Health Quality & Safety Commission New Zealand
Kupu Taurangi Hauora o Aotearoa

POMRC
Perioperative Mortality Review Committee

Perioperative Mortality in New Zealand:

Fifth report of the Perioperative Mortality Review Committee

Report to the Health Quality & Safety Commission New Zealand

June 2016

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Foreword

As the Chair of the Health Quality & Safety Commission (the Commission), I am pleased to welcome the fifth report of the Perioperative Mortality Review Committee (the POMRC).

This report presents information on perioperative mortality in New Zealand during 2009–2013 for two new clinical areas: 30-day mortality following operations and procedures under general anaesthesia and day-of-the-week mortality. As part of the POMRC's continued surveillance of perioperative mortality over time, rates for a number of clinical areas and procedures included in previous reports are presented here for 2009–2014.

Thirty-day mortality following operations and procedures under general anaesthesia is a broad indicator of quality and safety. For Māori, higher 30-day mortality rates following general anaesthesia add to data indicating a need for renewed efforts to reduce inequity of health outcomes in New Zealand. Research is needed to better understand the Māori patient journey in the surgical setting, from access through to postoperative care, in hospital and after discharge home. The Commission's Māori Caucus has provided some insightful commentary and recommendations on the POMRC's analyses of this issue.

The finding that perioperative mortality varies by the day of the week is consistent with international data – elective procedures performed over weekend days are associated with higher mortality rates than those performed during weekdays. In this report, the POMRC summarises the international evidence, showing increased mortality risk for weekend admissions and procedures. Other countries have begun developing national responses to the emerging body of research, using large national hospital administrative data sets that show increased mortality risk for weekend admissions. NHS England, for example, recently established a Seven Days a Week Forum to develop clinical standards for reducing variation in mortality for those admitted acutely on weekends and weekdays (NHS England 2016). This may not be the right answer for New Zealand. For hospitals that perform elective surgery at weekends, locally relevant work is needed to understand better how care can be provided consistently across the seven days of the week.

Mortality rates for selected clinical areas and procedures reported previously by the POMRC are compared with those in countries of comparable economies and levels of development. New Zealand perioperative mortality rates are generally consistent with those of other countries reported in the international literature.

The POMRC continues to progress the development of a system for local review of perioperative deaths. It is now in the stages of piloting a standardised form for collecting mortality review information in five different district health boards across the country. The form will serve as the template for a web-based national perioperative reporting system, which is also currently being developed. Using the web-based system, the POMRC will be able to collate information from multiple reviews, extract themes and disseminate key lessons to improve the quality and safety of perioperative care.

This report reflects the POMRC's commitment to improving perioperative care through the national surveillance of mortality, and its approach to aligning and comparing its work with international research developments. This work provides assurance to New Zealanders that our surgical services are safe by international standards. More importantly, it provides impetus and guidance for ongoing improvement. There is no place for complacency in the pursuit of excellence, and astute review of mortality data nationally and locally is one of the most important drivers of quality improvement in surgery and anaesthesia. Dr Wilson and the many other individuals who have worked on this report are to be congratulated.

Professor Alan Merry ONZM FRSNZ
Chair, Health Quality & Safety Commission

Chair's Introduction

I am pleased to present the fifth report of the Perioperative Mortality Review Committee (the POMRC). The POMRC is a statutory committee that reviews perioperative deaths. It reports to the Health Quality & Safety Commission, providing sector-wide recommendations that aim to prevent these deaths and support quality improvement throughout the sector.

This report presents the findings on perioperative mortality during 2009–2013 for two new clinical areas:

1. Thirty-day mortality following operations and procedures under general anaesthesia.
2. Day-of-the-week mortality.

The first of these areas was chosen because 30-day mortality following operative procedures with a general anaesthetic is a broad indicator of perioperative mortality. In previous reports, the POMRC was only able to report on same or next day mortality following operations and procedures under general anaesthesia. Extending the timeframe to 30 days allows us to capture deaths that occur more distal to the operative procedures, many of which occur outside the hospital after discharge.

Day-of-the week mortality was chosen as the second new clinical area of interest because of the growing body of literature demonstrating poorer mortality outcomes following operative procedures conducted on or around the time of the weekend. The increased risk of death associated with weekend procedures, seen internationally and in this report, underscores the importance of ensuring any variation in the quality and safety of care between the weekends and weekdays is reduced.

In addition to the two new clinical areas, mortality for the selected tracking procedures and clinical areas from previous reports are extended here for the 2009–2014 time period. These tracking procedures and clinical areas include cholecystectomy, same or next day mortality following general anaesthesia, hip and knee arthroplasty, colorectal resection, coronary artery bypass graft, percutaneous transluminal coronary angioplasty, mortality in admissions with an American Society of Anesthesiologists (ASA) score of 4 or 5, and mortality in elective admissions for those classified as ASA 1 or 2.

This year the POMRC has also woven a number of composite case stories throughout the report. Most of these are based on themes extracted from multiple reviews in the national reportable events database. The clinical lessons included in the cases offer valuable considerations for strengthening the quality of postoperative care and helping prevent perioperative deaths.

The international comparisons chapter has been expanded to include the best information available on perioperative mortality in other countries with similar economies, some also with similar health care systems. There is extensive literature on the effect of the day of the week on mortality, which has been summarised to provide background for that chapter. This information will help those seeking assurance about the safety of New Zealand's perioperative patient care.

In the next year, the POMRC will further develop the local system for reviewing perioperative deaths. This system is currently being trialled in pilot sites across selected district health boards. A national web-based system is also being developed which will enable the POMRC to collate the review findings nationally, and share important quality improvement themes and lessons learned from the reviews with others. Conducting multidisciplinary reviews on perioperative deaths is the focus of the POMRC's annual workshop for 2016. The workshop discussions will help strengthen and streamline the developing review system, ensure its appropriateness for health care providers, and support multidisciplinary reviews at the institutional level.

Dr Leona Wilson ONZM
Chair, Perioperative Mortality Review Committee

Executive Summary

The Perioperative Mortality Review Committee (the POMRC) is a statutory committee that reviews and reports on perioperative deaths with a view to reducing perioperative mortality and morbidity, and supporting continuous quality and safety improvements in New Zealand.

The POMRC's definition of *perioperative deaths* includes:

- deaths that occurred after an operative procedure, either within 30 days after the operative procedure, or after 30 days of the procedure but before discharge from hospital to a home or rehabilitation facility
- deaths that occurred while under the care of a surgeon in hospital even though an operation was not undertaken.

For the purposes of the POMRC's definition of perioperative deaths, an *operative procedure* refers to any procedure requiring anaesthetic (local, regional or general) or sedation. This includes a broad range of diagnostic and therapeutic procedures carried out in designated endoscopy or radiology rooms, such as gastroscopies, colonoscopies, and cardiac or vascular angiographic procedures.

Perioperative mortality in New Zealand 2009–2013

In this report the POMRC has examined perioperative mortality in New Zealand during 2009–2013 for two new clinical areas of interest: (1) 30-day mortality following operations and procedures under general anaesthesia,[1] and (2) day-of-the-week mortality.

Thirty-day mortality following operations and procedures under general anaesthesia was selected as it is a broader indicator of perioperative mortality. For previous reports, the POMRC analysed deaths following a general anaesthetic that occurred on the day of the first procedure, or the following day. Same or next day mortality provides an indication of the risk of death in the short 48-hour period that includes the time during and after operative procedures. However, many postoperative deaths occur over a longer time scale – some patients can be relatively stable in the first few days after an operative procedure and then slowly deteriorate as a result of infection and other complications. Having 30-day mortality rates allows us to capture these types of postoperative deaths, as well as the additional proportion of deaths that occur after discharge from hospital, but within 30 days of the procedure.

Day-of-the-week mortality was selected because it is an emerging area of interest internationally, both in terms of the growing body of research, and the implications for the quality and safety of weekend postoperative care. There is now converging evidence from a number of studies of national hospital administrative data sets that, compared to weekdays, the risk of mortality is higher following both acute admissions and procedures occurring on or around the time of the weekend.[2]

The increased mortality risk observed following weekend admissions and procedures conducted around the time of the weekend has become widely known as the 'weekend effect'. The weekend effect is most likely driven by the interplay of multiple patient factors (eg, disease severity) and care-related factors (eg, reduced weekend services); however, understanding the relative influence of these factors, and how they vary across specific settings and procedures, requires further investigation through research. Future research can enhance our understanding of the weekend effect and help us identify the sources of unwanted variation in

1 Thirty-day mortality following operations and procedures under general anaesthesia is analysed as 30-day mortality following admission with one or more general anaesthetics. See Appendix 2 for further details on the methods.

2 One study of particular relevance found the adjusted odds of death within 30 days of elective admissions in England during 2008–2011 was 44% and 82% higher in elective operative procedures carried out on a Friday or a weekend respectively, compared with a Monday (Aylin et al 2013). See Aylin et al (2010), Freemantle et al (2015) and Ruiz et al (2015b) for other key population-based studies.

postoperative outcomes throughout the week, particularly any aspects of care that are amenable to change. This will enable more targeted quality improvement interventions to be designed and implemented.

For the chapter on day-of-the-week mortality, the POMRC has examined mortality in the first 30 days following an operative procedure, taking into account the day of the week on which the procedure was performed. Multivariate analyses of mortality following admissions with at least one general anaesthetic were used to compare weekend rates with Tuesday[3] rates, adjusting for socio-demographic and clinical factors (using only the first procedure as the index for those who underwent multiple procedures in one admission). For the first time, the POMRC has used the Charlson Comorbidity Index (CCI)[4] in multivariate analyses of mortality by day of the week as well as the American Society of Anesthesiologists (ASA) physical status score. Both are measures of the patient's health status prior to surgery and anaesthesia, and are predictive of mortality risk. The CCI has been used in large studies analysing administrative data sets, possibly when the ASA score was not available, as was the case with some international studies in this area. The ASA score also provides a measure of severity of overall health status.

Key findings from new clinical areas

For the two new clinical areas examined, as with other clinical areas previously examined, higher 30-day mortality rates were consistently associated with:

- increasing age
- comorbidities and poorer overall health status (higher CCIs and ASA scores)
- emergency (unarranged) admissions into hospital.

In New Zealand during 2009–2013, the following key findings were observed for each new clinical area examined.

Thirty-day mortality following operations and procedures under general anaesthesia

- There were 6755 deaths and cumulative mortality was 0.56% of admissions. Most of these deaths occurred among acute admissions and at public hospitals.
- Cardiovascular causes were the most commonly listed underlying reason for mortality within 30 days of receiving a general anaesthetic, regardless of admission type.
- Among both acute and elective admissions, mortality was significantly higher for those aged over 65 years, those with a first ASA score of 3 or more, those who received more than one anaesthetic during their admissions, and those with higher New Zealand Deprivation Index (NZDep) deciles.
- Mortality after an operation or procedure with a general anaesthetic was significantly higher for Māori for than for Europeans after adjusting for socio-demographic and clinical factors. This was true for Māori admitted both acutely and electively.

