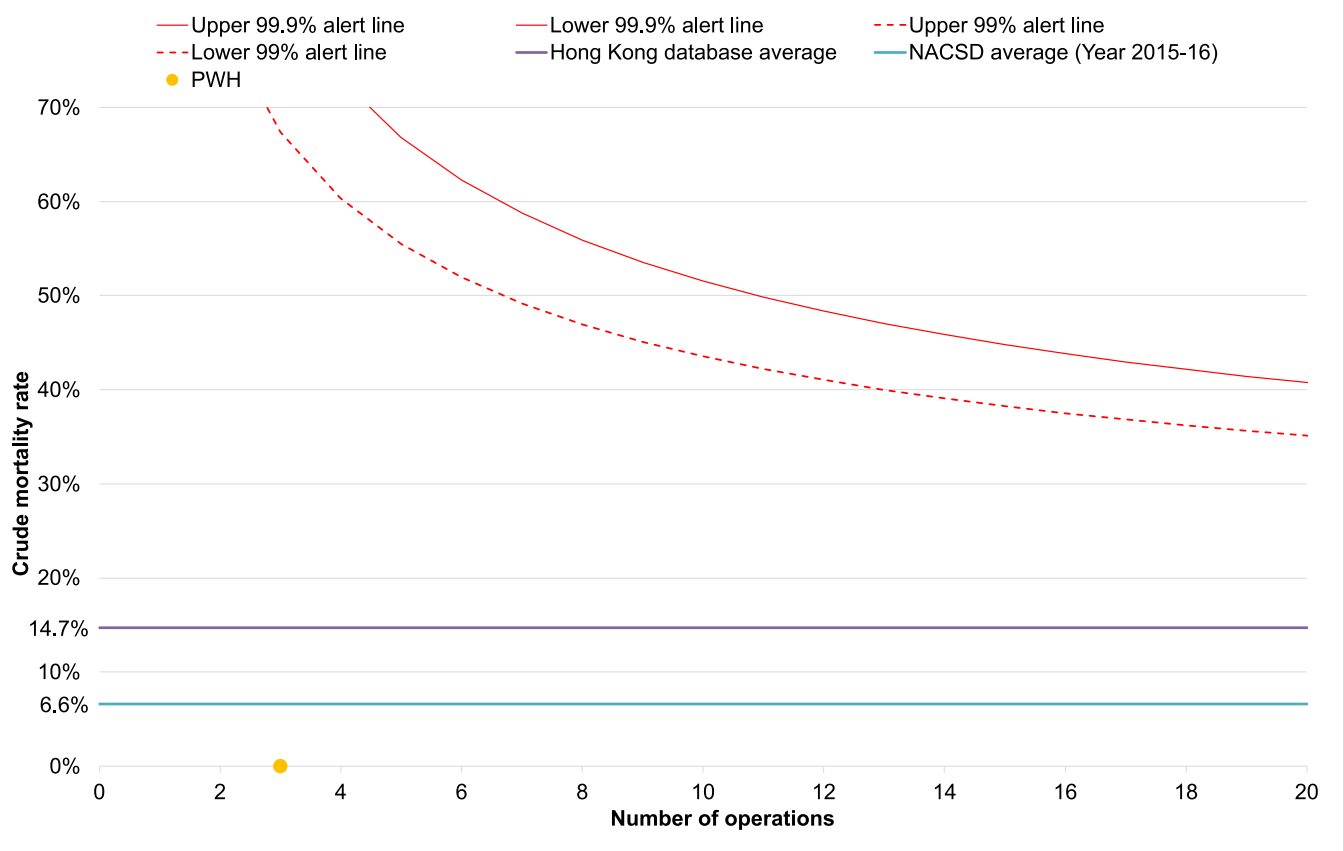
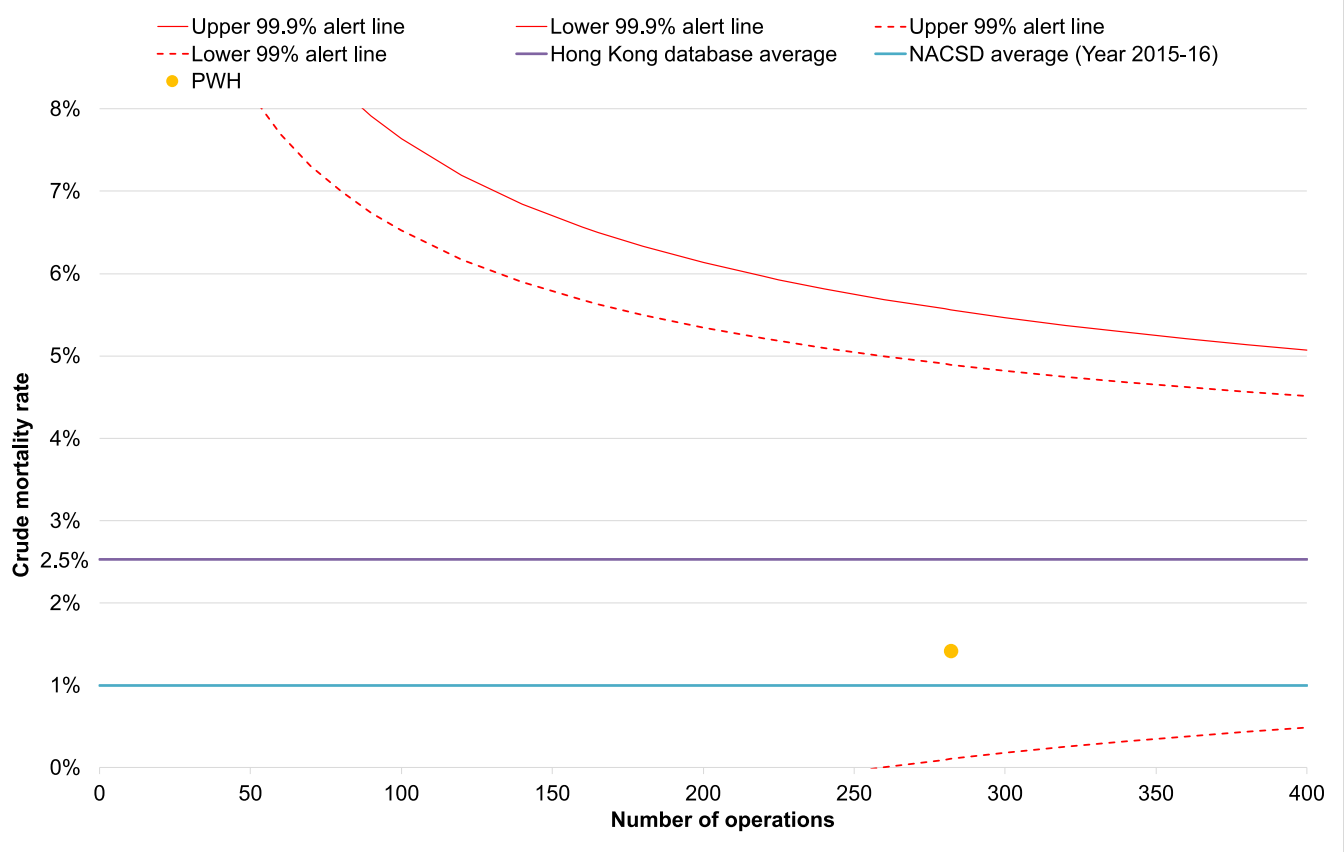


Fig 2.29c ***Emergency*** isolated CABG surgery: Crude ***mortality*** rate

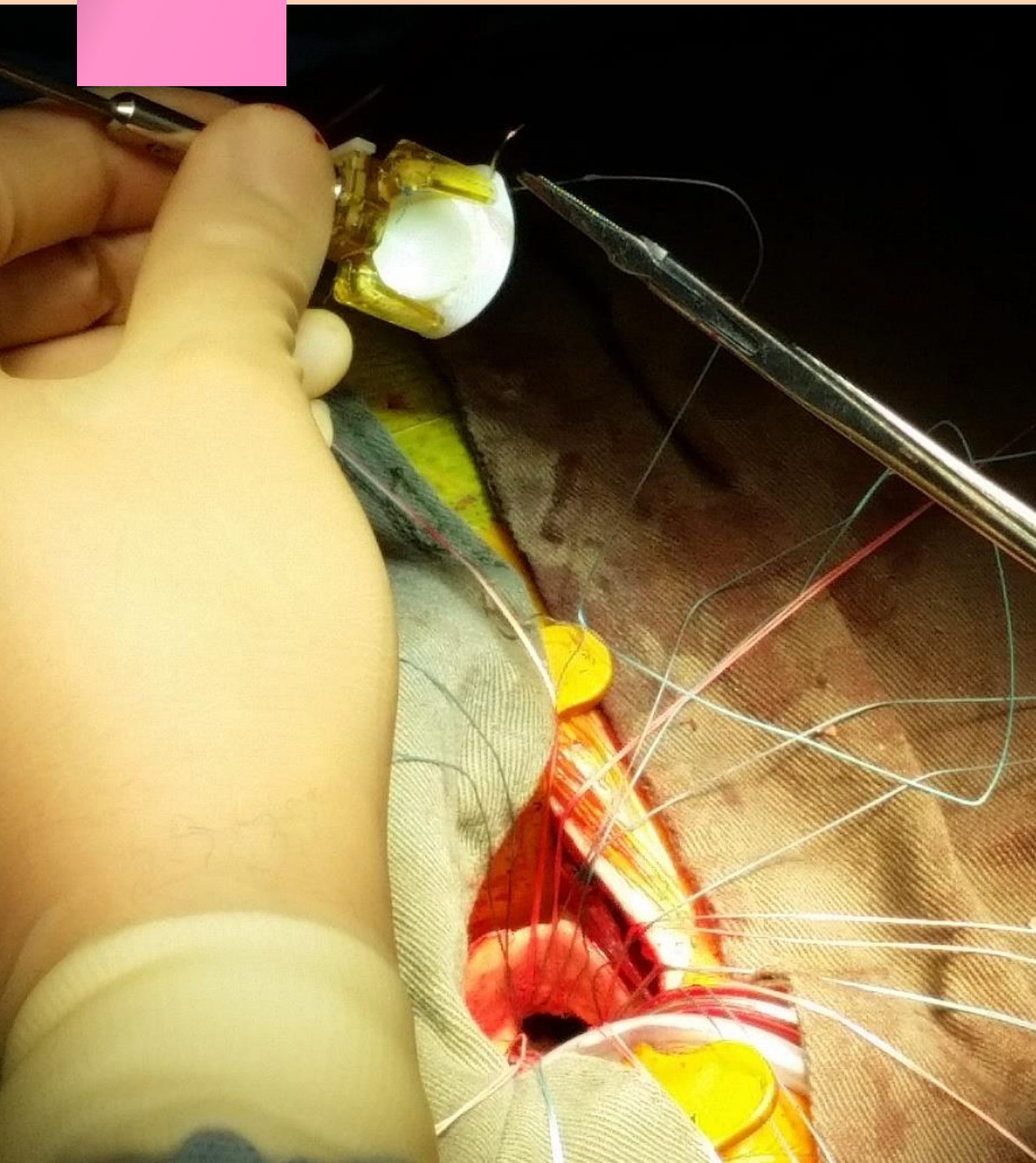


CABG SURGERY

Fig 2.29d ***All*** isolated CABG surgery: Crude ***mortality*** rate



VALVE SURGERY

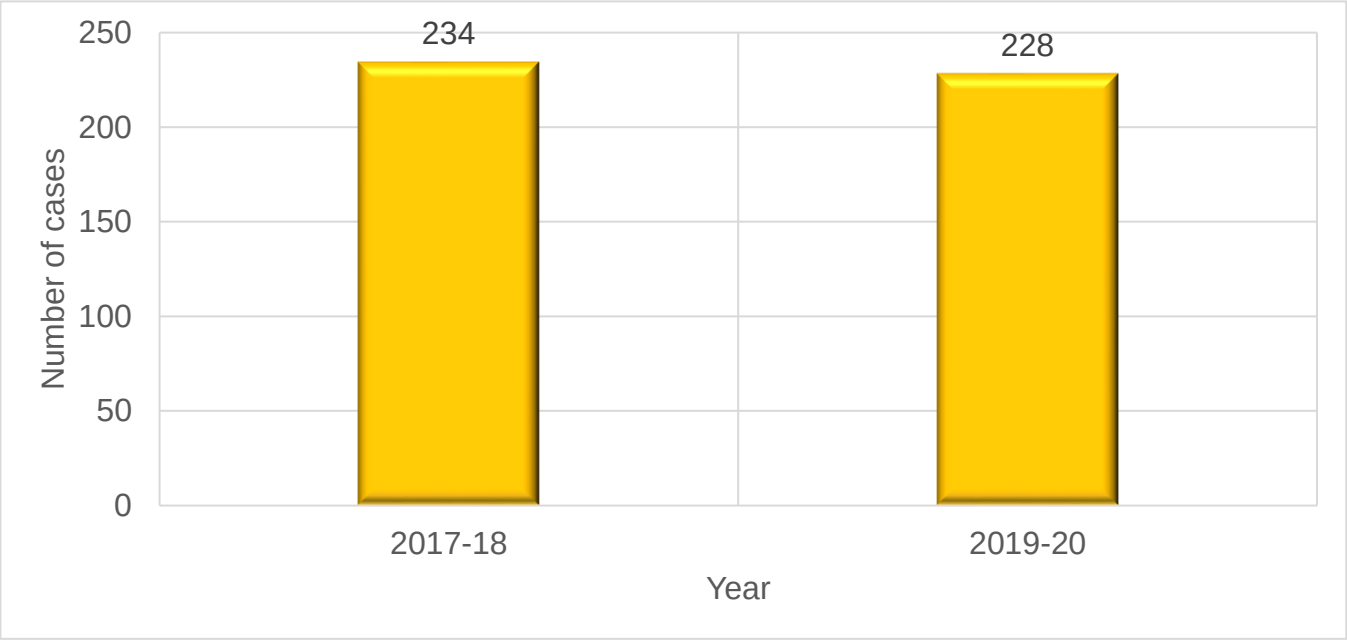


VALVE SURGERY

Isolated valve surgery in the context of the overall workload

- Fig 3.01 shows the number of isolated valve surgeries done between the calendar years 2017 and 2020. There were 228 isolated valve surgeries performed in total during the calendar years 2019 and 2020, which comprised 27% of all cardiac surgical operations at the PWH.
- There were 152 (18%) 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 (PWH: 13%, 2017-2018).