Day-of-the-week mortality

- Mortality among all admissions whose first procedure with a general anaesthetic was on a Saturday or Sunday was significantly higher compared to mortality among those whose first procedure was on Tuesday (ie, a 'weekend effect' was shown), after adjusting for socio-demographic and clinical factors (CCI and ASA score).
- Among those admitted acutely, the risk of mortality following the first procedure with a general anaesthetic was significantly higher if the day of procedure was either Saturday or Sunday, compared to Tuesday, after adjusting for socio-demographic and clinical factors.
- Among those admitted electively, the risk of mortality following the first procedure with a general anaesthetic was significantly higher for weekend procedures (Saturday and Sunday combined), compared to Tuesday procedures, after adjusting for socio-demographic and clinical factors.

3 See the methods section of the day-of-the-week mortality chapter for the rationale behind the use of Tuesday as the comparison day of the week.

4 The CCI is a score based on the number of patient comorbidities, each of which carry different weights according to type of comorbid condition. Higher scores indicate more comorbidities and more severe clinical condition (Charlson et al 1987, 1994).

- The association between increased mortality risk and weekend procedures was greater for those admitted electively (ie, the weekend effect was more pronounced for elective procedures).

Perioperative mortality: tracking procedures and clinical areas

The following section summarises key findings from 2009–2014 for the tracking procedures and clinical areas that were included in previous POMRC reports. Thirty-day mortality rates for these procedures and clinical areas are summarised in Table 1, along with the rates from previously reported time periods since 2005–2009.

It is important to note that changes in mortality over time should be interpreted with caution as a range of factors related to coding and small variations in data sets across years (due to time lapses in receiving and entering data) could influence apparent changes in rates. These factors also explain why some of the rates presented in each report may appear to differ slightly from year to year.

In New Zealand during 2009–2014, cumulative mortality rates and other findings for each of the tracking procedures and clinical areas were generally consistent with those reported from previous periods. The only exceptions were acute admissions for colorectal resection and also elective/waiting list admissions with an ASA score of 4 or 5. For both of these, cumulative mortality appears to have decreased slightly compared to rates reported in earlier periods.

The following key findings were observed in New Zealand during 2009–2014.

Cholecystectomy

- There were 146 deaths. The overall cumulative mortality was 0.37% of admissions.
- Mortality was higher when an open procedure was undertaken (3.53% of admissions) or when a laparoscopic procedure was converted to an open procedure (1.04% of admissions).
- Cumulative mortality rates were higher among acute admissions (0.70% of admissions) than elective/waiting list admissions (0.22% of admissions).

General anaesthesia (same or next day mortality)

- There were 1805 deaths (0.12% of admissions), most of which occurred among acute admissions and at public hospitals.
- Mortality was between 0.11% and 0.15% of admissions each year.

Hip arthroplasty

- There were 792 deaths. The six-year cumulative mortality rate was 1.53% of admissions.
- Cumulative mortality over the six years was higher for acute admissions (7.11%) compared to elective/waiting list admissions (0.12%).

Knee arthroplasty

- There were 61 deaths. The cumulative mortality rate was low (0.17% of admissions).
- Almost all (98.3%) admissions were elective/waiting list admissions.

Colorectal resection

- There were 816 deaths. Cumulative mortality was 3.92% of admissions.
- Cumulative mortality was higher for acute admissions (8.45%) than for elective/waiting list admissions (2.03%).
- Cumulative mortality among acute admissions decreased slightly from 9.8% in 2005–2009 to 8.45%.
- Other findings are generally consistent with previous reports.

Coronary artery bypass graft (CABG)

- There were 337 deaths. Cumulative mortality was 2.92% of admissions.
- Cumulative mortality was higher among acute admissions (4.89%).

Percutaneous transluminal coronary angioplasty (PTCA)

- There were 572 deaths. Thirty-day cumulative mortality was 1.77% of admissions.
- Mortality was higher among acute admissions (2.43%).

Mortality in admissions with an ASA score of 4 or 5

- There were between 460 and 538 deaths per annum. The six-year cumulative mortality rate was 12.62%.
- Mortality was high for admissions with an ASA score of 5 (48.14% over the six-year period) and higher for acute admissions (18.15%) than for elective/waiting list admissions (5.14%).

Mortality in elective/waiting list admissions with an ASA score of 1 or 2

- There were between 38 and 75 deaths per annum. The cumulative mortality rate was 0.05%.
- Cumulative mortality declined slightly from previous years (down from 0.07% during 2006–2010).

Table 1: Current and Previously Reported Cumulative Mortality (per 100,000) for POMRC Tracking Procedures and Clinical Areas, New Zealand 2005–2014

TOPICS ANALYSED OVER TIME	2005–2009	2006–2010	2007–2011	2008–2012	2009–2014
Cumulative 30-Day Mortality Rate per 100,000					
Cholecystectomy: Acute		1040.9 (1.04%)	975.0 (0.98%)	821.7 (0.82%)	697.1 (0.70%)
Cholecystectomy: Elective/Waiting List		164.6 (0.16%)	151.0 (0.15%)	181.8 (0.18%)	224.7 (0.22%)
Hip Arthroplasty 45+ Yrs: Acute*	7268.6 (7.27%)		6608.9 (6.61%)	7098.0 (7.10%)	7113.8 (7.11%)
Hip Arthroplasty 45+ Yrs: Elective/Waiting List	235.3 (0.24%)		180.5 (0.18%)	171.0 (0.17%)	124.3 (0.12%)
Knee Arthroplasty 45+ Yrs: Elective/Waiting List	206.9 (0.21%)			142.8 (0.14%)	168.3 (0.17%)
Colorectal Resection: Acute	9818.3 (9.82%)		8456.0 (8.46%)		8449.8 (8.45%)
Colorectal Resection: Elective/Waiting List	2057.7 (2.06%)		1700.6 (1.70%)		2031.5 (2.03%)
Coronary Artery Bypass Graft (CABG)				2645.0 (2.47%)	2918.8 (2.92%)
Percutaneous Transluminal Coronary Angioplasty (PTCA)				1661.3 (1.66%)	1768.5 (1.77%)
ASA 4 & 5 (High-Risk Anaesthesia)				13,701.9 (13.70%)	12,621.2 (12.62%)
ASA 1 & 2, Elective/Waiting List (Low-Risk Anaesthesia)		68.8 (0.07%)	62.9 (0.06%)	54.5 (0.05%)	51.4 (0.05%)
Cumulative One-Day Mortality Rate per 100,000					
General Anaesthesia	119.1 (0.12%)		125.5 (0.13%)	121.5 (0.12%)	124.6 (0.12%)

* These patients commonly have hip arthroplasty to treat a fractured hip.

Data limitations

Data in this report was sourced from the National Minimum Dataset (NMDS) and the National Mortality Collection (NMC). The NMDS and NMC data sets have limitations associated with coding accuracy and data completeness. Both data sets are dependent on the quality of clinical records and classification systems.

Some private day-stay or outpatient hospitals, facilities and in-rooms do not report any surgical and procedural events to the NMDS. The Ministry of Health is unable to estimate the extent to which the NMDS undercounts events from private surgical, procedural day-stay or outpatient hospital, and facility or in-room hospitalisations. For this report the data presented is likely to undercount some private hospital events, with the magnitude of this undercount being difficult to quantify.

Small variation in the data sets across time can also result in slight variations in the mortality and hospitalisation rates included in each annual report. This variation can be caused by lapses in the time it takes for the data from each year to be entered into the NMDS and NMC databases, and also through changes in coding over the years. Such variation limits the ability to compare findings between time periods of interest.

Additional information on data limitations is provided in Appendix 2 of this report.

Developing local systems for perioperative mortality review in New Zealand

The POMRC's Tier 1 project continues to progress work towards developing local multidisciplinary perioperative review systems in New Zealand. Local review systems will enable the POMRC to collect in-depth clinical and contextual information on perioperative deaths from public and private hospitals throughout the country. Reviewing in-depth information allows common themes, at both the clinical and systems levels, to be identified. This will result in a deeper understanding of the potentially preventable factors underlying perioperative deaths, and serve to inform local quality improvement initiatives.

Since the previous report, five pilot sites have been recruited to help trial and further refine the developing local review processes in partnership with the POMRC. These pilot sites include Waikato DHB, Whanganui DHB, Waitemata DHB, Counties Manukau DHB and Nelson Marlborough DHB. These pilot sites were selected so the POMRC could trial the local review processes in health care institutions with varying patient demographics. Ongoing consultation with Southern Cross Hospitals, as an example of an integrated set of private hospitals, will also inform the developing local review processes.

A working group, consisting of members from the POMRC and representatives from the pilot sites, has been established to oversee and guide the development of the review and data submission processes.

Developing a web-based national perioperative reporting system

The POMRC is working towards developing a national web-based system that will allow consistent reporting at a local level. This system will also enable the POMRC to collate information from local reviews of perioperative deaths, and then disseminate key themes and quality improvement lessons nationally. The working group is currently refining the Tier 1 form (now on version 3), which will be used by local groups to record information from their reviews of perioperative deaths. The Tier 1 form will eventually become the data entry template for those entering information derived from local reviews onto the website.

In the next year a paper-based version of the Tier 1 form will be trialled in the five pilot sites. The working group will assess the utility of the form, making appropriate modifications based on feedback from the pilot sites. An in-depth analysis of selected perioperative deaths of interest will be conducted, to identify common themes, clusters of events and potentially preventable causes of death.

Improving the quality of perioperative data

Reviewing the NMDS

In parallel with the Tier 1 project work, the POMRC is continuing its work towards improving the quality of national data collected on perioperative deaths. Currently the POMRC publishes information on perioperative mortality using data from the NMDS, which receives the coded discharge data from health care institutions throughout the country. In the forthcoming stages of this work-stream, the NMDS data will be reviewed for all deaths that fall within the POMRC's scope (approximately 6000 per annum), with the aim of both confirming and augmenting the NMDS data.

Comparing administrative and clinical registry data sources

Although the NMDS contains largely complete information on all publicly funded day and inpatient hospital admission events (occurring at both public and private hospitals), the NMDS contains incomplete information on privately funded hospital events at private hospitals. To assess how private hospital admissions data missing from the NMDS might affect estimates of perioperative mortality, the POMRC compared elective hip and knee joint arthroplasty data obtained from the New Zealand Joint Registry against data from the NMDS. The New Zealand Joint Registry is a clinical register; it captures information on all admission events for arthroplasty procedures collected from both public and private hospitals in New Zealand. The POMRC's comparison of these two data sources revealed that a number of additional procedures included in the New Zealand Joint Registry were absent from the NMDS, and similarly a small number of procedures were included in the NMDS only. Although the number of recorded arthroplasty procedures was higher in the New Zealand Joint Registry than the NMDS, the 30-day mortality estimates for 2007–2011 hip and knee arthroplasty procedures were similar for both data sources (Hider et al 2016).