Fig 3.01 Isolated valve surgery at the PWH, 2017-2020



VALVE SURGERY

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 164 isolated single valve operations performed during 2019-2020.
- There were 141 (86%) elective patients who underwent isolated single valve operations at the PWH during 2019-2020.
- There has been a small proportion of patients who undergo isolated valve surgeries as urgent, emergency, or salvage cases. The remaining 23 (14%) were urgent, emergency, or salvage operations at the PWH between 2019 and 2020.

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

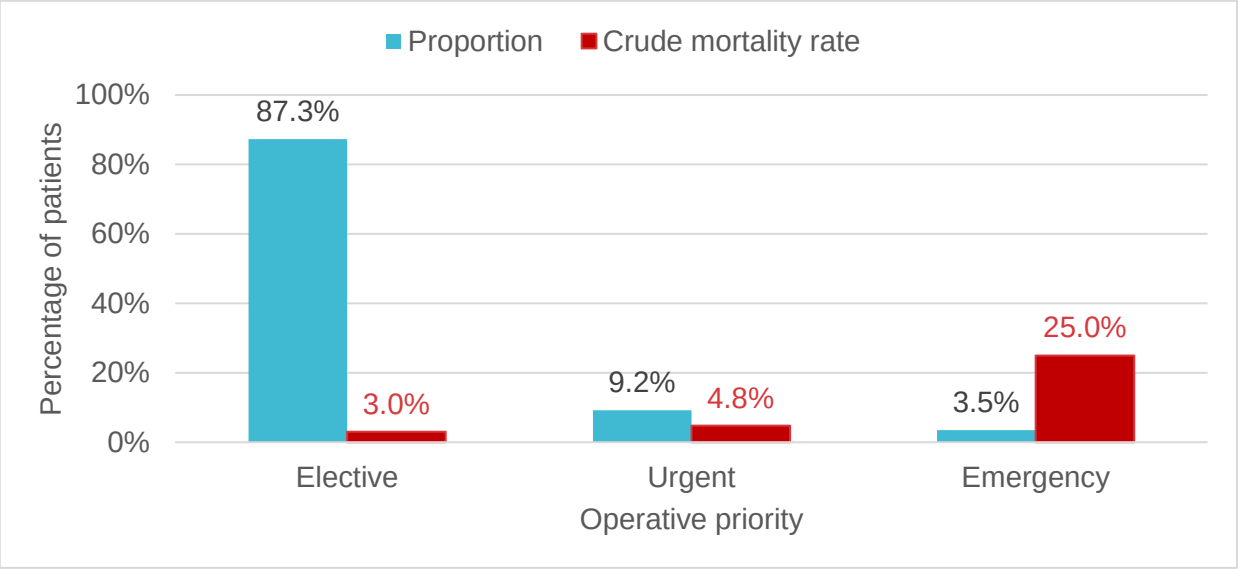


Fig 3.03 Isolated single valve surgery: Operative priority

		Valve treated		
		Aortic alone	**Mitral alone**	**Tricuspid alone**
Priority	**Elective**	64	75	2
	Urgent	7	11	0
	Emergency	2	3	0
	All	73	89	2

VALVE SURGERY

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 (91.7%) isolated single valve procedures were first-time operations at the PWH between 2019 and 2020.
- Among all isolated single valve operations, 14 (8.5%) had previous cardiac operations between 2019 and 2020 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

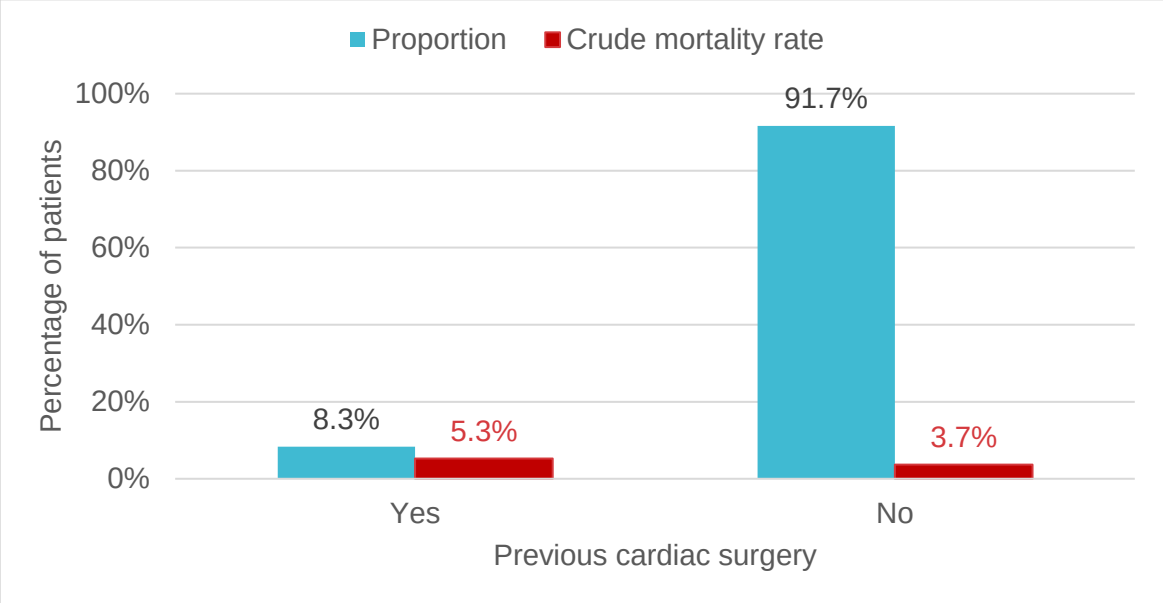


Fig 3.05 Isolated single valve surgery: Previous cardiac surgery

		Valve treated		
		Aortic alone	**Mitral alone**	**Tricuspid alone**
Previous cardiac surgery	**Yes**	8	4	2
	No	65	85	0
	All	73	89	2

VALVE SURGERY

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.
- Almost half of the isolated aortic valve operations, 44% of our case load was for aortic stenosis between 2019 and 2020 at the PWH.
- Among all patients who had isolated mitral valve surgery at the PWH, 67% had mitral regurgitation between 2019 and 2020.
- 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

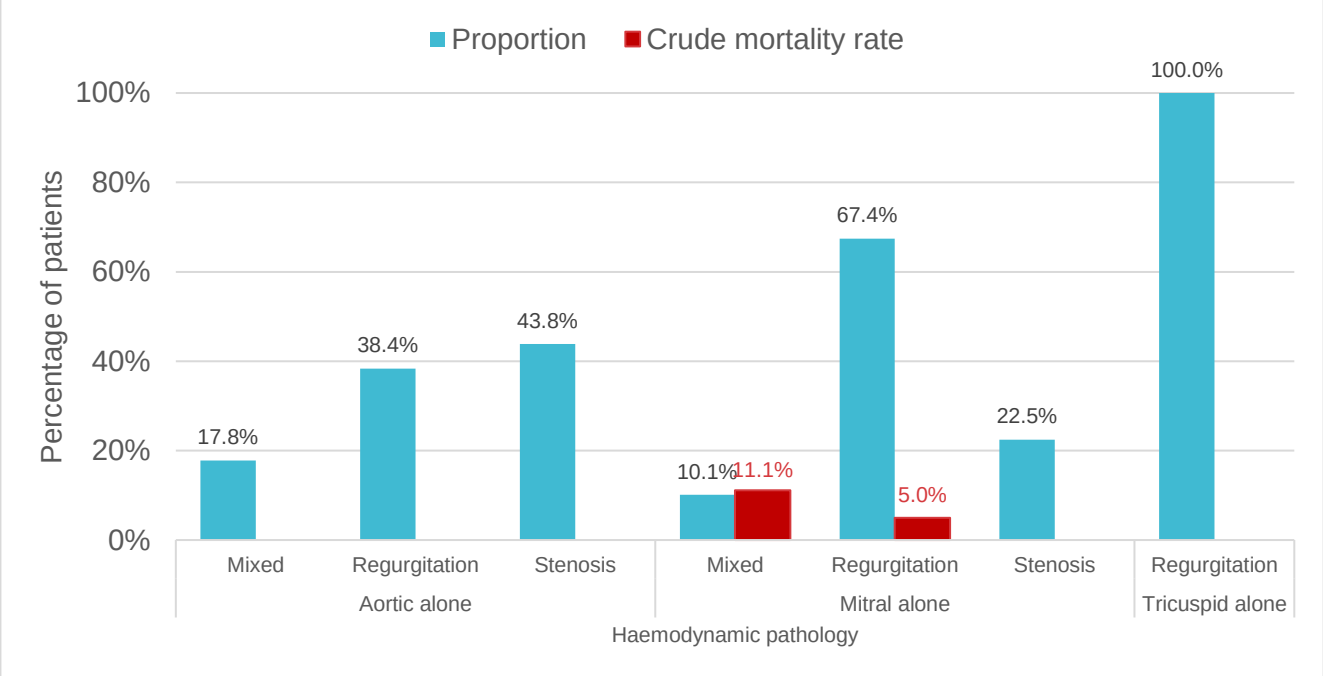


Fig 3.07 Isolated single valve surgery: Haemodynamic pathology

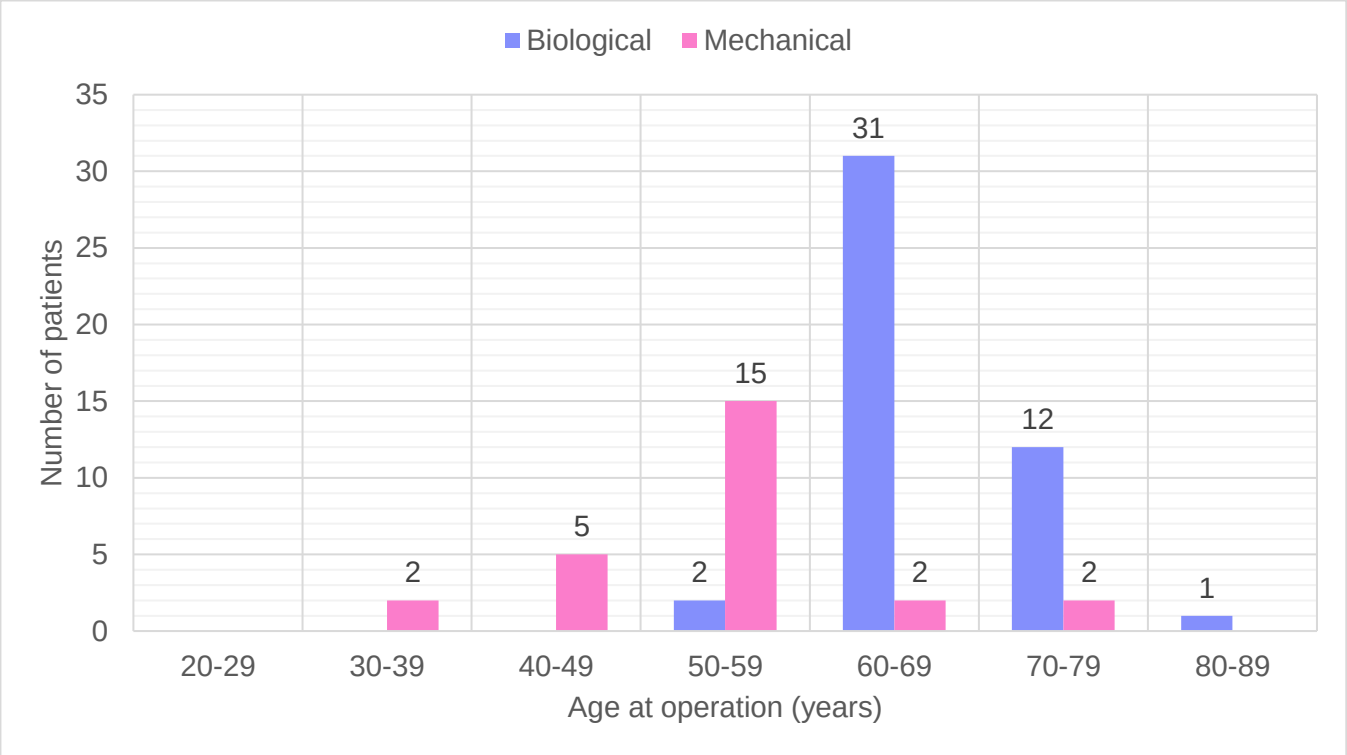
		Valve treated		
		Aortic alone	**Mitral alone**	**Tricuspid alone**
Haemodynamic pathology	**Mixed**	13	9	0
	Regurgitation	28	60	2
	Stenosis	32	20	0
	All	73	89	2

VALVE SURGERY

Aortic valve surgery

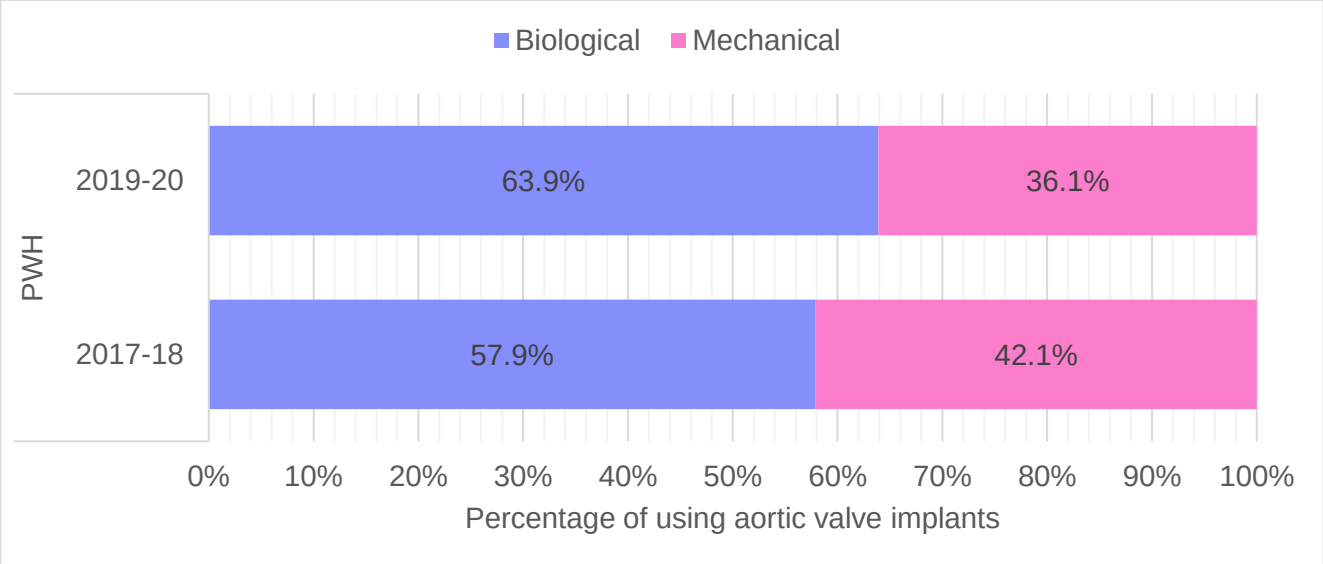
- Fig 3.08 shows the usages of biological and mechanical aortic valve implants according to patient age during the calendar years 2019 and 2020.
- Most (91.7%) of the biological prostheses were implanted in patients above 60 years of age at the PWH.
- The proportion of biological prostheses used for all AVR was 63.9% at the PWH, while that of mechanical prostheses was 36.1% during 2019-2020. The result is close to the figure in the US that bioprosthesis made up 63.6% of aortic valve implants between 2007 and 2011.
- Fig 3.09 shows the two types of aortic valve implant distribution between 2017 and 2020. Compared to the previous reports, 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 improved durability of certain types of biological valves resulting in their use in younger patients and mirrors our findings in our previous report.

Fig 3.08 Isolated valve surgery: Biological and mechanical aortic valve implants, 2019-2020



VALVE SURGERY

Fig 3.09 Isolated valve surgery: Aortic valve implants, 2017-2020



VALVE SURGERY

Native valve pathology

- Fig 3.10 shows the native valve pathology distributions for isolated single valve surgeries.
- The dominant native valve pathology of isolated aortic and mitral valve surgeries was both degenerative between 2019 and 2020
- Chronic rheumatic changes of mitral and tricuspid 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	32	40	0
	Calcific degeneration	13	0	0
	Congenital	11	5	0
	Active infective endocarditis	4	8	0
	Rheumatic	12	29	0
	Other native valve pathology	1	3	0
	Previous infective endocarditis	3	5	0
	Annuloaortic ectasia	0	0	0
	Native valve not present	4	1	0
	Functional regurgitation	0	3	2
	Ischaemic	0	1	0

VALVE SURGERY

Mitral valve surgery

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

- Fig 3.11 shows the haemodynamic pathology distributions for isolated mitral valve surgeries.
- The vast majority of mitral valve repairs and replacements were performed for mitral regurgitation and stenosis respectively.
- Degenerative and rheumatic valve disease were the dominant pathologies seen in patients undergoing isolated mitral valve repair and replacement respectively during 2019-2020.
- 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 Isolated mitral valve surgery: Haemodynamic pathology and valve procedure

		Haemodynamic pathology			
		Stenosis	Regurgitation	Mixed	All
Valve procedure	Replacement	31	22	17	70
	Repair	1	77	2	80
	All	32	99	19	150

VALVE SURGERY

Type of mitral valve repair

- Fig 3.12 shows the type of mitral valve repair at the PWH.
- Most of the isolated mitral valve repairs were complex operations, involving two or more repair procedures.
- Most (95.0%) of mitral valve repairs had ring annuloplasty between 2019 and 2020.
- Artificial chordal implantation was the second most popular technique (72.5%) in mitral valve repair surgery following annuloplasty.

Fig 3.12 Isolated valve surgery: Type of mitral valve repair

		Count	Proportion
Type of mitral valve repair	Annuloplasty (ring)	76	95.0%
	Artificial chord	58	72.5%
	Leaflet resection	0	0.0%
	Other	3	3.8%
	Annuloplasty (suture)	0	0.0%
	Leaflet patch	13	16.3%
	Commisurotomy	4	5.0%

VALVE SURGERY

Tricuspid valve surgery

Tricuspid valve repair in the context of all tricuspid valve surgeries

- Fig 3.13 shows the isolated tricuspid valve surgical outcomes.
- There were 43 (19%) of all isolated valve(s) surgeries involving tricuspid valve procedures between 2019 and 2020 at the PWH, which is consistent with the figures in the preceding report.
- Isolated single tricuspid valve surgery (2) was rare between 2019 and 2020. The tricuspid valve may occasionally need repair by annuloplasty in conjunction with mitral valve surgery. Hence, the tricuspid valve rarely requires surgery as an isolated procedure alone. On average, fewer than 60 cases of isolated tricuspid valve surgery per annum were reported in the UK.
- Tricuspid valve repair was mainly for regurgitations between 2019 and 2020.

Fig 3.13 Isolated valve surgery: Tricuspid valve repair and replacement

		Tricuspid valve surgery		
		Repair	Replacement	All
Valve procedure	Tricuspid alone	1	1	2
	Tricuspid plus another valve	37	4	41
	All that include tricuspid valve surgery	38	5	43

VALVE SURGERY

Logistic EuroSCORE and the crude mortality rate

The overall mortality rate for 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 4.1% in 2019-2020 (HK: 5%, 2017-2018).
- Fig 3.14 shows the O/E ratios of isolated single valve surgeries at the PWH. Predominant isolated single valve surgery was isolated mitral valve surgery at the PWH between 2019 and 2020.
- Fig 3.15 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 EursoSCORE, 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 mortality reported was 1.7% (predicted mortality was 7.9%) and the O/E ratio was 0.22 approximately. Similarly, the 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 mortality reported for *isolated tricuspid valve* surgery was less than 10% in the UK in 2011-2016 (PWH: 0.0%, 2019-2020 vs the UK: <10%, 2011-2016).

The proportion of patients by logistic EuroSCORE distribution

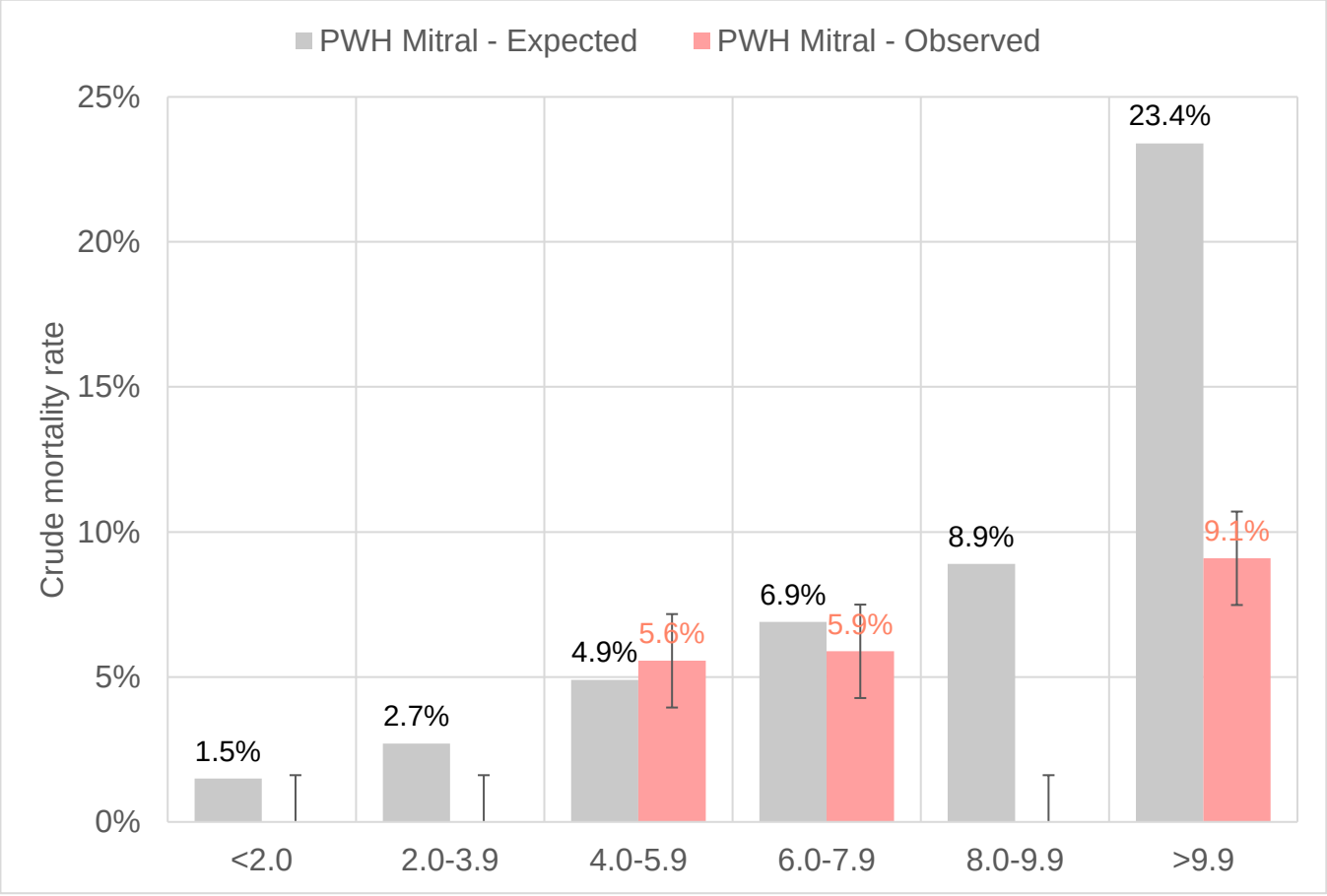
- Fig 3.16 shows the proportions of patients having isolated aortic, mitral, and tricuspid valve surgeries according to their logistic EuroSCORE at the PWH.
- Between 2019 and 2020, most patients who underwent isolated aortic and mitral valve surgeries had logistic EuroSCORE ranging from 2.0 to 3.9 (26.0%) and greater than 9.9 (24.7%) respectively.
- 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.