In future, options for linking data from both the NMDS and the New Zealand Joint Registry will be explored. The New Zealand Joint Registry, being a clinical register, contains more detailed information on hip and knee arthroplasty procedures compared to the NMDS, including details of revision procedures and devices used. Combining information across the NMDS and the New Zealand Joint Registry could provide a more complete understanding of the patients who undergo these treatments and their outcomes.

Improving ASA score records

The ASA Physical Status Classification System score is a strong predictor of perioperative mortality – evident in both this report and previous reports from the POMRC. Having accurate ASA scores is important because it allows us to estimate perioperative mortality for various procedures, adjusting for any patient disease severity, giving us some indication of how much mortality might be due to aspects of the procedure and perioperative care.

In this report, recording ASA scores continues to be an issue for New Zealand, with significant numbers of undocumented ASA scores observed in the analyses of 30-day mortality following operations and procedures under general anaesthesia (in all age groups, about 20% of acute admissions and 30% of elective admissions had no stated ASA score). The POMRC notes that there does seem to have been some improvement in reporting of ASA scores – in 2009, 63.7% of admissions with a general anaesthetic had recorded an ASA score, which increased to 71.6% of admissions in 2014.

World Health Organization surgical care metrics

The POMRC continues to monitor the two World Health Organization (WHO) public health metrics for surgical care included in previous reports: day-of-surgery mortality rate and inpatient mortality rate. These two metrics are reported for all surgical procedures during 2009–2014:

- day-of-surgery mortality rate: 0.12%
- inpatient mortality rate: 0.40%.

Future work will continue to explore and expand the use of WHO metrics as standardised indicators for surgical care in New Zealand. This is part of the POMRC's long-term approach for comparing New Zealand data with other international jurisdictions.

Fifth report recommendations

The following four categories of recommendations were informed by data presented in this report. The first three of these categories were developed by the POMRC. The final category of recommendations was developed by the Māori Caucus, convened by the Health Quality & Safety Commission.

1. Improvements to care:[5]

a. Non-operative treatment for patients who are assessed as having an ASA status of 5 must be considered.

b. The risk of dying perioperatively should be discussed with all patients contemplating an operation with a significant risk.

c. Death following elective surgery performed on the weekend should be investigated in depth by that health care institution, assessing all potential contributory factors.

2. Better documentation:

a. All patients should have their ASA status recorded in their clinical anaesthetic record.

3. Further research and research funding:

a. The difference in mortality between patients having procedures in the weekend compared to weekdays, in particular those admitted electively, should be investigated.

b. The reasons for increased perioperative mortality of Māori should be further investigated.

4. Recommendations from the Māori Caucus to the POMRC for better data analysis:

a. The impact that the Māori population age structure has on analyses of perioperative mortality should be investigated.

b. The Charlson Comorbidity Index should be considered to strengthen future analyses and better understand how severity of illness impacts Māori perioperative mortality.

5 It was noted from the POMRC consultation that some DHBs did not perform elective procedures during the weekends.

Perioperative Mortality 2009–2013

The following chapters present the perioperative mortality findings for the two new clinical areas examined in this report:

- Thirty-day mortality following operations and procedures under general anaesthesia.
- Day-of-the-week mortality.

Thirty-day mortality following operations and procedures under general anaesthesia

Mortality following general anaesthesia has declined significantly over the past 50 years, decreasing from about 1.06% before the 1970s, to about 0.12% in the 1990s–2000s. This is despite patients' pre-operative baseline physical health becoming poorer (higher ASA scores) (Bainbridge et al 2012). Improvements in the safety of anaesthesia, through improved anaesthetic technology, professional training and the development of basic standards of anaesthesia care have likely contributed to the reduction in mortality. In recent decades, various countries have implemented national patient safety initiatives and quality improvement programmes, such as the National Surgical Quality Improvement Programme (NSQIP) in the United States (US) to help monitor and reduce adverse postoperative events. National and multi-national professional organisations, such as the Australian and New Zealand College of Anaesthetists (ANZCA), have also formed to provide specialist training and accreditation, and establish national clinical standards of practice. Globally, advances have been made in the safety of anaesthesia through the use of evidence-based tools and checklists that help standardise safe care practices. These include the Harvard standards for patient monitoring during anaesthesia (now used almost universally in higher and upper-middle income countries) and, more recently, the World Health Organization (WHO) Surgical Safety Checklist (Weisser and Gawande 2015; WHO 2009).

Thirty-day mortality following operations and procedures under general anaesthesia provides an important measure of perioperative deaths. In previous years, the Perioperative Mortality Review Committee (POMRC) was only able to analyse same or next day mortality following general anaesthesia. This provides a less stable mortality estimate, which is impacted more by the events occurring during or immediately after surgery. Thirty-day mortality rates, on the other hand, are influenced by aspects of perioperative care that take place over the weeks following surgery, and are a better measure of the impact of anaesthesia and surgery on the patient. Because of the nature of the administrative data collected in New Zealand, we are able to capture those deaths that occur after discharge from hospital but still within 30 days after surgery. This is important because the in-hospital 30-day perioperative mortality rate has been shown to underestimate the total 30-day perioperative mortality rate by approximately 30% (Ariyaratnam et al 2015).

Day-of-the-week mortality

Day-of-the-week mortality was chosen as a clinical area of interest because of the converging evidence from international studies. There is a growing evidence base, from studies[6] using population hospital administrative data sets, that shows weekend admissions and elective procedures occurring on or around the time of the weekend are associated with increased mortality (compared to weekday admissions and procedures). This increased mortality risk associated with weekend admissions and procedures has become widely known as the 'weekend effect'. The underlying causes of the weekend effect are multi-factorial, and likely due to the complex interplay of patient- and care-related factors (see Box 1, page 12). Key studies from the international literature demonstrating the weekend effect are summarised in the chapter 'Perioperative Mortality in New Zealand and International Comparisons' (page 53).

6 See Aylin et al (2010, 2013), Freemantle et al (2015), Ruiz et al (2015b) for key population-based studies.

Box 1: Explaining the 'weekend effect' – patient factors and weekend service provision

Unpacking the underlying reasons for the weekend effect is challenging. There are two main causes suggested to account for the higher mortality observed among weekend admissions: (1) weekend patients differ from weekday patients ('patient effects'), and (2) the quality of weekend care differs from weekdays ('care effects') (Concha et al 2014).

Weekend patients may differ from those on weekdays because those admitted on weekends are generally sicker and present to hospitals with more severe illness – this could bias any observed mortality as sicker patients are more likely to die (Aylin 2015). However, converging evidence shows the weekend effect persists, even after potentially confounding patient case-mix and clinical factors are controlled for in study analyses (Aylin et al 2010; Freemantle et al 2015). Similarly, for this report, the weekend effect was still observed after the POMRC adjusted for patient comorbidities and severity of illnesses using the Charlson Comorbidity Index (CCI) and ASA scores. Although there may always be some residual confounding from other patient factors not able to be controlled for in analyses, this evidence does suggest other non-patient factors contribute to the weekend effect (Aylin 2015).

Medical professionals and researchers responding to studies demonstrating a weekend effect have noted that aspects of weekend care may play a significant causal role (Hodgson 2015; Potluri 2015; Freemantle et al 2015). Weekend service provision, both inside and outside the hospital, differs from weekdays – hospital staff levels vary, with fewer senior consultants, and there are fewer diagnostic services available (NHS England 2013).

It is unclear how much of the weekend effect is explained by patient factors and how much is explained by aspects of weekend care. Although both explanations likely play a role, patient factors possibly explain less of the effect in elective settings (Aylin 2015). Generally fewer non-emergency patients are admitted over the weekend – most elective surgical cases occur on weekdays and those elective procedures that take place on the weekend, being planned procedures, are often lower-risk and on healthier patients. This theory is supported by a national study on hospital admissions in England during 2008–2009, which found weekend admissions were associated with a 9% increased odds of death for emergency admissions, but a much higher 32% increased odds of death for elective admissions (see Mohammed et al 2012).

Hospitals are more equipped to provide emergency care on weekends and may lack the appropriate mix of expertise needed to manage postoperative care or any resulting complications (Verma 2013). Patients admitted for elective procedures towards the end of the week would encounter the weekend care configuration in the first 48 hours of their postoperative care, when they are most at risk from developing complications (Aylin et al 2013). Any reduced service provision may impact how closely patients can be monitored and how quickly staff can respond to patient deterioration.

The evidence from a large national study showing the risk of mortality following elective procedures is higher on weekends compared to other days of the week, after adjusting for patient factors (Aylin et al 2013), together with the finding that the weekend effect may be more pronounced in elective settings (Mohammed et al 2012), lends some support to the argument that aspects of weekend care might have more impact on elective patient outcomes. However, further research is needed to identify those aspects of weekend care that have the most impact on mortality, and are amenable to change. This will help inform quality improvement policy and interventions that aim to minimise any unwanted variation in care outcomes throughout the week.

Thirty-Day Mortality following Operations and Procedures under General Anaesthesia

This chapter uses information from the National Minimum Dataset (NMDS) (calculated using National Health Index data) and the National Mortality Collection (NMC) to review 30-day mortality following a general anaesthetic, and presents background information on hospital admissions where one or more general anaesthetics were performed. Detailed information about data sources and methods are presented in Appendix 2.

Key findings

In New Zealand during 2009–2013, in relation to 30-day mortality rates following operations and procedures under general anaesthesia:

- There were 6755 deaths. Cumulative mortality was 0.56% of admissions. Most of these deaths occurred among acute admissions and at public hospitals.
- Cardiovascular causes were the most commonly listed underlying reason for mortality within 30 days of receiving a general anaesthetic, regardless of admission type.
- Mortality rates were higher for those admitted acutely than for those admitted electively. This was true for every age group (except for the small peak in acute admissions at ages 0–4 years).
- Among both acute and elective admissions, mortality was significantly higher for those aged over 65 years, those with a first ASA score of 3 or more, those who received more than one anaesthetic during their admission, and those with higher New Zealand Deprivation Index (NZDep) deciles. These differences were significant after adjusting for socio-demographic (age, gender, ethnicity, NZDep decile) and clinical (ASA score) factors.
- Mortality after an operation or procedure with a general anaesthetic was significantly higher for Māori than for Europeans after adjusting for socio-demographic and clinical factors. This was true for Māori admitted both acutely and electively.
- For those admitted acutely, the risk of mortality after receiving a general anaesthetic was significantly lower for those aged under 45 years and for females. For those admitted electively or from the waiting list, the risk of mortality after a general anaesthetic was lower for those aged under 45 years, females and those of Asian/MELAA/Other[7] ethnicity. These differences were significant after adjusting for socio-demographic and clinical factors.
- When all hospital admission types were combined, and emergency status and ASA score of the last listed general anaesthetic was considered, the risk of mortality after one or more general anaesthetics was significantly higher for those with an ASA score of 3, 4 or 5, those with more than one anaesthetic during their admission, and for procedures that were given an emergency status. Mortality was significantly lower for those aged under 45 years and for females. These differences were significant after adjusting for socio-demographic and clinical factors.