VALVE SURGERY

Fig 3.14 Isolated ***single valve*** surgery: Mortality data and O/E ratio

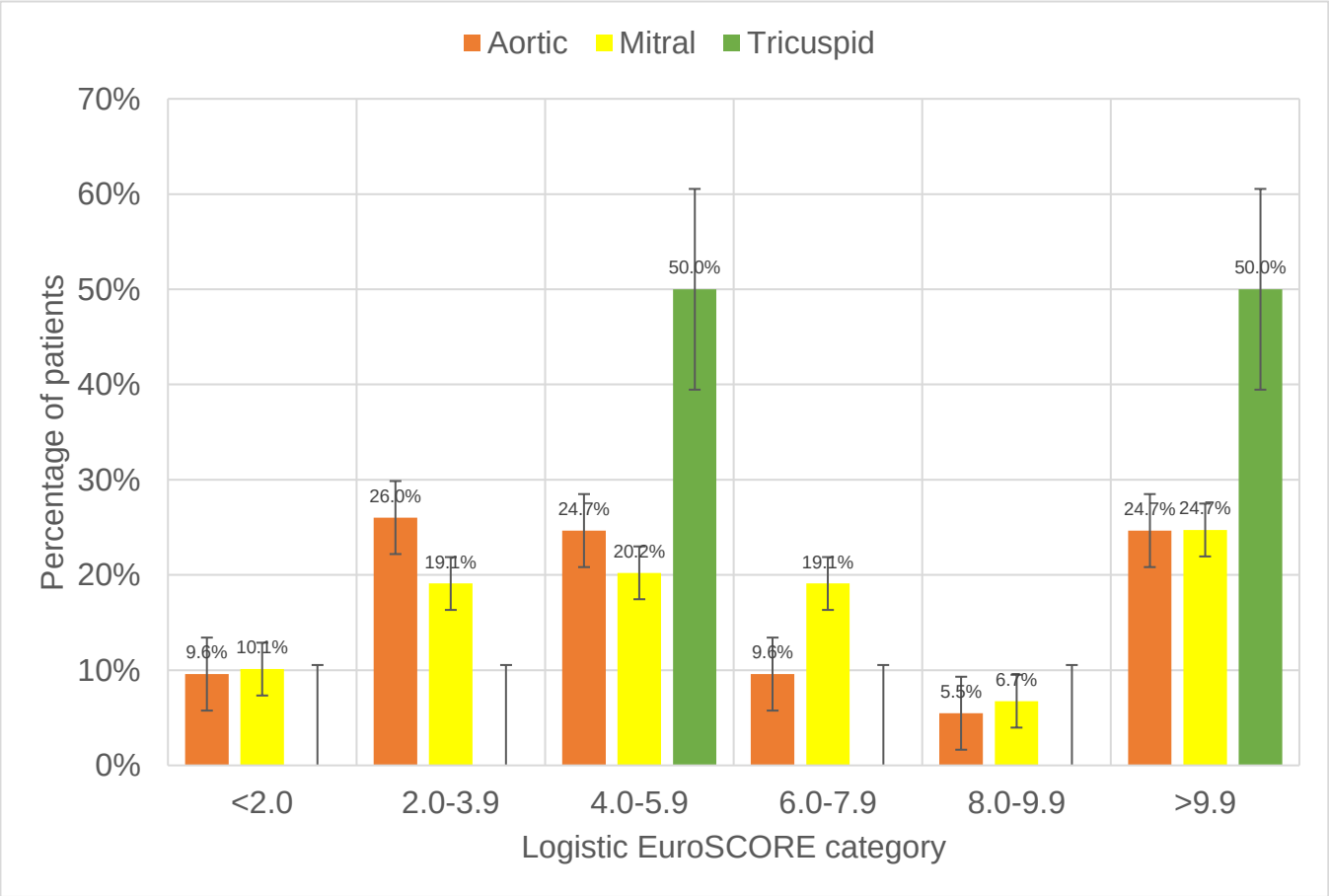
		Count		Mortality		
		All	Deaths	Observed (O)	Expected (E)	O/E Ratio
Valve treated	Aortic alone	73	0	0.0%	10.2%	0.00
	Mitral alone	89	4	4.5%	9.4%	0.48
	Tricuspid alone	2	0	0.0%	8.3%	0.00

Fig 3.15 Isolated ***mitral valve*** surgery: Observed mortality and expected logistic EuroSCORE



VALVE SURGERY

Fig 3.16 Isolated ***valve*** surgery: Proportion of patients at the PWH by logistic EuroSCORE



VALVE SURGERY

Logistic EuroSCORE and the crude mortality rate

The overall mortality rate for isolated multiple valves surgery

- In this section, isolated multiple valve surgeries include combined mitral and tricuspid valve surgeries, combined aortic and mitral valve surgeries, and combined aortic, mitral, and tricuspid surgeries.
- Fig 3.17 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 2019 and 2020.

Fig 3.17 Isolated ***multiple valves*** surgery: Mortality data and O/E ratio

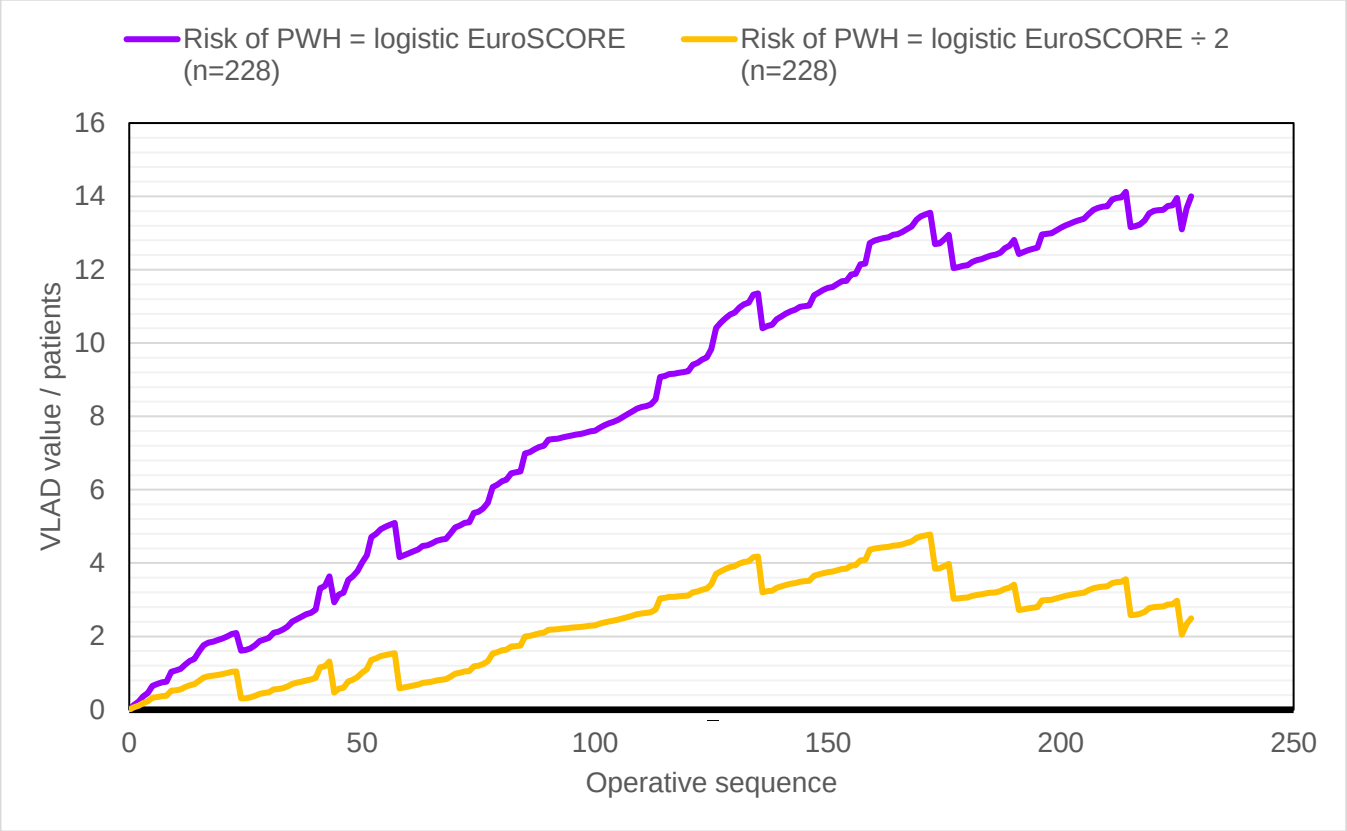
		Count		Mortality		
		All	Deaths	Observed (O)	Expected (E)	O/E Ratio
Valve treated	Mitral & tricuspid	33	4	12.1%	12.8%	0.95
	Aortic & mitral	23	0	0.0%	7.2%	0.00
	Aortic & tricuspid	3	0	0.0%	12.3%	0.00
	Aortic, mitral & tricuspid	5	1	20.0%	15.6%	1.28

VALVE SURGERY

VLAD plot for isolated valve surgery

- Fig 3.18 shows the VLAD plot for isolated valve surgical outcomes using the EuroSCORE and EuroSCORE÷2 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, almost 14 extra lives had been saved for the isolated valve group at the PWH.

Fig 3.18 Isolated valve surgery: VLAD plot at the PWH



VALVE SURGERY

Other immediate post-operative outcomes

- Fig 3.19 to Fig 3.21 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 3.19), **post-operative stroke** rate (Fig 3.20), and **new haemofiltration / dialysis** rate (Fig 3.21). Fig 3.22 to Fig 3.24 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 2019-2020.
- These three key outcomes at the PWH fall comfortably within the control limits, showing satisfactory quality.

Re-operation for bleeding

Fig 3.19 Isolated valve surgery: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	**Count**	10	218
	Proportion	4.4%	95.6%
	Dead	3	6
	Crude mortality rate	1.3%	2.6%

Post-operative stroke

Fig 3.20 Isolated valve surgery: New post-operative stroke

		Yes	No
New post-operative stroke	**Count**	3	225
	Proportion	1.3%	98.7%
	Dead	1	8
	Crude mortality rate	0.4%	3.5%

VALVE SURGERY

Post-operative HF / dialysis

Fig 3.21 Isolated valve surgery: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	**Count**	6	222
	Proportion	2.6%	97.4%
	Dead	5	4
	Crude mortality rate	2.2%	1.8%

Funnel plots for other immediate post-operative outcomes in isolated valve surgery

Fig 3.22 Isolated valve surgery: Crude ***re-operation for bleeding*** rate

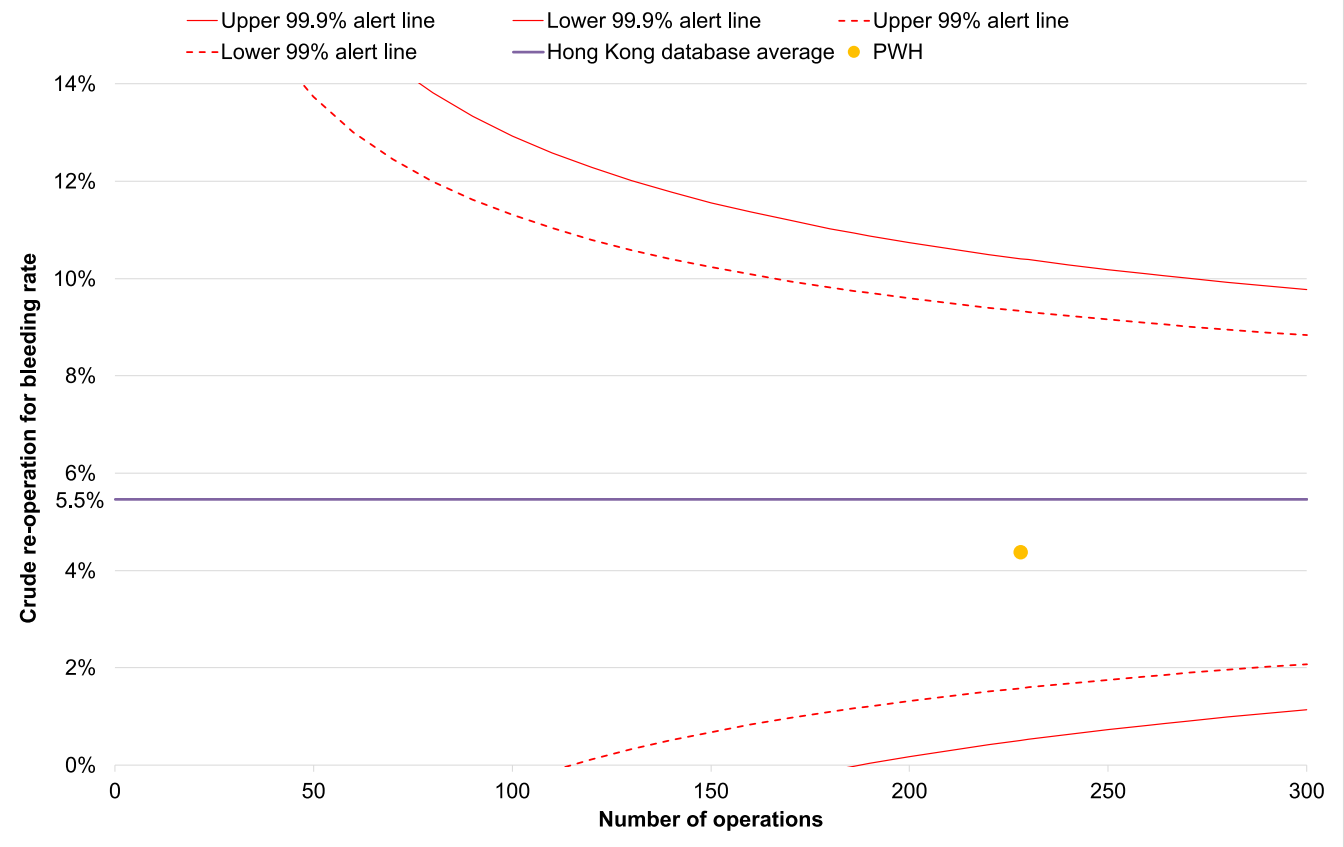


Fig 3.23 Isolated valve surgery: Crude ***post-operative stroke*** rate

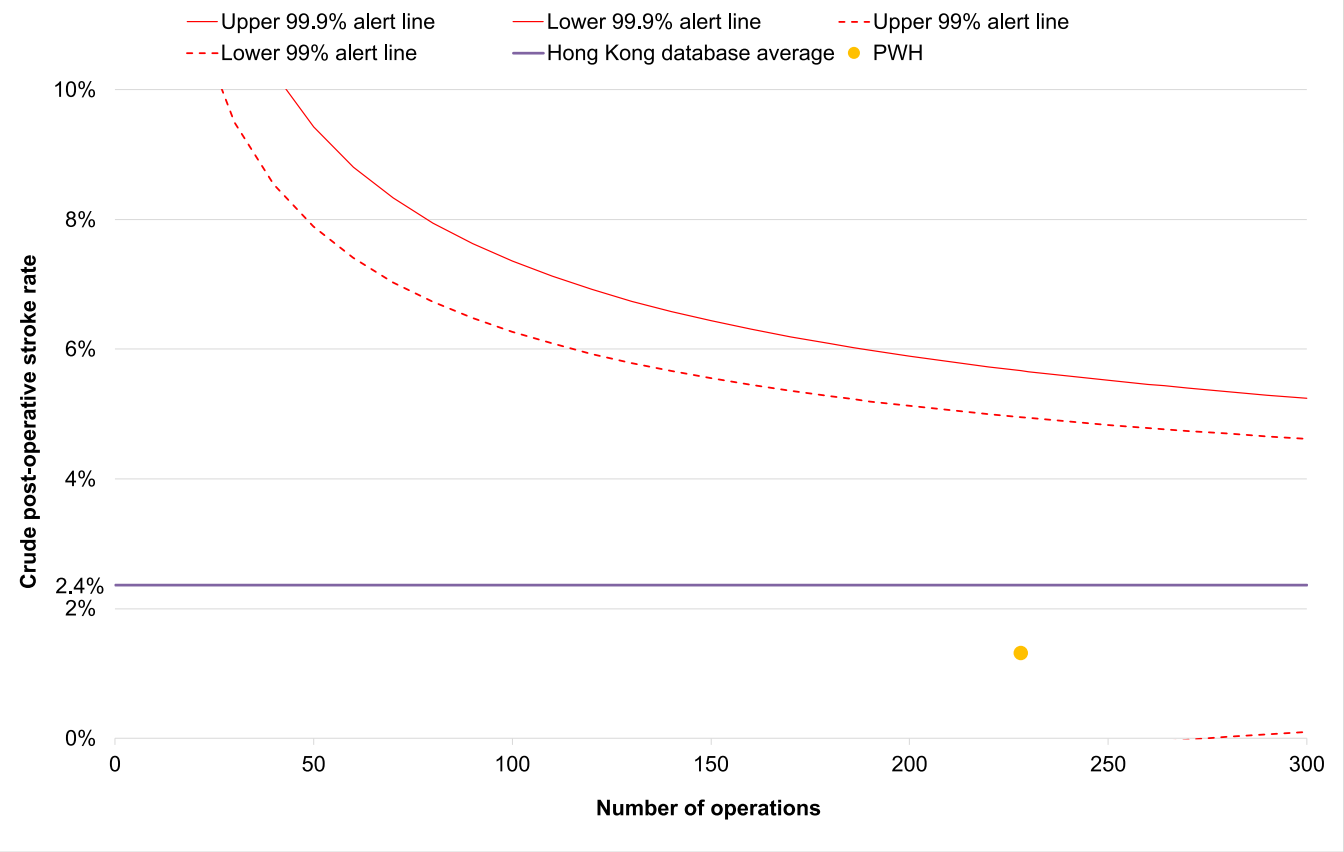
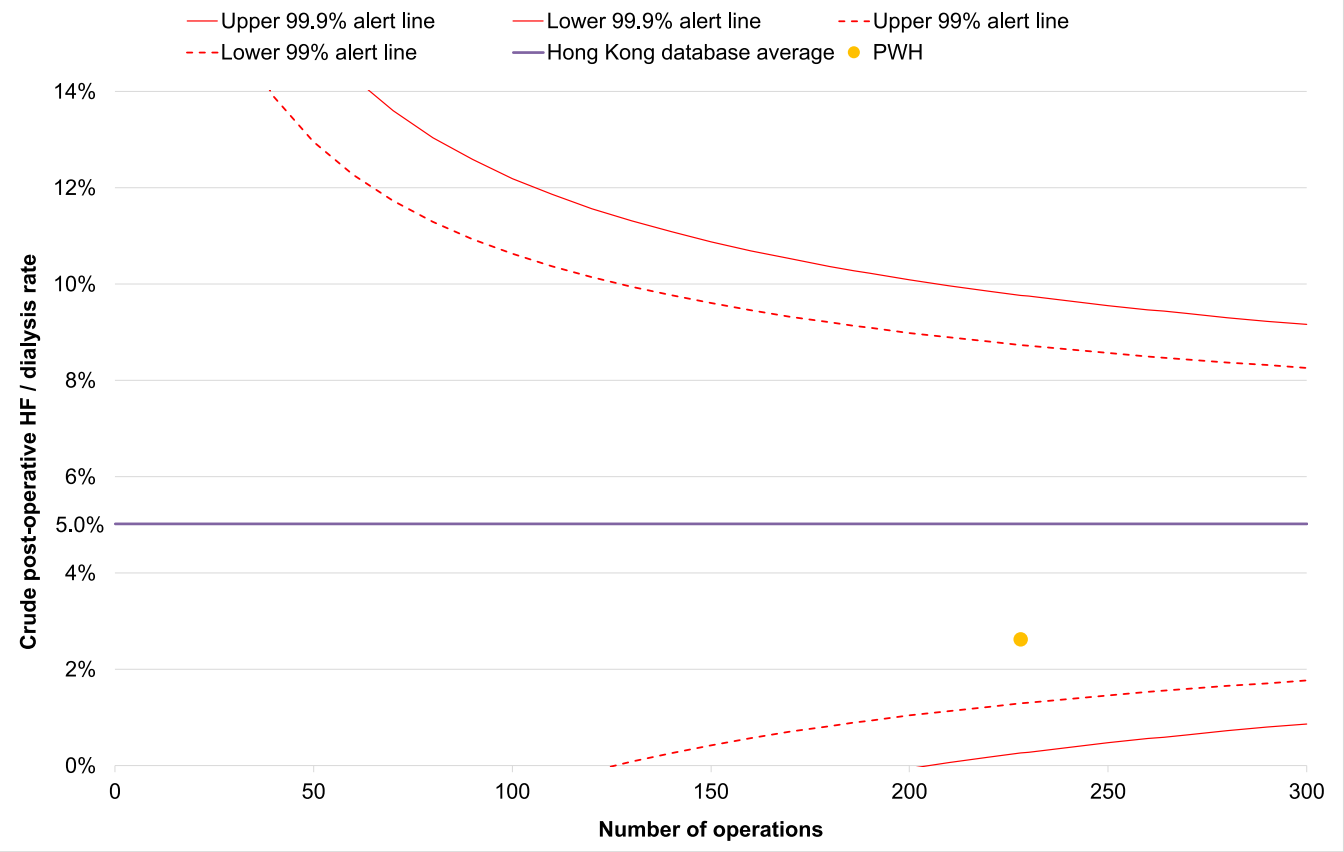


Fig 3.24 Isolated valve surgery: Crude ***post-operative HF / Dialysis*** rate



VALVE SURGERY

Funnel plot of the crude mortality rate for isolated valve surgery

Isolated valve, isolated aortic valve replacement, and isolated mitral valve surgery

- Fig 3.25 to Fig 3.27 show the funnel plots for the mortality of the isolated valve, isolated aortic valve replacement, 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 2019-2020. The ***light purple*** horizontal line represents the average data from all cardiac units in Hong Kong during 2019-2020. The ***light blue*** horizontal line is served as a reference on the chart, which represents the average of the data in the United Kingdom NACSD during the period 2004-2016.
- The results of these three funnel plots demonstrated that the crude mortality rate at the PWH fell within the alert lines between 2019 and 2020, 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.
- For the isolated aortic valve replacement surgery, the improvements seen in the UK during 2015-2016 were less pronounced than at the PWH during the period 2019–2020.

Fig 3.25 ***Isolated valve*** surgery: Crude ***mortality*** rate

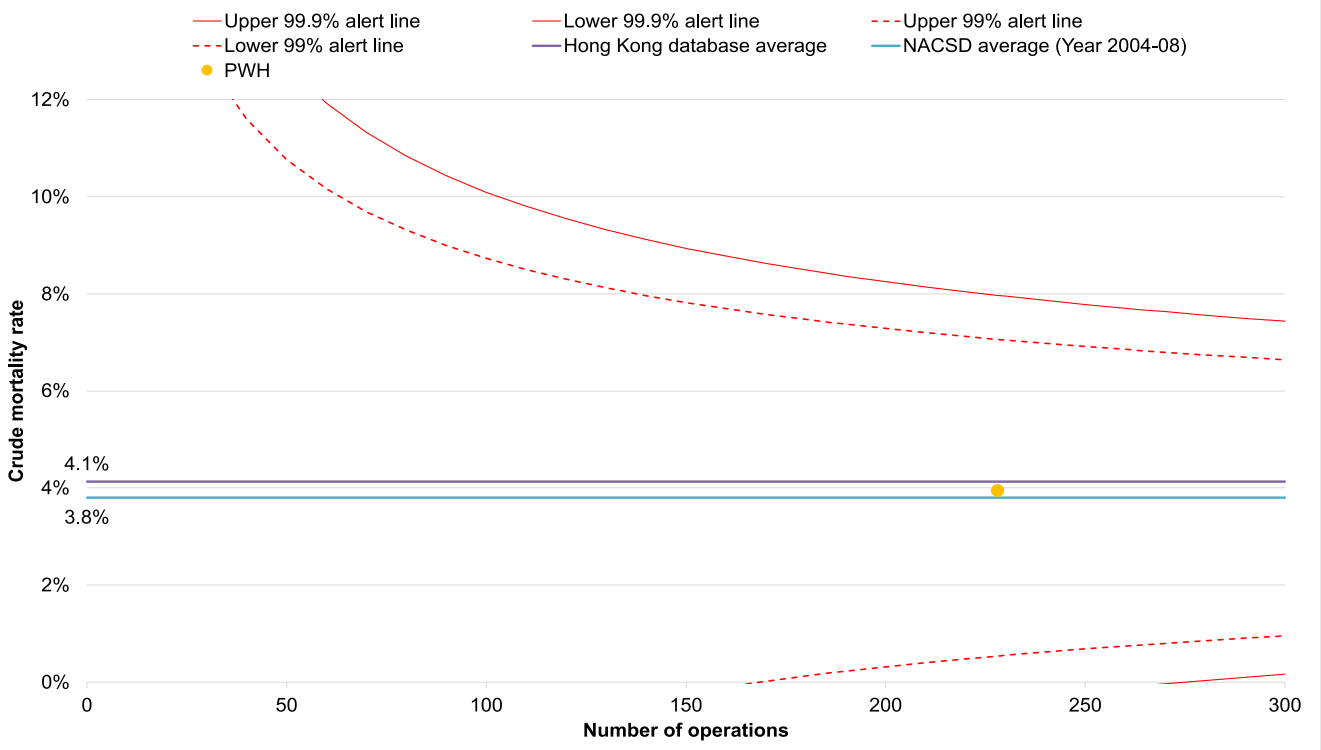


Fig 3.26 ***Isolated aortic valve replacement*** surgery: Crude ***mortality*** rate