7 MELAA: Middle Eastern/Latin American/African.

Recommendations

Improvements to care

- Non-operative treatment for patients who are assessed as having an ASA status of 5 must be considered.
- The risk of dying perioperatively should be discussed with all patients contemplating an operation with a significant risk.

Better documentation

- All patients should have their ASA status recorded in their clinical anaesthetic record.

Further research and research funding

- The reasons for increased perioperative mortality of Māori should be further investigated.

Thirty-day mortality following one or more general anaesthetics

Thirty-day mortality following one or more general anaesthetics by year

In New Zealand during 2009–2013, there were 6755 deaths within 30 days of a general anaesthetic. The overall mortality rate for the five-year period was 0.56% of admissions (Table 2). The annual rate was between 0.5% and 0.6% of admissions.

Table 2: Annual Number of Deaths and Hospital Admissions with One or More General Anaesthetics, New Zealand 2009–2013

	Deaths	Admissions	Mortality per 100 Admissions (%)
One or More General Anaesthetics			
2009	1,358	236,005	0.58
2010	1,328	237,796	0.56
2011	1,415	243,437	0.58
2012	1,297	244,297	0.53
2013	1,357	249,824	0.54
Total	6,755	1,211,359	0.56

Numerator: NMC: Deaths within 30 days of a general anaesthetic.
Denominator: NMDS: Hospital admissions with one or more general anaesthetics.

Thirty-day mortality following one or more general anaesthetics by admission type

In New Zealand during 2009–2013, there were 6755 deaths within 30 days following a general anaesthetic. Most of these deaths occurred during an acute admission (72%) and at a public hospital (99%). All of the six deaths at private hospitals occurred among elective/waiting list admissions.

Thirty-day mortality following one or more general anaesthetics by cause of death

In New Zealand during 2009–2013, for all admission types, cardiovascular causes were the most commonly listed underlying reason for mortality within the 30 days of receiving a general anaesthetic (Table 3). Cancers and gastrointestinal conditions also featured prominently.

Table 3: Thirty-Day Mortality following Hospital Admission with One or More General Anaesthetics by Admission Type and Main Underlying Cause of Death, New Zealand 2009–2013

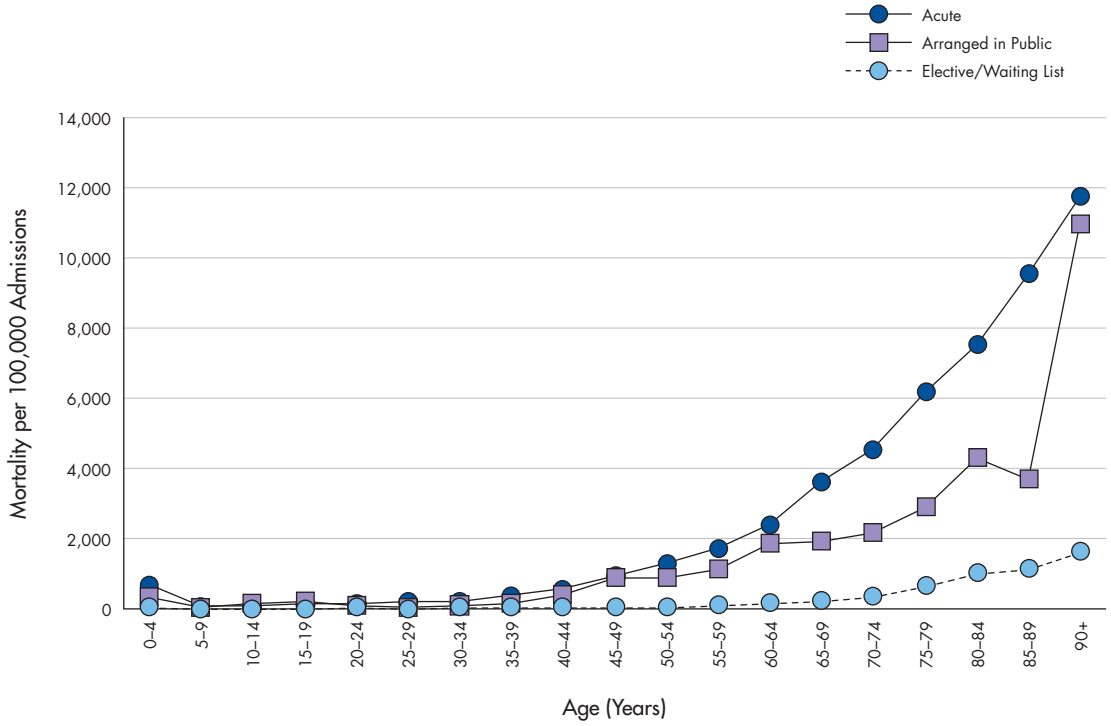
MAIN UNDERLYING CAUSE OF DEATH	Total Deaths 2009–2013	Annual Average	Deaths in Category (%)
General Anaesthetic			
Acute			
Myocardial Infarction	256	51.2	6.5
Other Ischaemic Heart Disease	231	46.2	5.9
Other Cardiovascular Causes	693	138.6	17.7
Non-Insulin Dependent Diabetes	108	21.6	2.8
Cancers	926	185.2	23.6
Emphysema and COPD	93	18.6	2.4
Other Respiratory Diseases	67	13.4	1.7
Gastrointestinal Conditions	514	102.8	13.1
Falls	345	69	8.8
Other Injuries/External Causes	218	43.6	5.6
Other Causes	467	93.4	11.9
Total Acute	3918	783.6	100.0
Arranged in Public			
Myocardial Infarction	41	8.2	7.5
Other Ischaemic Heart Disease	34	6.8	6.2
Other Cardiovascular Causes	115	23	21.1
Cancers	169	33.8	31.0
Other Causes	134	26.8	24.6
Injuries	52	10.4	9.5
Total Arranged in Public	545	109	100.0
Elective/Waiting List			
Myocardial Infarction	68	13.6	7.2
Other Ischaemic Heart Disease	101	20.2	10.7
Other Cardiovascular Causes	168	33.6	17.9
Cancers	369	73.8	38.2
Respiratory Diseases	41	8.2	4.4
Gastrointestinal Conditions	57	11.4	6.1
Injuries	25	5	2.7
Other Causes	112	22.4	11.9
Total Elective/Waiting List	941	188.2	100
Grand Total	5404	1080.8	100

(Missing = 1427).
Data source: NMC: Thirty-day deaths following a general anaesthetic (as recorded in the NMDS).
COPD: Chronic obstructive pulmonary disease.

Thirty-day mortality following one or more general anaesthetics by age

In New Zealand during 2009–2013, 30-day mortality following one or more general anaesthetics increased with increasing age for all admission types, although a small peak in mortality is evident for those aged 0–4 years in the acute category (Figure 1). Acute admissions had generally higher mortality rates in every age group compared with publicly arranged (semi-acute) admissions, which in turn had generally higher rates for each age group compared with elective/waiting list admissions.

Figure 1: Thirty-Day Mortality following Hospital Admission with One or More General Anaesthetics by Age and Admission Type, New Zealand 2009–2013

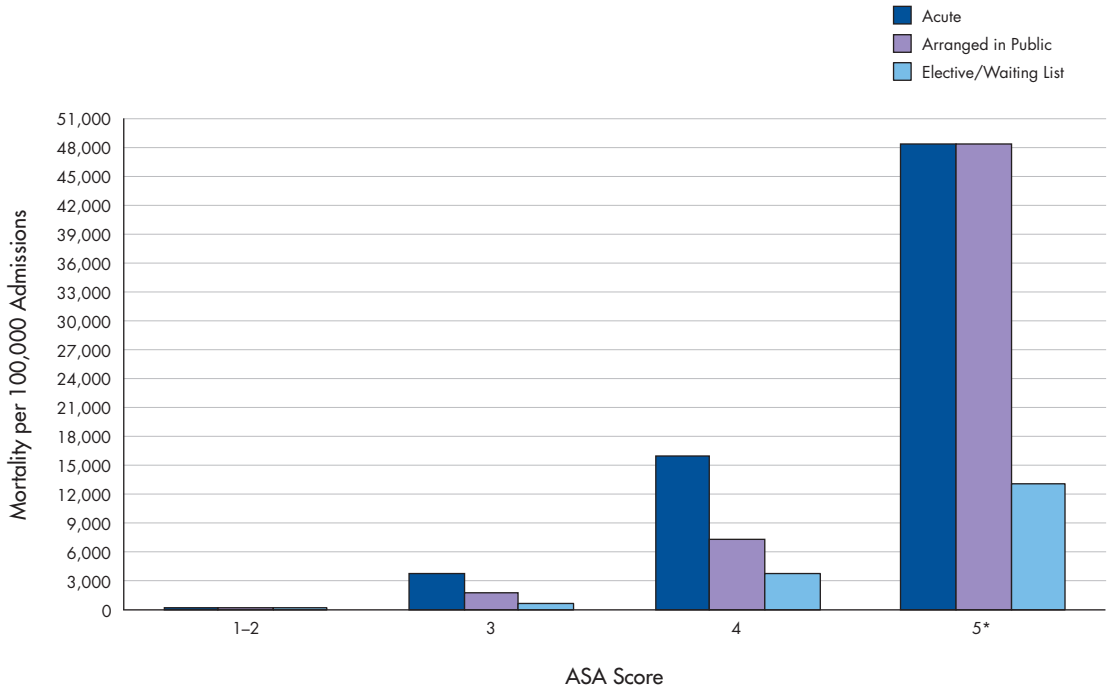


Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Hospital admissions with one or more general anaesthetics listed in the first 90 procedures.

Thirty-day mortality following one or more general anaesthetics by ASA score

Thirty-day mortality following one or more general anaesthetics increased with ASA score for each admission type during 2009–2013 (Figure 2). Within ASA categories 1–4, and most evident for those admissions with an ASA score of 3 or 4, there was a higher rate of mortality for those admitted acutely than for those admitted electively/from the waiting list or semi-acutely. Among those patients admitted with an ASA score of 5 there were high mortality rates, especially for acute admissions and publicly arranged (semi-acute) admissions. Note that the sample sizes were small for elective/waiting list admissions with ASA scores of 5 (3 deaths).

Figure 2: Thirty-Day Mortality following Hospital Admission with One or More General Anaesthetics by Admission Type and ASA Score, New Zealand 2009–2013



Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Hospital admissions with one or more general anaesthetics listed in the first 90 procedures. ASA score is first listed ASA score per admission.
* Care should be taken when interpreting ASA 5 scores for elective/waiting list and publicly arranged (semi-acute) admissions, as each are based on <3 deaths.