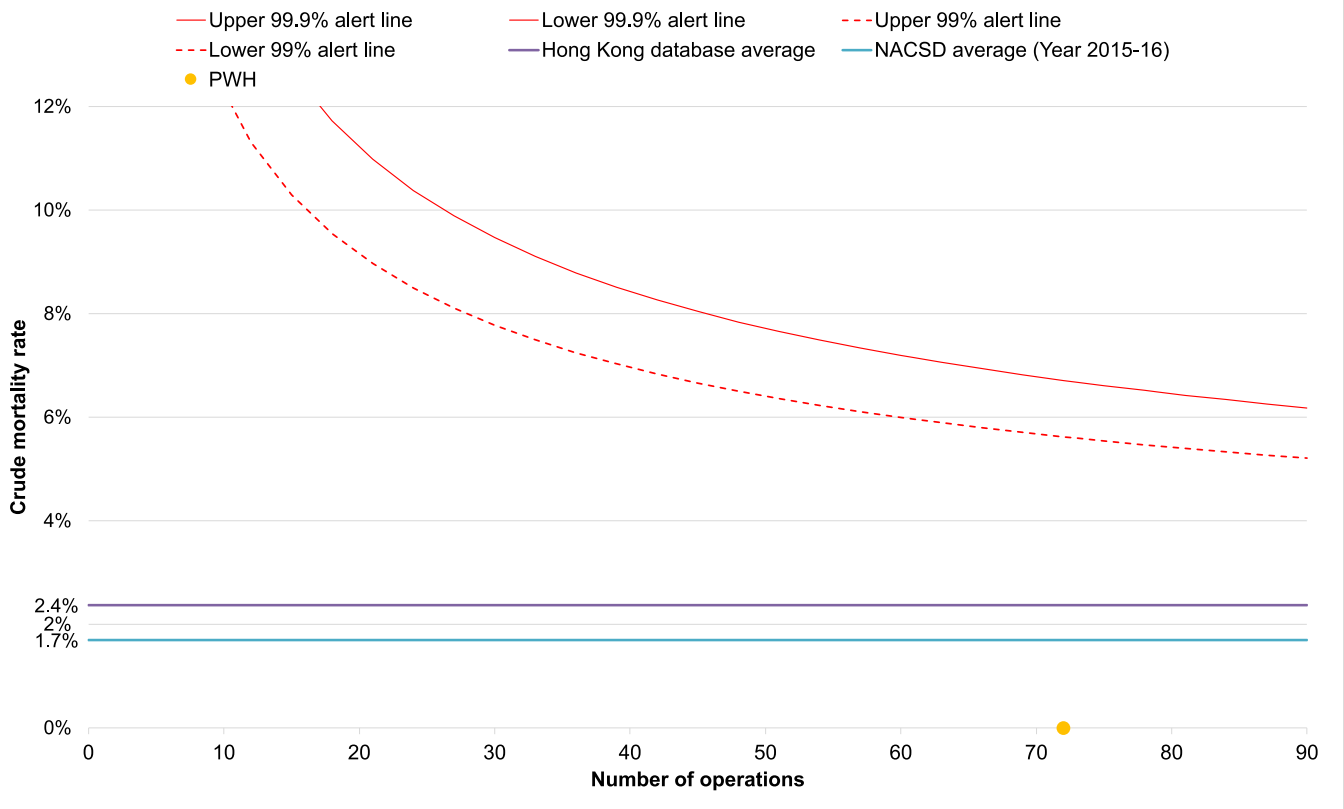
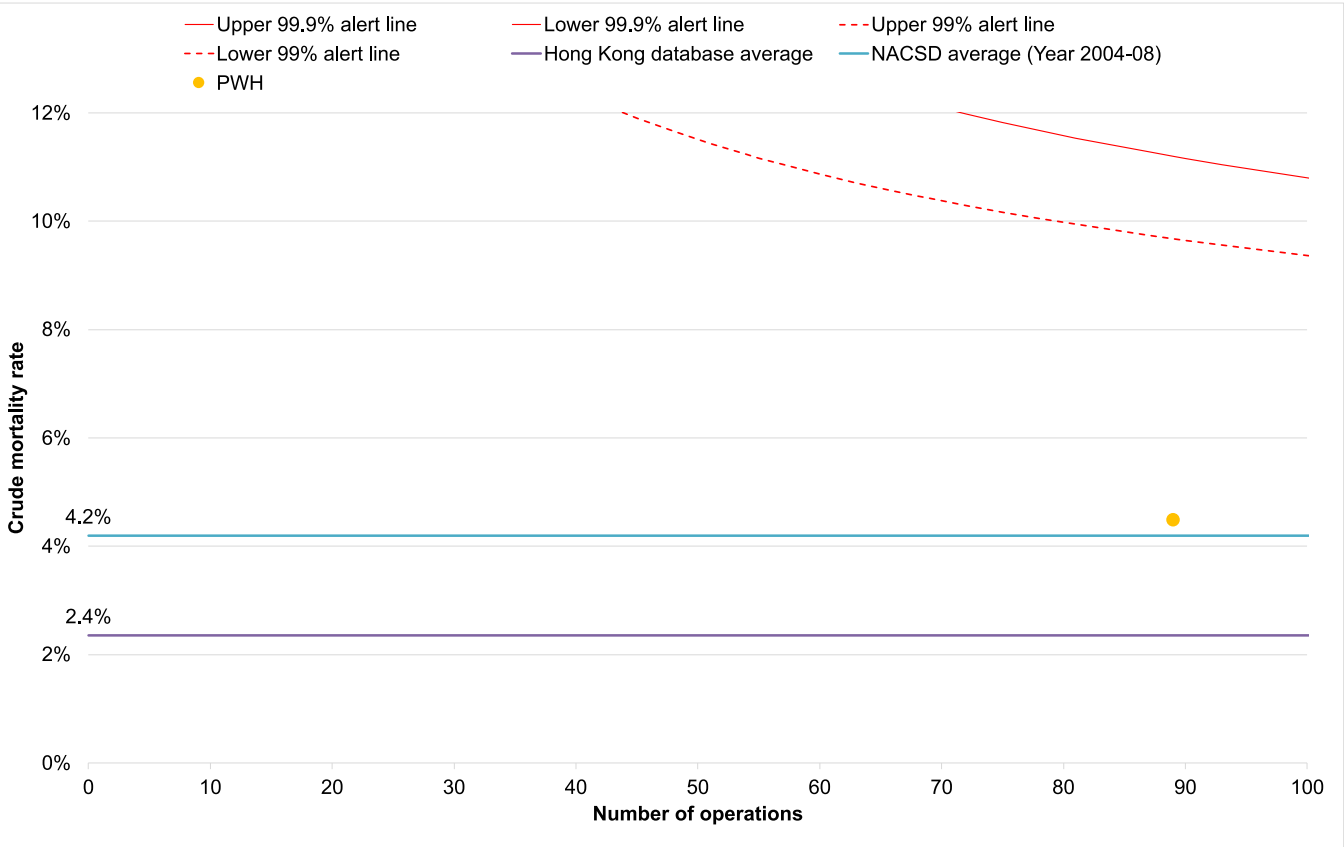


Fig 3.27 ***Isolated mitral valve*** surgery: Crude ***mortality*** rate



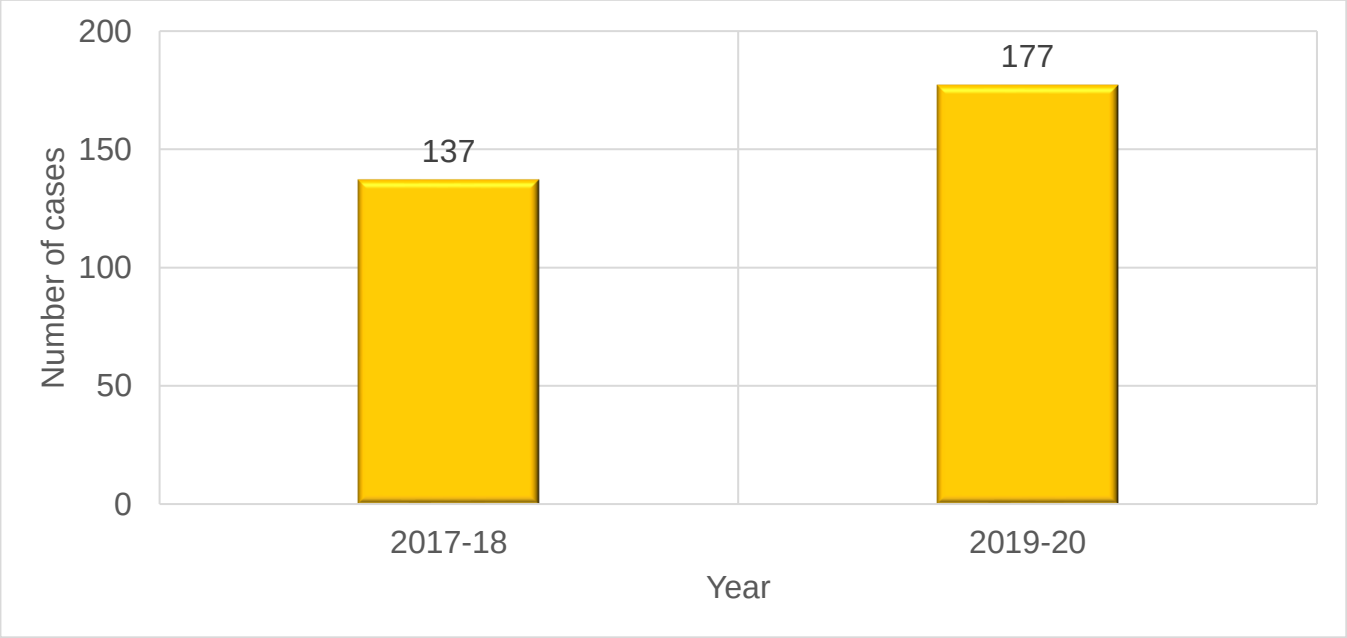
SURGERY ON THE AORTA

SURGERY ON THE AORTA

Surgery on the aorta 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 pre-dominated by emergency aortic procedures. However, we think it is still an important category to give us some idea of performance, whilst taking into account the caution required in applying statistical analysis.
- Fig 4.01 shows the number of surgeries done on the aorta between the calendar years 2017 and 2020. 177 procedures in total fell into this category during the calendar years 2019 and 2020.
- Surgery on the aorta made up 21% of all cardiac surgeries between 2019 and 2020 at the PWH. The proportion of surgery on the aorta for the PWH has remained steady, maintaining the increase of 2017-2018 (PWH: 19%, 2017-2018 vs the UK: 3.47%, 2015-2016).

Fig 4.01 Surgery on the aorta at the PWH, 2017-2020



SURGERY ON THE AORTA

Number and details of segments treated for surgery on the aorta

- Fig 4.02 shows the segment details treated for surgeries on the aorta at the PWH.
- Between 2019 and 2020, there were 36 (20%) 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 (PWH: 44%, 2019-2020).
- The isolated descending aorta was the second most common site for aortic surgeries at the PWH.
- Open repair of the ruptured ***descending*** aorta has become a routine operation over time.
- The logistic EuroSCORE (22.5%) and crude mortality rate (0/39=0.0%) were reported for the isolated descending aortic (descending) surgery.

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	7	2	2	11
		Ascending	7	6	5	60	78
		Arch	0	0	0	13	13
		Descending	0	0	0	39	39
	2	Root & ascending	0	7	1	5	13
		Ascending & arch	1	0	0	5	6
		Ascending & Descending	0	0	0	0	0
		Descending & abdominal	0	0	0	3	3
		Descending & arch	0	0	0	4	4
	3	Root, ascending & arch	0	0	0	0	0
		Ascending, arch & descending	2	0	0	6	8
		Root, ascending & descending	0	0	0	0	0
	4	Root, ascending, arch & descending	0	1	0	1	2
		All	10	21	8	138	177

SURGERY ON THE AORTA

Pathology and arterial cannulation for surgeries on the aorta

- 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 (45%).
- 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 (113/145), which is particularly useful in emergency situations with haemodynamically unstable patients.

Fig 4.03 Surgery on the aorta: Pathophysiology at the PWH

		Count
Pathophysiology	Aneurysm	49
	Dissection	79
	Aneurysm and Dissection	29
	Others	20
	Patient count	177

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

		Count
Arterial cannulation	Ascending aorta	24
	Arch	5
	Axillary/subclavian	1
	Femoral	113
	Others	2
	Patient count	145

SURGERY ON THE AORTA

Logistic EuroSCORE and the crude mortality rate

Overall expected logistic EuroSCORE distribution for the major aortic surgery

- The crude mortality was 9.8% for Hong Kong overall (HK: 9.8% in 2019-2020 vs HK: 12.1% in 2017-2018 & the UK: 8.9% in 2015-2016). The predicted mortality (logistic EuroSCORE) as a percentage was 20.4% (HK: 19.2% in 2017-2018).
- Fig 4.05 shows the observed and expected mortality of major aortic surgery at the PWH.
- Overall observed and expected mortality rates were 5.1% and 22.3% at the PWH respectively. The O/E ratio was 0.23 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 6.9% in this high-risk group, which was less than the expected mortality rate of 27.7%. Most surgeries in this group were emergent or salvage procedures.

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

	Logistic EuroSCORE category						Operative priority		
	<2.0	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.9	>9.9	Elective	Non-elective	All
Count	0	1	14	11	20	131	75	102	177
Dead	0	0	0	0	0	9	2	7	9
Observed mortality rate	0.0%	0.0%	0.0%	0.0%	0.0%	6.9%	2.7%	6.9%	5.1%
Expected mortality rate	0.0%	2.7%	4.8%	6.8%	8.8%	27.7%	18.4%	25.2%	22.3%

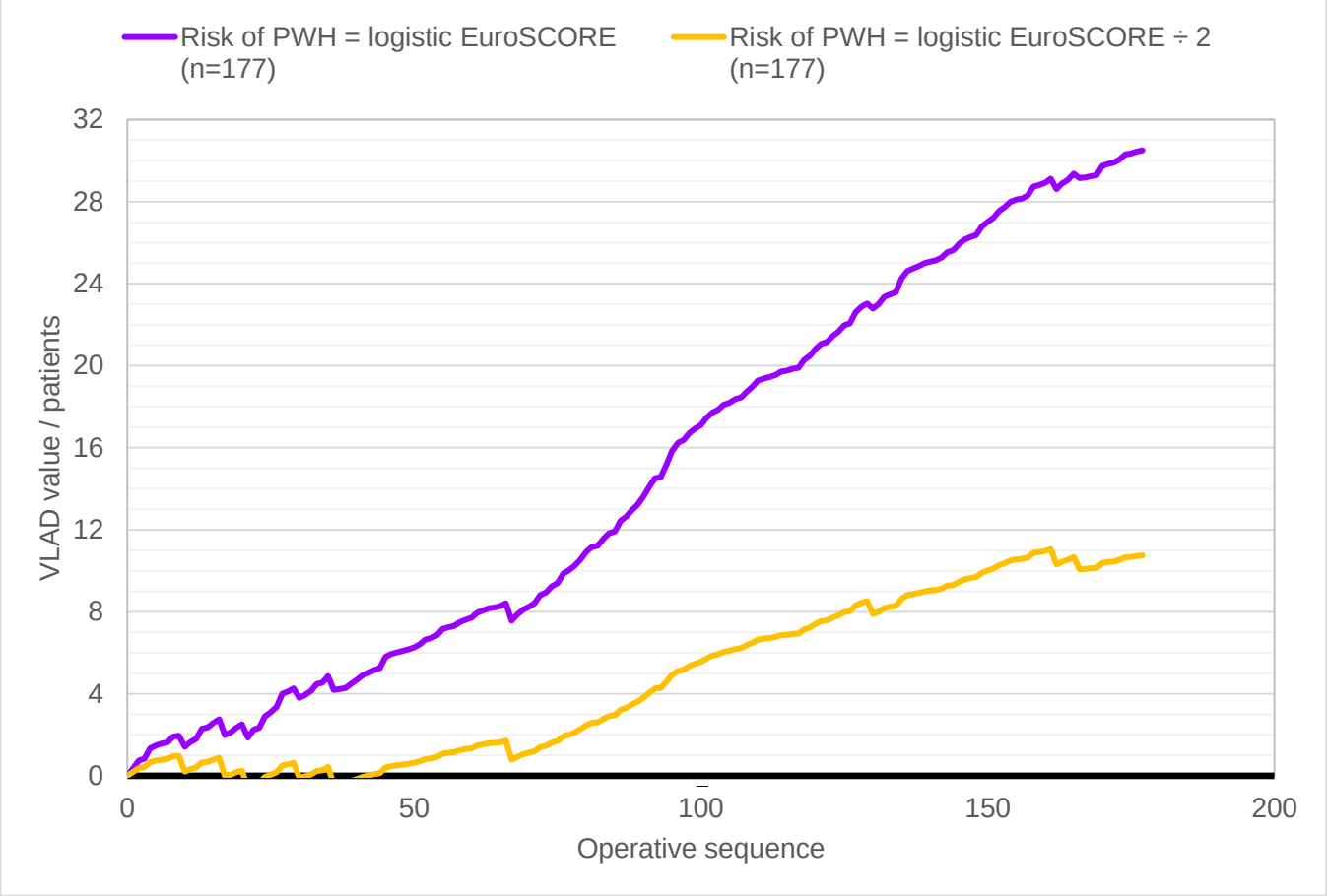
SURGERY ON THE AORTA

VLAD plot for surgery on the aorta

All major aortic surgery

- Fig 4.06 shows the VLAD plot for major aortic surgery using the EuroSCORE and EuroSCORE÷2 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, almost 31 extra lives had been saved for the major aortic group at the PWH.