Thirty-day mortality following one or more general anaesthetics by socio-demographic factors, number of anaesthetics and ASA score

Acute admissions

During 2009–2013, 30-day mortality following an acute hospital admission with one or more general anaesthetics was significantly higher for those age groups over 65 years (vs 45–64 years), those who received more than one anaesthetic during their admission, those with a first ASA score of 3 or more, Māori (vs European), and those in NZDep deciles 7–10 (vs deciles 1–2) (Table 4). The risk of mortality was significantly lower for those groups aged under 45 years (vs 45–64 years) and for females (vs males). The differences for each of these variables were statistically significant even after the other socio-demographic and clinical factors (age, gender, ethnicity, NZDep decile and ASA score) were adjusted for in the multivariate model.

Elective/Waiting list admissions

Thirty-day mortality after an elective/waiting list hospital admission with a general anaesthetic during 2009–2013 was significantly higher for those groups aged over 65 years (vs 45–64 years), those who received more than one anaesthetic during their admission, Māori (vs European), those in NZDep deciles 5–10 (vs 1 and 2), and those with a first ASA score of 3 or 4 (vs ASA scores 1–2) (Table 5). The risk of mortality was significantly lower for those aged 25–44 years (vs 45–64 years), females (vs males) and Asian/MELAA/Other (vs European). These differences were evident after the other socio-demographic and clinical factors (age, gender, ethnicity, NZDep decile and ASA score) were adjusted for in the multivariate model.

Last ASA score and emergency status for all admissions combined

During 2009–2013, when the emergency status and ASA score of the last listed general anaesthetic were considered, 30-day mortality following any admission type with one or more general anaesthetics was significantly higher for those with an ASA score of 3, 4, 5 or not stated (vs ASA scores 1–2), those with more than one anaesthetic during their admission, and those procedures that were given an emergency status (Table 6). Age groups under 45 years and females (vs males) were associated with a reduction in the mortality odds ratio.

Table 4: Thirty-Day Mortality following Acute Admission with One or More General Anaesthetics by Age Group, Gender, Number of Anaesthetics, First ASA Score, Ethnicity and NZDep Decile, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
Acute Admissions									
Age Group	0–24 Years	256	101,861	251.3	0.25	0.16*	0.14–0.18	0.27*	0.23–0.31
	25–44 Years	280	76,690	365.1	0.37	0.23*	0.20–0.26	0.39*	0.34–0.45
	45–64 Years	953	60,235	1,582.1	1.58	1		1	
	65–79 Years	1,617	34,228	4,724.2	4.72	3.09*	2.85–3.35	2.01*	1.84–2.19
	80+ Years	1,870	20,751	9,011.6	9.01	6.19*	5.71–6.70	3.51*	3.21–3.84
Gender	Male	2,610	137,582	1,897.1	1.90	1		1	
	Female	2,366	156,183	1,514.9	1.51	1.03	0.97–1.09	0.93*	0.87–0.99
Number of Anaesthetics	1	4,008	272,036	1,473.3	1.47	1		1	
	2+	955	21,714	4,398.1	4.40	3.47*	2.99–4.02	2.01*	1.86–2.18
First ASA Score	1–2	354	192,626	183.8	0.18	1		1	
	3	1,533	38,697	3,961.5	3.96	22.40*	19.95–25.16	7.86*	6.94–8.91
	4	1,790	11,150	16,053.8	16.05	103.87*	92.51–116.63	34.40*	30.36–38.98
	5	313	646	48,452.0	48.45	H*	H	H*	H
	Not Stated	973	50,631	1,921.7	1.92	10.64*	9.42–12.02	7.58*	6.69–8.60
Ethnicity	European	3,813	189,761	2,009.4	2.01	1		1	
	Māori	620	53,357	1,162.0	1.16	0.58*	0.53–0.63	1.23*	1.18–1.36
	Pacific	247	26,889	918.6	0.92	0.45*	0.40–0.51	0.95	0.82–1.10
	Asian/ MELAA/ Other	217	19,980	1,086.1	1.09	0.54*	0.47–0.62	1.13	0.97–1.31
NZDep Decile	Deciles 1–2	628	42,748	1,469.1	1.47	1		1	
	Deciles 3–4	713	45,955	1,551.5	1.55	1.05	0.95–1.18	1	0.89–1.12
	Deciles 5–6	972	53,610	1,813.1	1.81	1.24*	1.12–1.37	1.07	0.96–1.19
	Deciles 7–8	1263	64,500	1,958.1	1.96	1.34*	1.22–1.47	1.16*	1.04–1.28
	Deciles 9–10	1349	83,688	1,611.9	1.61	1.10*	1.00–1.21	1.18*	1.06–1.31

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Acute hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, MELAA: Middle Eastern/Latin American/African, H: Odds ratios suppressed due to high mortality rates.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Table 5: Thirty-Day Mortality following Elective/Waiting List Admission with One or More General Anaesthetics by Age Group, Gender, Number of Anaesthetics, First ASA Score, Ethnicity and NZDep Decile, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
Elective/Waiting List Admissions									
Age Group	0–24 Years	32	232,488	13.8	0.01	0.16*	0.11–0.23	0.19*	0.13–0.27
	25–44 Years	49	174,931	28	0.03	0.33*	0.24–0.44	0.42*	0.30–0.57
	45–64 Years	220	255,970	85.9	0.09	1		1	
	65–79 Years	519	134,168	386.8	0.39	4.51*	3.86–5.29	3.02*	2.56–3.57
	80+ Years	345	31,532	1,094.1	1.09	12.86*	10.86–15.24	6.43*	5.33–7.76
Gender	Male	676	386,812	174.8	0.17	1		1	
	Female	489	442,276	110.6	0.11	0.63*	0.56–0.71	0.78*	0.69–0.88
Number of Anaesthetics	1	907	822,839	110.2	0.11	1		1	
	2+	258	6,250	4,128.0	4.13	39.02*	33.90–44.91	13.91*	11.92–16.23
First ASA Score	1–2	200	404,479	49.4	0.05	1		1	
	3	490	72,533	675.6	0.68	13.75*	11.66–16.21	4.80*	4.04–5.72
	4	207	5,491	3,769.8	3.77	79.19*	65.08–96.36	20.12*	16.28–24.86
	5	s	23	13,043.5	13.04	s	s	s	s
	Not Stated	265	346,563	76.5	0.08	1.55*	1.29–1.86	1.52*	1.26–1.84
Ethnicity	European	943	611,172	154.3	0.15	1		1	
	Māori	137	101,574	134.9	0.13	0.87	0.73–1.05	1.62*	1.33–1.97
	Pacific	34	38,082	89.3	0.09	0.58*	0.41–0.81	1	0.69–1.45
	Asian/ MELAA/ Other	23	50,038	46	0.05	0.30*	0.20–0.45	0.63*	0.41–0.96
NZDep Decile	Deciles 1–2	140	154,202	90.8	0.09	1		1	
	Deciles 3–4	181	150,932	119.9	0.12	1.32*	1.06–1.65	1.21	0.96–1.51
	Deciles 5–6	255	165,605	154	0.15	1.70*	1.38–2.09	1.33*	1.08–1.65
	Deciles 7–8	286	180,747	158.2	0.16	1.74*	1.43–2.14	1.33*	1.07–1.63
	Deciles 9–10	298	175,921	169.4	0.17	1.87*	1.53–2.28	1.46*	1.18–1.80

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Elective/Waiting list hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval, *: Significantly different from reference category, s: Suppressed due to small numbers, MELAA: Middle Eastern/Latin American/African.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Table 6: Thirty-Day Mortality following Hospital Admission with One or More General Anaesthetics by Age Group, Gender, Number of Anaesthetics, Last Documented ASA Score and Emergency Status, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
Acute, Arranged in Public and Elective/Waiting List Combined									
Age Group	0–24 Years	360	370,569	97.1	0.10	0.24*	0.21–0.27	0.38*	0.34–0.43
	25–44 Years	365	277,601	131.5	0.13	0.32*	0.29–0.36	0.48*	0.43–0.54
	45–64 Years	1,343	330,631	406.2	0.41	1		1	
	65–79 Years	2,340	177,473	1,318.50	1.32	3.28*	3.06–3.50	2.11*	1.97–2.27
	80+ Years	2,347	55,108	4,258.90	4.26	10.91*	10.19–11.67	4.55*	4.23–4.90
Gender	Male	3,607	579,057	622.9	0.62	1		1	
	Female	3,148	632,323	497.8	0.50	0.80*	0.76–0.84	0.91*	0.86–0.96
Number of Anaesthetics	1	5,395	1,180,452	457	0.46	1		1	
	2+	1,360	30,930	4,397.00	4.40	10.02*	9.43–10.64	3.13*	2.91–3.36
Last Documented ASA Score	1–2	501	645,664	77.6	0.08	1		1	
	3	2,075	123,178	1,684.60	1.68	22.07*	20.01–24.33	8.65*	7.80–9.58
	4	2,314	19,349	11,959.30	11.96	174.93*	158.6–192.9	45.54*	40.9–50.6
	5	419	785	53,375.80	53.38	H*	H	H*	H
	Not Stated	1,446	422,406	342.3	0.34	4.42*	3.99–4.90	4.75*	4.28–5.27
Emergency Status	Non-Emergency/ Not Stated	3,713	1,059,029	350.6	0.35	1		1	
	Emergency Procedure	3,042	152,353	1,996.70	2.00	5.79*	5.52–6.08	2.76*	2.60–2.94

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, H: Odds ratios suppressed due to high mortality rates.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Background: Hospital admissions with one or more general anaesthetics

Admissions with one or more general anaesthetics by admission type

In New Zealand during 2009–2013, the majority of admissions with one or more general anaesthetics were elective/drawn from the waiting list (68.4%) followed by acute admissions (24.2%). Arranged in public (semi-acute) admissions (occurring within seven days of referral) were the least common admission type (7.3%) (Table 7). Admissions to private hospitals accounted for 37.9% of the elective/waiting list admissions. Acute admissions to private hospitals were rare.