Fig 4.06 Surgery on the aorta: VLAD plot for ***all*** cardiac surgeries at the PWH



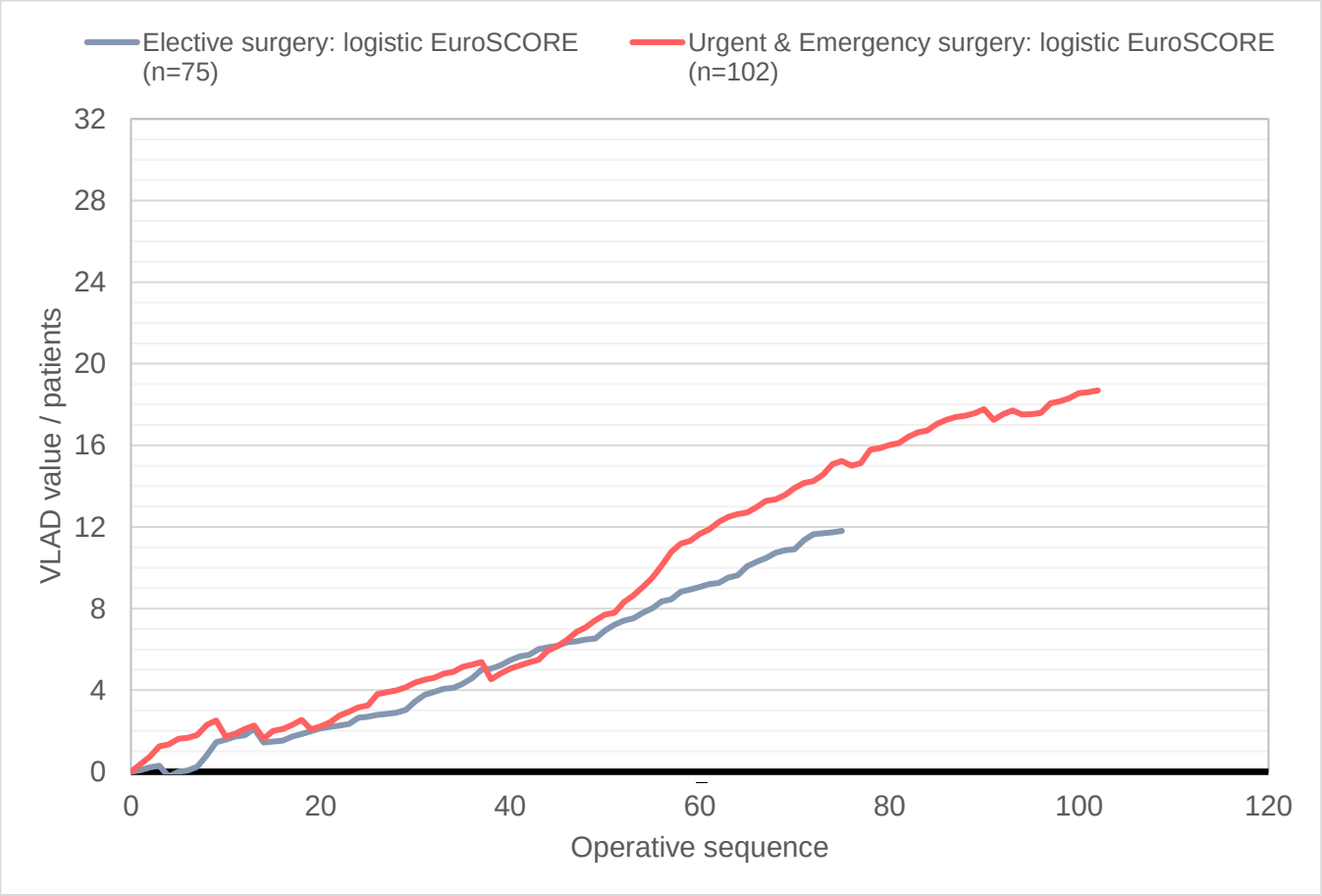
SURGERY ON THE AORTA

VLAD plot for surgery on the aorta

Elective, urgent, and emergency major aortic surgery

- Fig 4.07 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 40.7% during 2019-2020 (PWH: 40.7%, 2019-2020 vs the UK: 42%, 2015-2016). This suggests similar rates of emergency aortic surgery in the PWH and the UK.
- At the end of the two VLAD curves, almost 12 and 19 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 4.07 Surgery on the aorta: VLAD plot by ***operative priority*** at the PWH



SURGERY ON THE AORTA

Other immediate post-operative outcomes

- Fig 4.08 to Fig 4.10 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 4.08), **post-operative stroke** rate (Fig 4.09), and **new haemofiltration / dialysis** rate (Fig 4.10). Fig 4.11 to Fig 4.13 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 2019-2020.
- These three post-operative outcomes at the PWH fall comfortably within the control limits, showing satisfactory quality.

Re-operation for bleeding

Fig 4.08 Surgery on the aorta: Re-operation for bleeding or tamponade

		Yes	No
Re-operation for bleeding or tamponade	**Count**	7	170
	Proportion	4.0%	96.0%
	Dead	1	8
	Crude mortality rate	0.6%	4.5%

Post-operative stroke

Fig 4.09 Surgery on the aorta: New post-operative stroke

		Yes	No
New post-operative stroke	**Count**	12	165
	Proportion	6.8%	93.2%
	Dead	5	4
	Crude mortality rate	2.8%	2.3%

SURGERY ON THE AORTA

Post-operative HF / dialysis

Fig 4.10 Surgery on the aorta: New post-operative haemofiltration or dialysis

		Yes	No
New haemofiltration or dialysis post-operatively	**Count**	5	172
	Proportion	2.8%	97.2%
	Dead	2	7
	Crude mortality rate	1.1%	4.0%