Table 7: Hospital Admissions with One or More General Anaesthetics by Admission Type, New Zealand 2009–2013

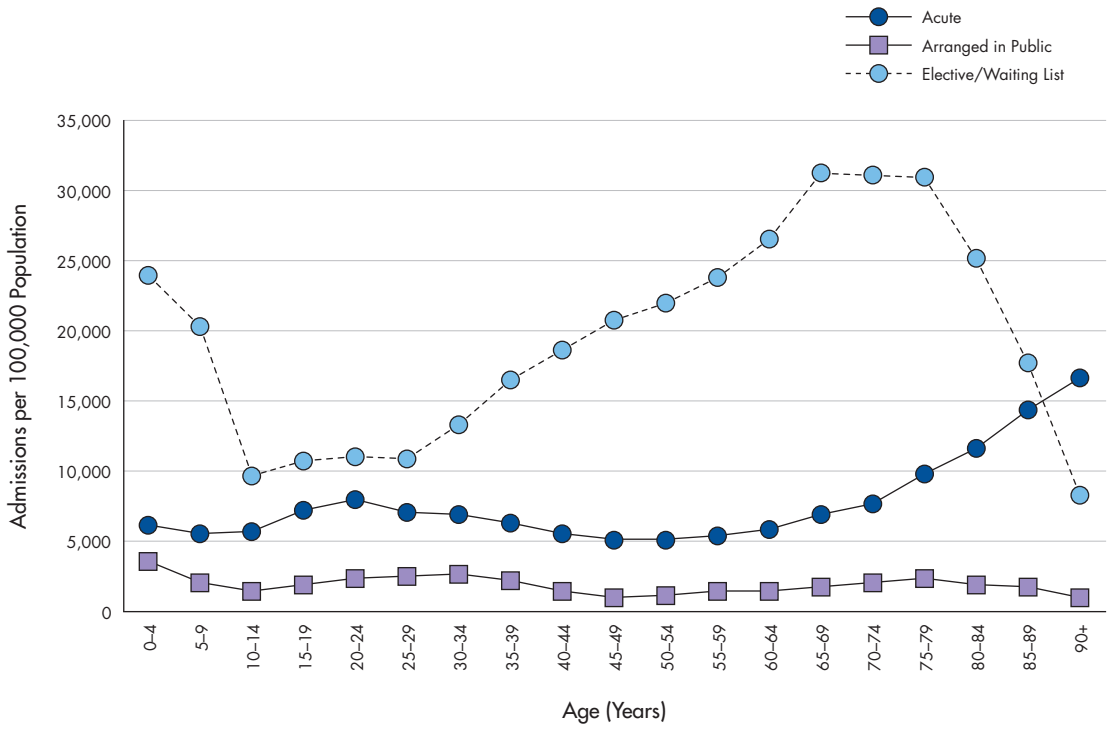
ADMISSION TYPE	Total Admission Events 2009–2013	Annual Average	Admissions (%)
One or More General Anaesthetics			
Acute	293,750	58,750	24.2
Arranged in Public	88,520	17,704	7.3
Elective/Waiting List	829,089	165,818	68.4
Total Admissions	1,211,359	242,272	100.0

Data source: NMDS: Hospital admissions with one or more general anaesthetics listed in the first 90 procedures.

Admissions with one or more general anaesthetics by admission type and age

From 2009 to 2013, elective/waiting list admissions with one or more general anaesthetics were highest in young people aged 0–4 years, and declined rapidly until ages 10–14 years (Figure 3). After this age, elective/waiting list admission rates began to increase again, peaking overall at 65–79 years before declining in the older age groups. Acute admission rates increased slightly during the teenage years up to the 20–24-year age group, after which rates declined. After ages 50–54, acute admissions increased again, reaching their highest level in those aged 90+ years.

Figure 3: Hospital Admissions with One or More General Anaesthetics by Age and Admission Type, New Zealand 2009–2013



Numerator: NMDS: Hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures.
Denominator: Statistics New Zealand: Estimated Resident Population (projected from 2009).

Admissions with one or more general anaesthetics by age, admission type and gender

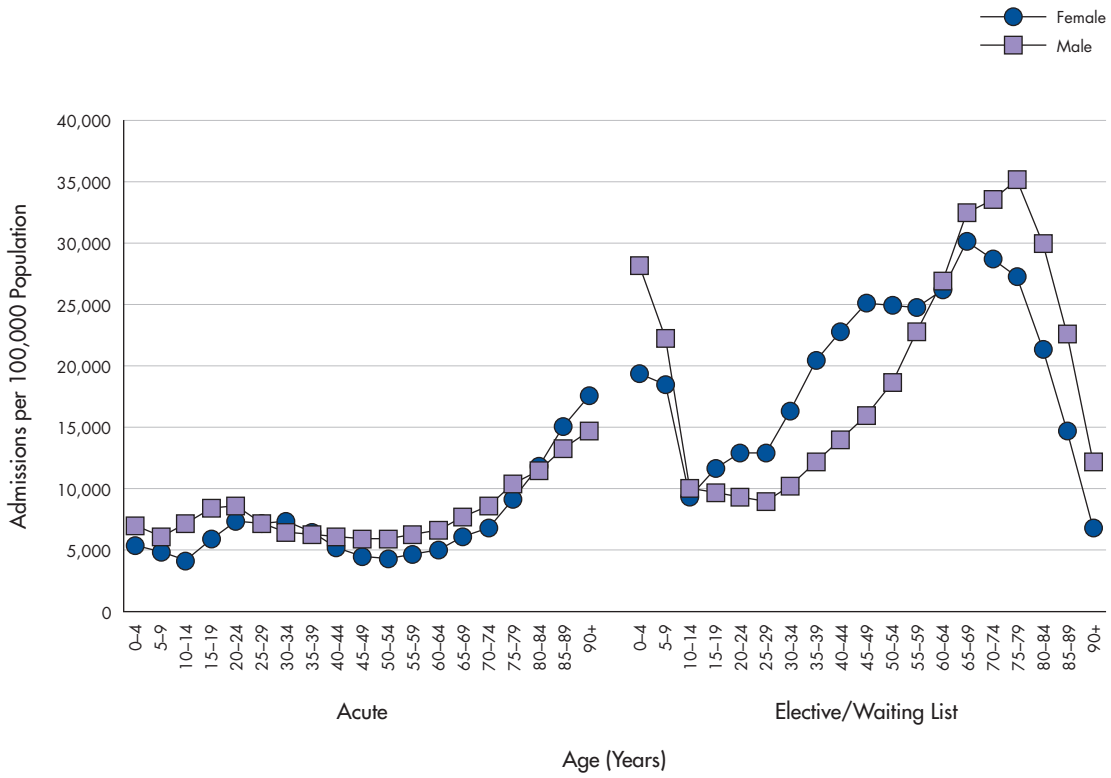
Acute admissions

In New Zealand, acute admission rates during 2009–2013 for males with one or more general anaesthetics decreased during childhood, with rates reaching their low point at ages 5–9 years, before increasing to a small peak in the late teens and early 20s (Figure 4). After this age, male acute admissions declined to another low point in the 40s and 50s, before increasing again with age up to 90+ years. For females, the trends were similar but with the initial low point shifted to the right, and then increasing to a small peak in their 20s and 30s. After the age of 70 years, female acute admission rates increased with age more quickly than for males.

Elective/Waiting list admissions

Elective/Waiting list admissions in children and young people were highest in those aged 0–4 years, with rates then declining rapidly to a low point at ages 10–14 years. Rates then increased to a maximum at approximately 70 years, before declining once more. Admission rates were higher for males than females from ages 0–14 years, and after 60 years of age.

Figure 4: Hospital Admissions with One or More General Anaesthetics by Age, Admission Type and Gender, New Zealand 2009–2013

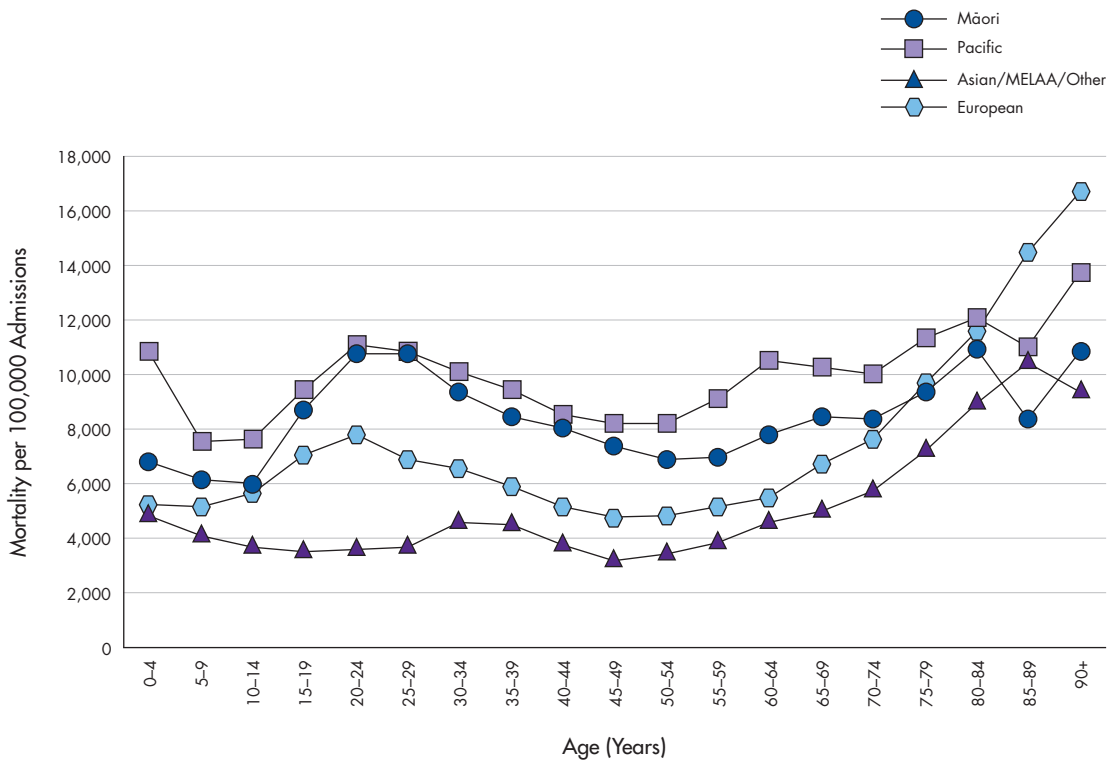


Numerator: NMDS: Hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures.
Denominator: Statistics New Zealand: Estimated Resident Population (projected from 2009).