Funnel plots for other immediate post-operative outcomes in major aortic surgery

Fig 4.11 Surgery on the aorta: Crude ***re-operation for bleeding*** rate

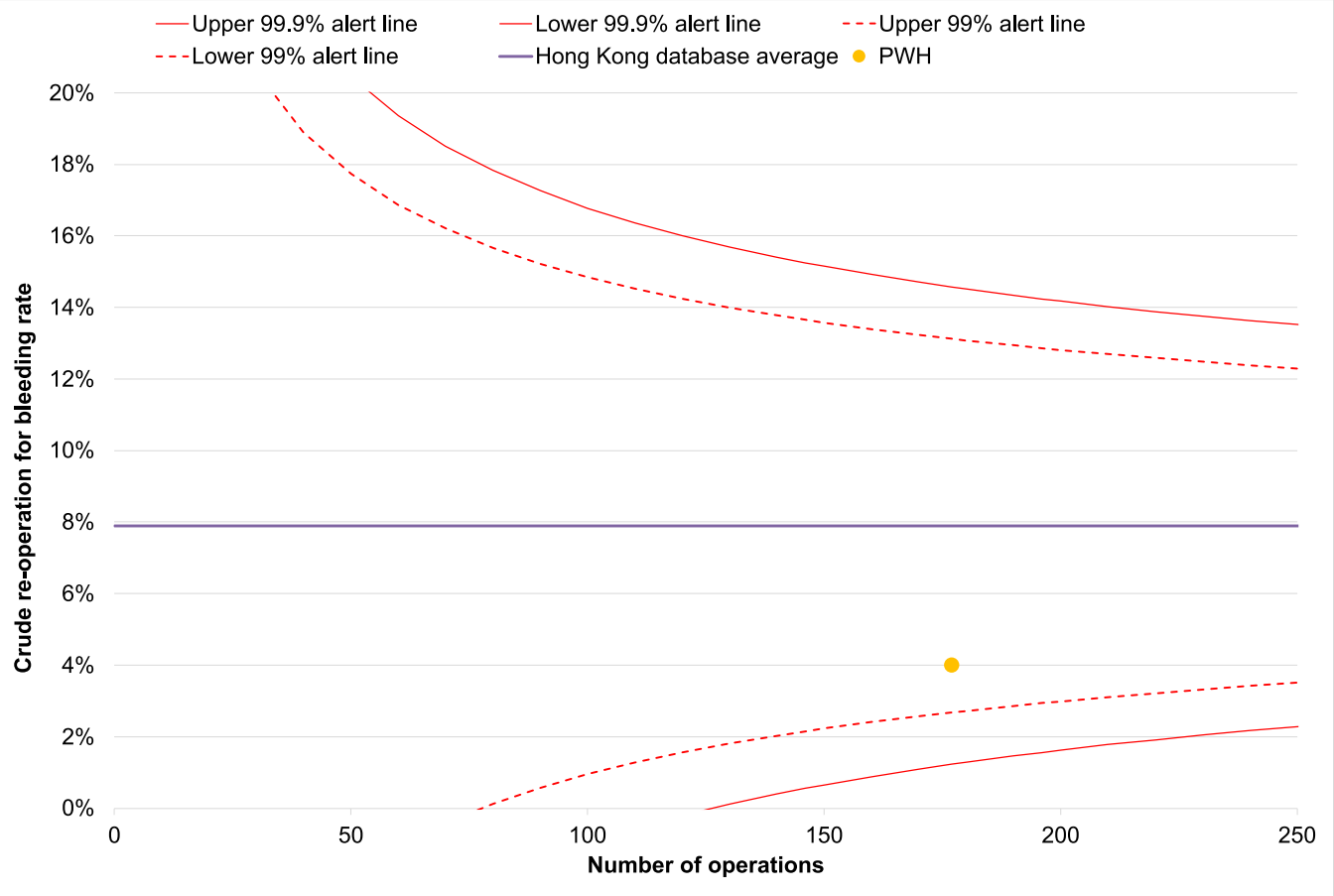


Fig 4.12 Surgery on the aorta: Crude ***post-operative stroke*** rate

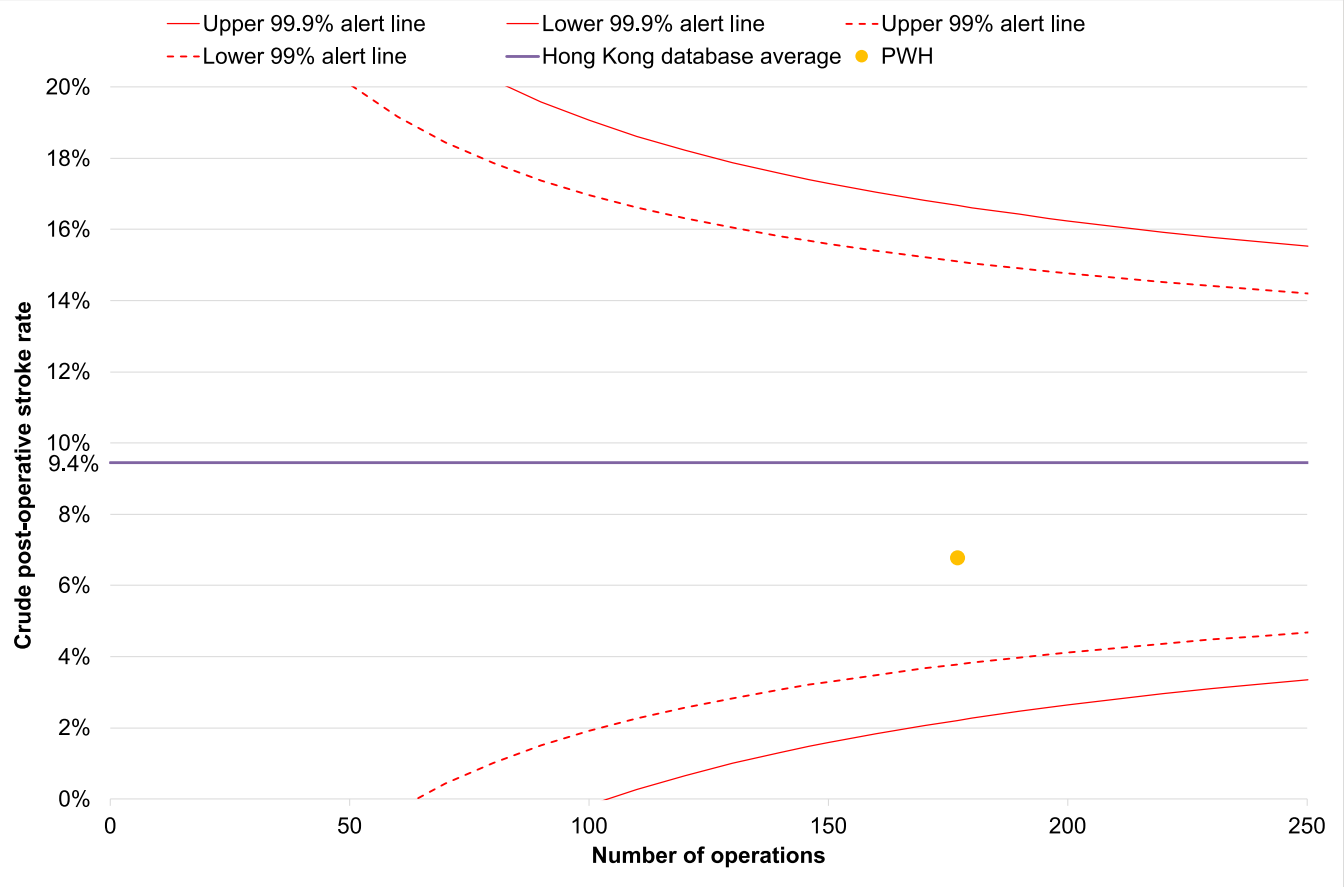
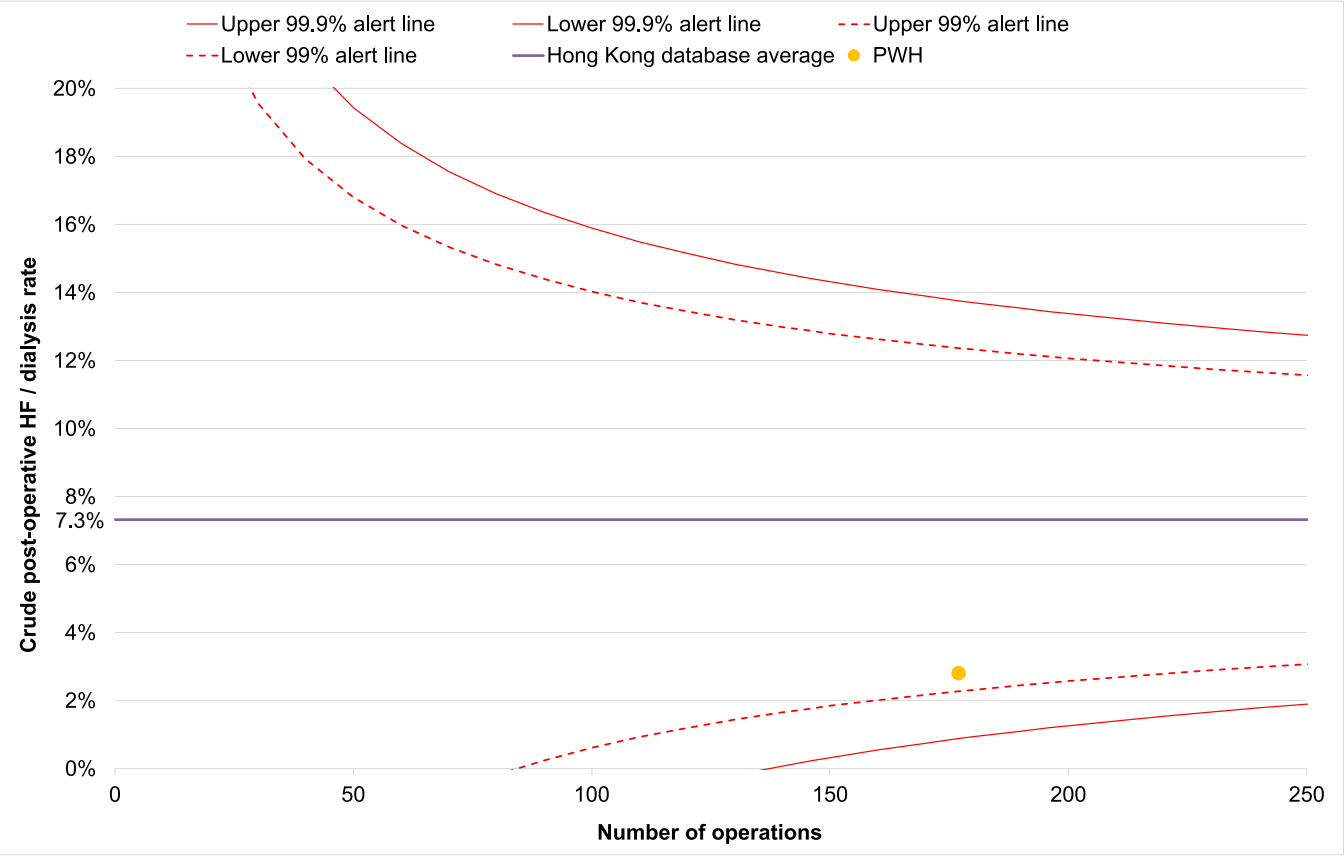


Fig 4.13 Surgery on the aorta: Crude ***post-operative HF / Dialysis*** rate

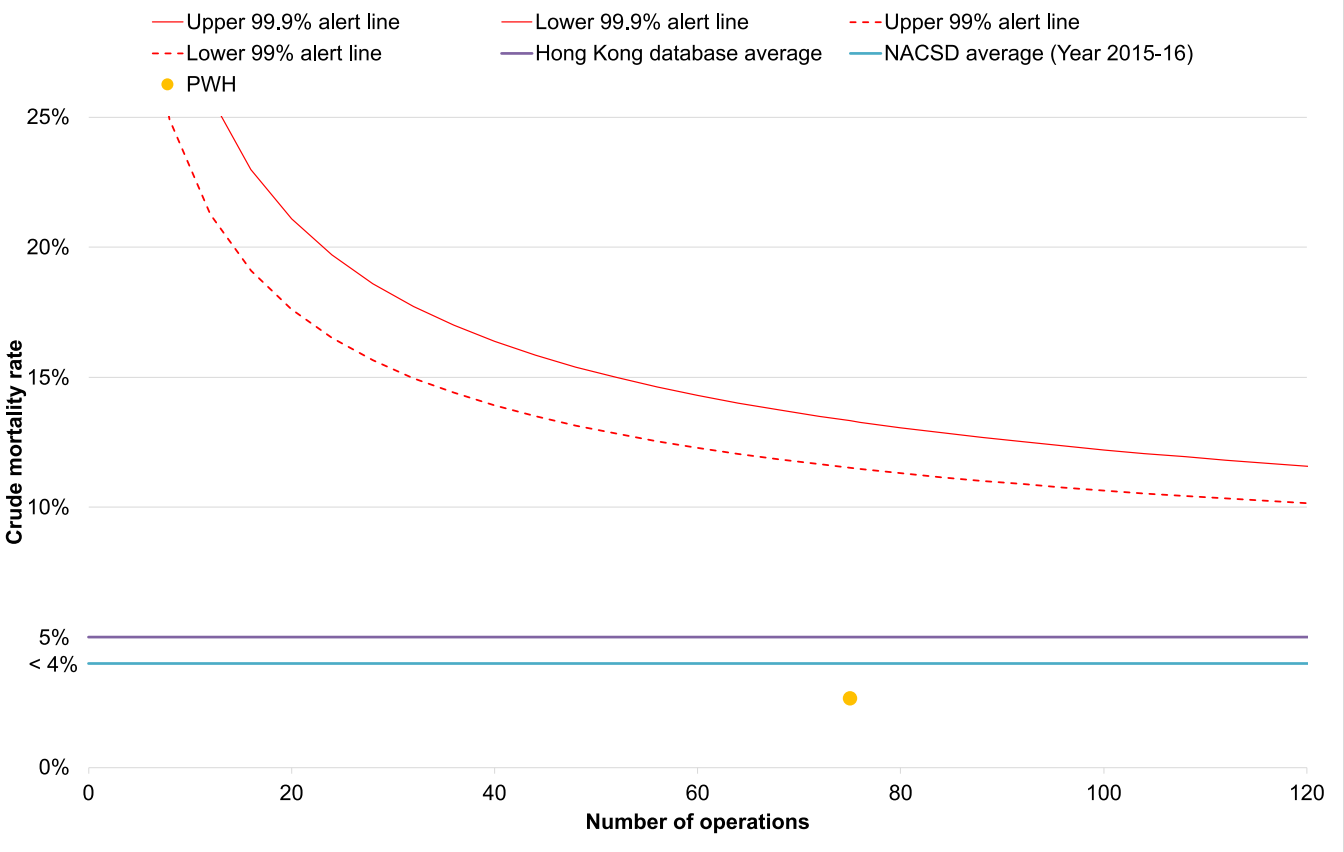


SURGERY ON THE AORTA

Funnel plot of the crude mortality rate for surgery on the aorta

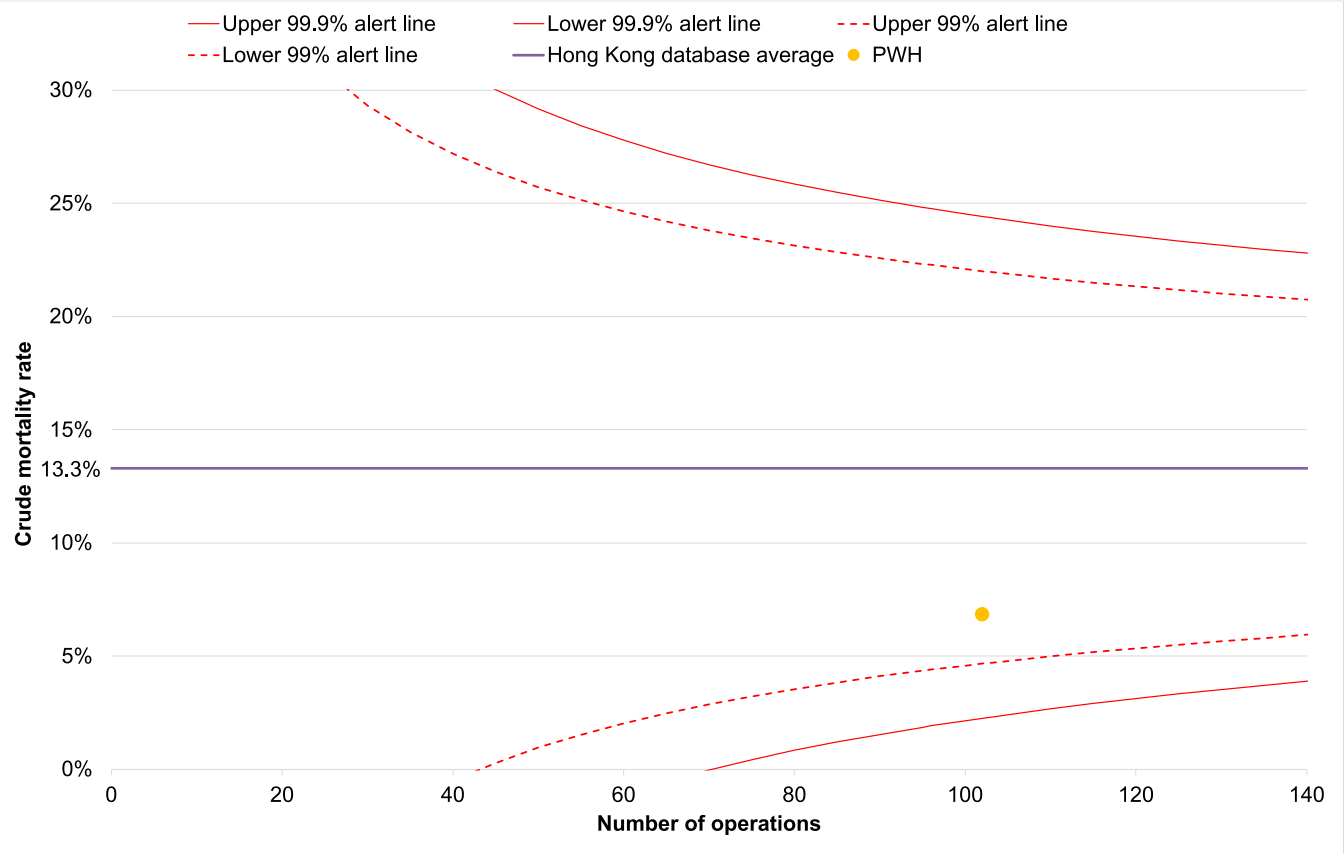
- Fig 4.14 and Fig 4.15 show the funnel plots of mortality for elective, urgent, and emergency (including salvage cases) major aortic surgery, with alert and alarm lines set at 99.0% and 99.9% respectively. The ***control limits*** refer to those generated by the submission of data from all cardiac units in Hong Kong during 2019-2020. The ***light purple*** horizontal line represents the average data from all cardiac units in Hong Kong during 2019-2020. The ***light blue*** horizontal line is served as a reference on the charts, which represents the average of the data in the United Kingdom NACSD during the period 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 2019 and 2020.
- Between 2019 and 2020, the overall satisfactory outcomes in the funnel plots are consistent with the VLAD analysis.

Fig 4.14 ***Elective*** surgery on the aorta: Crude ***mortality*** rate



SURGERY ON THE AORTA

Fig 4.15 ***Urgent and emergency*** surgery on the aorta: Crude ***mortality*** rate



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 some categories.
2. Significant improvements in survival for most cardiac surgical procedures, 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 recorded excellent outcomes for mitral and aortic valve operations.
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 reporting outcomes are undeniable. Hence, this publication is regarded as a preliminary indicator to drive improvement in the quality of care for cardiac surgery patients over time and quality assurance processes.

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 contributed to data collection and enable us to do so prospectively and at the point of clinical care. We believe all personnel involved in care also have a duty to collect data and ensure quality and this has been taken on with vigour by the majority. 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 Xi 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 μmol/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

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