Admissions with one or more general anaesthetics by age, admission type and ethnicity

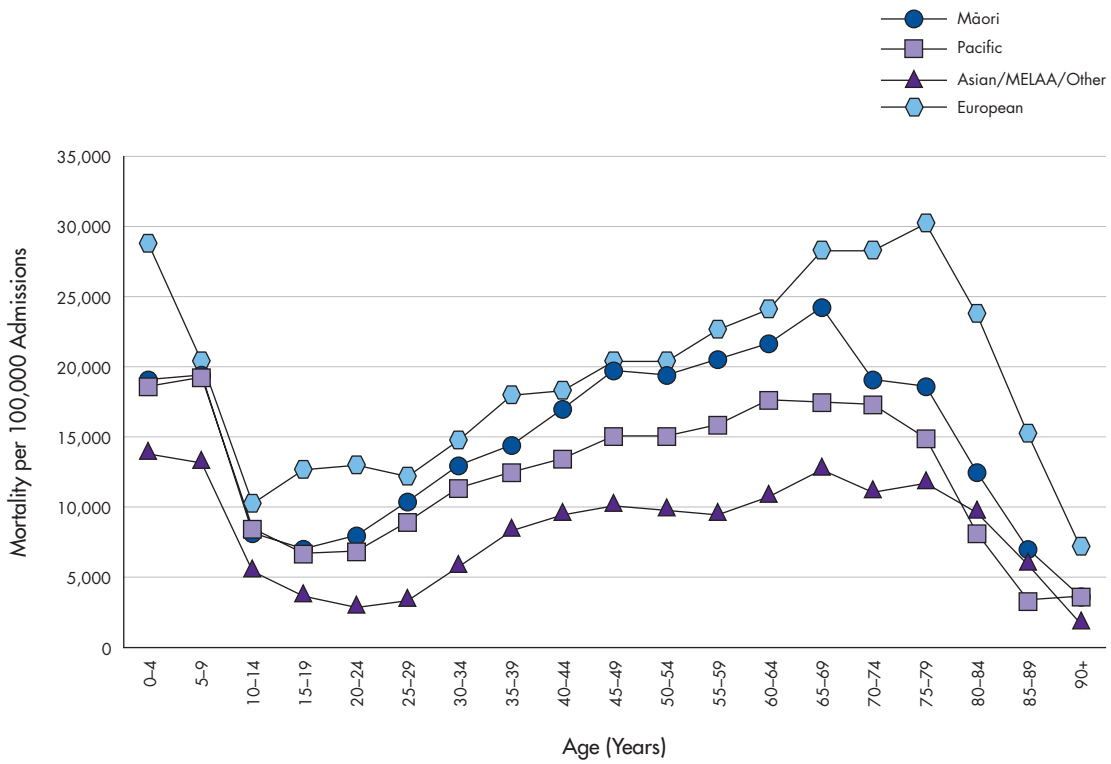
Acute admission rates during 2009–2013 where one or more general anaesthetics were administered were higher for Māori and Pacific peoples than for people of European or Asian ethnicity up until 75 years of age (Figure 5). After this, ethnic differences are less consistent. Elective/Waiting list admission rates with general anaesthesia were higher for people of European ethnicity in every age group (Figure 6).

Figure 5: Acute Hospital Admissions with One or More General Anaesthetics by Age, Admission Type and Ethnicity, New Zealand 2009–2013



Numerator: NMDS: Acute hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures.
Denominator: Statistics New Zealand: Estimated Resident Population (projected from 2009).
MELAA: Middle Eastern/Latin American/African.

Figure 6: Elective/Waiting List Hospital Admissions with One or More General Anaesthetics by Age, Admission Type and Ethnicity, New Zealand 2009–2013



Numerator: NMDS: Elective/Waiting list hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures.
Denominator: Statistics New Zealand: Estimated Resident Population (projected from 2009).
MELAA: Middle Eastern/Latin American/African.

Proportion of admissions with one or more general anaesthetics by age and ASA score

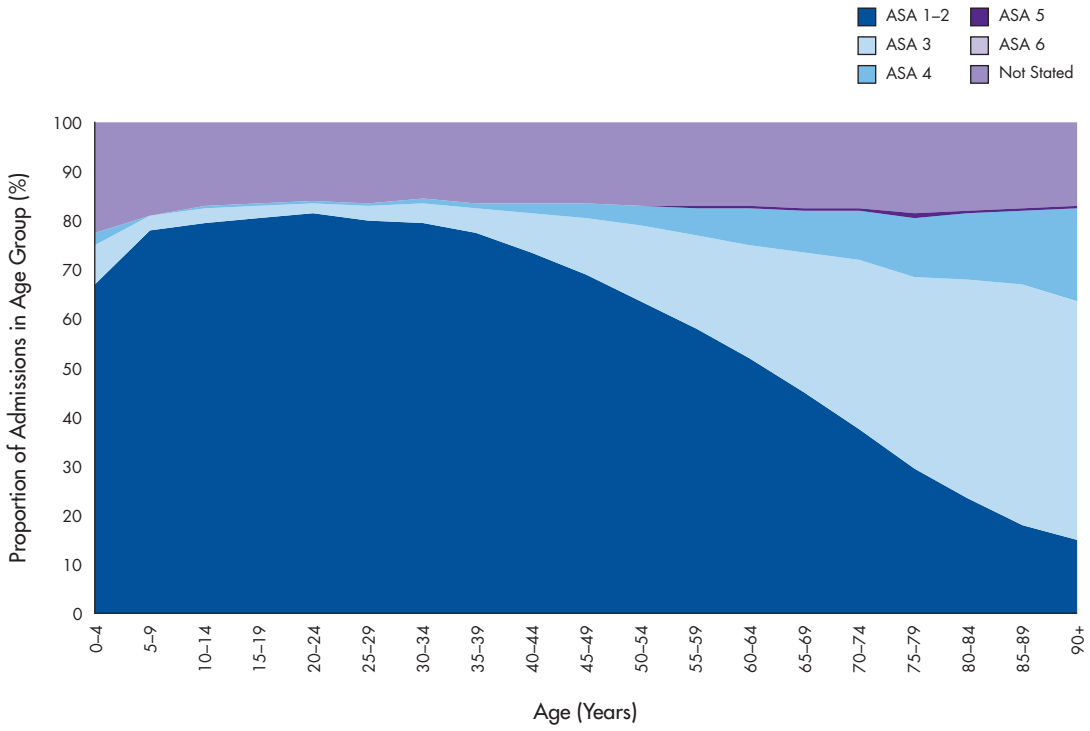
Acute admissions

The proportion of acute hospital admissions with one or more general anaesthetics, where the first documented ASA score was 3 or higher, increased progressively after the age of 30 years (Figure 7). In all age categories, about 20% of cases did not have an ASA score stated.

Elective/Waiting list admissions

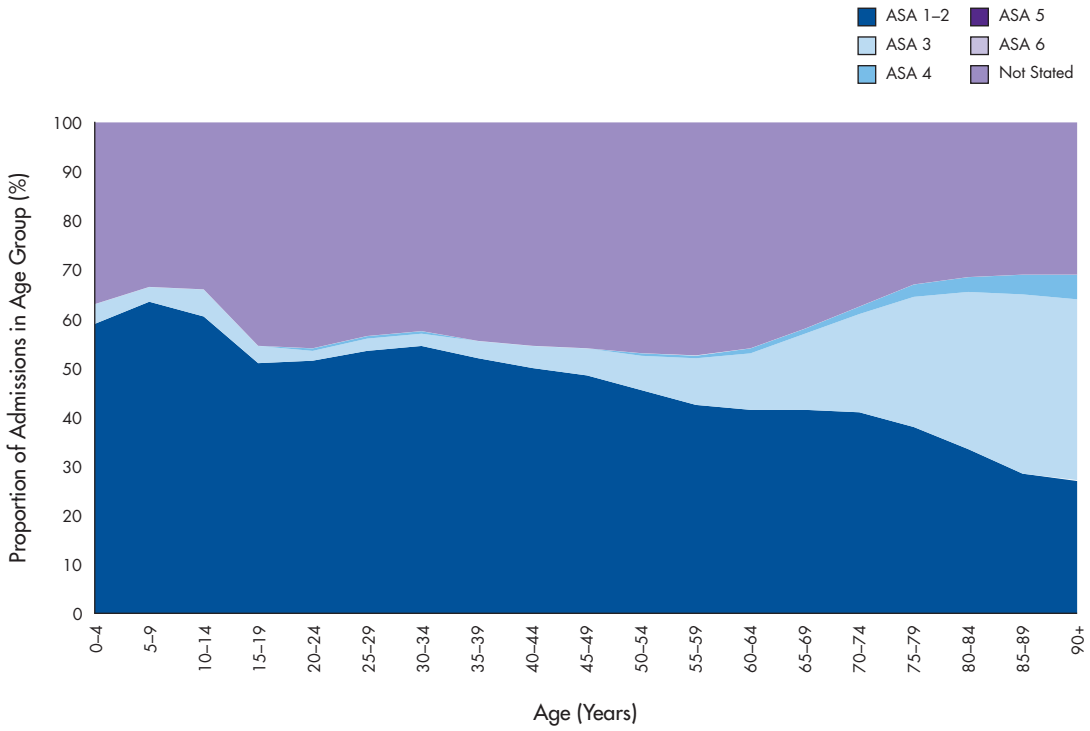
Similar patterns were observed for elective/waiting list admissions, although the proportion of admissions with an ASA score of 4 was less than for acute admissions (Figure 8). Additionally, the proportion of undocumented ASA cases is far higher than acute admissions, with at least 30% not stated for all age groups, making the interpretation of this data more difficult.

Figure 7: Proportion of Acute Hospital Admissions with One or More General Anaesthetics by Age and ASA Score, New Zealand 2009–2013



Data source: NMDS: Acute admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.

Figure 8: Proportion of Elective/Waiting List Hospital Admissions with One or More General Anaesthetics by Age and ASA Score, New Zealand 2009–2013



Data source: NMDS: Elective/Waiting list admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.

Day-of-the-Week Mortality

This chapter presents information from the NMDS and the NMC on mortality in the first 30 days following hospital admissions where one or more general anaesthetics were performed, examined by the day of the week the procedure occurred. This is the first report for which the POMRC includes day of the week in multivariate analyses of 30-day mortality.

Key findings

In New Zealand during 2009–2013, in the first 30 days following general anaesthetic, taking into account the day of the week the first procedure occurred:

- Mortality among all admissions whose first procedure with a general anaesthetic was on a Saturday or Sunday was significantly higher compared to mortality among those whose first procedure was on Tuesday (ie, a 'weekend effect' was shown), after adjusting for socio-demographic and clinical factors (CCI and ASA score).
- Among those admitted acutely, the risk of mortality following the first procedure with a general anaesthetic was significantly higher if the day of procedure was either Saturday or Sunday, compared to Tuesday, after adjusting for socio-demographic and clinical factors.
- Among those admitted electively, the risk of mortality following the first procedure with a general anaesthetic was significantly higher for weekend procedures (Saturday and Sunday combined), compared to Tuesday procedures, after adjusting for socio-demographic and clinical factors.
- The association between increased mortality risk and weekend procedures was greater for those admitted electively (ie, the weekend effect was more pronounced for elective procedures).
- Multivariate analyses revealed similar results when patient transfers were excluded. This suggests the observed weekend effects cannot be explained by the transferring in of sicker patients, or the discharge (transferring out) of healthier patients for postoperative care in other hospitals.
- The POMRC completed additional subgroup analyses of high- and low-risk procedures, as well as procedure-specific analyses (coronary artery bypass graft (CABG), hip/knee arthroplasty, colorectal resection). Some of these analyses showed significant differences in mortality between weekday and weekend procedures; however, these results are not reported here because of low statistical power related to small numbers of weekend deaths.

Recommendations

Improvements to care:[8]

- Death following elective surgery performed on the weekend should be investigated in depth by that health care institution, assessing all potential contributory factors.

Further research and research funding:

- The difference in mortality between patients having procedures in the weekend compared to weekdays, in particular those admitted electively, should be investigated.

8 It was noted from the POMRC consultation that some DHBs did not perform elective procedures during the weekends.

Data sources, methods and limitations

In the multivariate analyses presented in this chapter, mortality in the first 30 days following admission with an initial general anaesthetic was analysed for each weekday, comparing against Tuesday rates, and adjusting for socio-demographic and clinical factors. This was done for both acute and elective admission types, with additional analyses excluding patient transfers.

The following details of the methods should be considered when reading this chapter:

- Tuesday was used as the comparison day of the week for all analyses because it is thought to be a relatively stable day in terms of patient volume and case-mix, and representative of other weekdays. Other studies have used Monday as a reference day, but this day may be impacted by service disruptions that continue on from the weekend (eg, a back-log of specialist diagnostic testing and acute admissions requiring operations created from the weekend that could not be addressed until the following Monday). To investigate whether choosing Tuesday as the reference day was appropriate, additional analyses of mortality following all admissions with one or more general anaesthetics (2009–2013) were re-run – using each weekday as a reference day and comparing against the weekend (Saturday and Sunday combined). These showed there was a significant increase in mortality odds ratios (a 'weekend effect') for weekend procedures, regardless of which weekday was chosen as the reference day. There were also no significant differences in the magnitude of the odds ratios produced when each of the different weekdays were used as the reference.
- 'Weekend' deaths (Saturday and Sunday) were combined for the elective analysis because of small numbers of Saturday and Sunday deaths. Combining these into a total 'weekend' count was required to achieve adequate statistical power.
- Patient transfers were excluded to restrict the admissions only to those whose care was provided at a single hospital over the weekend (see Table 11). Some patients may have been transferred into the hospital where they died on the weekend, but had the procedure at a different hospital; similarly, some patients may have had a procedure at one hospital and then been transferred out to a different hospital for postoperative care.
- All day cases were excluded from analyses.

Additional information on data sources, methods and interpretation notes are presented in Appendix 2.

Day-of-the-week mortality following admissions with one or more general anaesthetics

Mortality following admissions with one or more general anaesthetics by day of procedure, socio-demographic factors, CCI and ASA score

All admissions

During 2009–2013, among all types of admissions, mortality in the first 30 days following an initial general anaesthetic was significantly higher for those patients aged over 64 years (vs 45–64 years), those with a first ASA score of 3–5 (vs ASA 1–2), Māori (vs European), those with domiciles in NZDep deciles 5–10 (vs 1–2), those with one or more comorbidities (vs none), those undergoing a procedure in the weekend (vs Tuesday) and those who were admitted acutely (vs elective admissions) (Table 8). Mortality odds ratios were significantly lower among those aged under 45 years (vs 45–64 years), females (vs males) and Pacific peoples (vs European). These differences occurred when the risk was adjusted for other socio-demographic and clinical factors.

Table 8: Day-of-the-Week Mortality following All Admissions with One or More General Anaesthetics by Age Group, Gender, First ASA Score, Ethnicity, NZDep Decile and Charlson Comorbidity Index, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
All Admissions									
Age Group	0–24 Years	360	370,569	97.1	0.10	0.24*	0.21–0.27	0.56*	0.50–0.64
	25–44 Years	365	277,601	131.5	0.13	0.32*	0.29–0.36	0.62*	0.55–0.70
	45–64 Years	1,343	330,631	406.2	0.41	1.00		1.00	
	65–79 Years	2,340	177,473	1,318.5	1.32	3.28*	3.06–3.50	1.80*	1.73–2.01
	80+ Years	2,347	55,108	4,258.9	4.26	10.91*	10.19–11.67	3.53*	3.27–3.82
Gender	Male	3,607	579,057	622.9	0.62	1.00		1.00	
	Female	3,148	632,323	497.8	0.50	0.80*	0.76–0.84	0.94*	0.89–0.99
First ASA Score	1–2	597	646,851	92.3	0.09	1.00		1.00	
	3	2,237	123,222	1,815.4	1.82	20.00*	18.27–21.90	4.17*	3.78–4.61
	4	2,204	19,460	11,325.8	11.33	138.19*	126.08–151.45	14.53*	13.11–16.10
	5	344	727	47,317.7	47.32	H*	H	H*	H
	Not Stated	1,373	421,122	326.0	0.33	3.54*	3.22–3.90	3.79*	3.43–4.18
Ethnicity	European	5,196	856,727	606.5	0.61	1.00		1.00	
	Māori	860	171,602	501.2	0.50	0.83*	0.77–0.89	1.10*	1.01–1.20
	Pacific	320	72,915	438.9	0.44	0.72*	0.65–0.81	0.75*	0.65–0.85
	Asian/ MELAA/ Other	268	76,929	348.4	0.35	0.57*	0.51–0.65	0.87	0.76–1.00
NZDep Decile	Deciles 1–2	832	209,419	397.3	0.40	1.00		1.00	
	Deciles 3–4	972	210,833	461.0	0.46	1.16*	1.06–1.27	1.05	0.95–1.16
	Deciles 5–6	1,346	235,253	572.1	0.57	1.44*	1,32–1.57	1.12*	1.02–1.24
	Deciles 7–8	1,711	265,556	644.3	0.64	1.63*	1.50–1.77	1.20*	1.09–1.31
	Deciles 9–10	1,834	284,815	643.9	0.64	1.63*	1.50–1.76	1.24*	1.13–1.36
Charlson Comorbidity Index	0	1,454	1,053,464	138.0	0.14	1.00		1.00	
	1–2	2,420	110,349	2,193.0	2.19	16.22*	15.20–17.31	4.89*	4.54–5.27
	3+	2,881	47,569	6,056.5	6.06	46.64*	43.76–49.71	10.52*	9.74–11.35
Day of the Week	Tuesday	1,141	239,476	476.5	0.48	1.00		1.00	
	Wednesday	1,144	240,217	476.2	0.48	1.00	0.92–1.09	1.07	0.97–1.16
	Thursday	1,141	239,149	477.1	0.48	1.00	0.92–1.09	0.98	0.90–1.07
	Friday	1,046	202,261	517.2	0.52	1.08	0.99–1.19	1.01	0.92–1.10
	Saturday	672	39,279	1,710.8	1.71	3.64*	3.30–4.00	1.43*	1.29–1.60
	Sunday	540	36,459	1,481.1	1.48	3.14*	2.83–3.48	1.33*	1.19–1.50
	Monday	1,071	214,541	499.2	0.50	1.05	0.96–1.14	1.07	0.98–1.18
Admission Type	Elective	1792	917,609	195.3	0.20	1.00		1.00	
	Acute	4963	293,750	1,689.5	1.69	8.78*	8.32–9.27	4.56*	4.29–4.85

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, MELAA: Middle Eastern/Latin American/African, H: Odds ratios suppressed due to high mortality rates.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Acute admissions

During 2009–2013, among acute admissions, mortality in the first 30 days following an initial general anaesthetic was significantly higher for those patients aged over 64 years (vs 45–64 years), those with a first ASA score of 3–5 (vs ASA 1–2), those with domiciles in NZDep deciles 9–10 (vs 1–2), those with one or more comorbidities (vs none), and those undergoing a procedure in the weekend or on a Monday (vs Tuesday) (Table 9). Mortality odds ratios were significantly lower among those aged under 45 years (vs 45–64 years), and Pacific peoples (vs European). These differences occurred when the risk was adjusted for other socio-demographic and clinical factors.

Elective/Waiting list admissions

During 2009–2013, among elective admissions, mortality in the first 30 days following an initial general anaesthetic was significantly higher for those patients aged over 64 years (vs 45–64 years), those with a first ASA score of 3–5 (vs ASA 1–2), Māori (vs European), those with domiciles in NZDep deciles 5–10 (vs 1–2), those with one or more comorbidities (vs none), and those undergoing a procedure in the weekend (vs Tuesday) (Table 10). Mortality odds ratios were significantly lower among those aged less than 45 years (vs 45–64 years), females (vs males) and those of Asian/MELAA/Other ethnicity (vs European). These differences occurred when the risk was adjusted for other socio-demographic and clinical factors.

Table 9: Day-of-the-Week Mortality following Acute Admission with One or More General Anaesthetics by Age Group, Gender, First ASA Score, Ethnicity, NZDep Decile and Charlson Comorbidity Index, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
Acute Admissions									
Age Group	0–24 Years	254	101,858	249.4	0.25	0.16*	0.14–0.18	0.52*	0.45–0.61
	25–44 Years	277	76,686	361.2	0.36	0.23*	0.20–0.26	0.60*	0.52–0.69
	45–64 Years	949	60,231	1,575.6	1.58	1.00			
	65–79 Years	1,613	34,224	4,713.1	4.71	3.09*	2.85–3.35	1.72*	1.57–1.88
	80+ Years	1,870	20,751	9,011.6	9.01	6.19*	5.71–6.70	3.13*	2.86–3.43
Gender	Male	2,604	156,176	1,667.3	1.67	1.00		1.00	
	Female	2,359	137,574	1,714.7	1.71	1.03	0.97–1.09	0.98	0.92–1.05
First ASA Score	1–2	354	192,626	183.8	0.18	1.00		1.00	
	3	1,533	38,697	3,961.5	3.96	22.40*	19.95–25.16	4.57*	4.02–5.20
	4	1,790	11,150	16,053.8	16.05	103.87*	92.51–116.63	16.01*	13.93–19.23
	5	313	646	48,452.0	48.45	H*	H	H*	H
	Not Stated	973	50,631	1,921.7	1.92	10.64*	9.42–12.04	5.69*	5.01–6.47
Ethnicity	European	3,802	189,748	2,003.7	2.00	1.00		1.00	
	Māori	620	53,357	1,162.0	1.16	0.58*	0.53–0.63	1.02	0.93–1.13
	Pacific	246	26,888	914.9	0.91	0.45*	0.40–0.51	0.72*	0.63–0.83
	Asian/ MELAA/ Other	217	19,980	1,086.1	1.09	0.54*	0.47–0.62	0.96	0.82–1.12
NZDep Decile	Deciles 1–2	626	42,745	1,464.5	1.46	1.00		1.00	
	Deciles 3–4	709	45,950	1,543.0	1.54	1.05	0.95–1.18	1.00	0.88–1.12
	Deciles 5–6	970	53,608	1,809.4	1.81	1.24*	1.12–1.37	1.04	0.93–1.16
	Deciles 7–8	1,258	64,495	1,950.5	1.95	1.34*	1.22–1.47	1.11	0.99–1.23
	Deciles 9–10	1,349	83,688	1,611.9	1.61	1.10	1.00–1.21	1.14*	1.02–1.27
Charlson Comorbidity Index	0	1,027	247,627	414.7	0.41	1.00		1.00	
	1–2	1,841	29,192	6,306.5	6.31	16.16*	14.96–17.46	4.06*	3.72–4.44
	3+	2,095	16,931	12,373.8	12.37	33.91*	31.41–36.60	7.81*	7.13–8.55
Day of the Week	Tuesday	744	45,969	1,618.5	1.62	1.00		1	
	Wednesday	794	45,543	1,743.4	1.74	1.08	0.98–1.19	1.12	1.00–1.25
	Thursday	790	46,636	1,693.9	1.69	1.05	0.95–1.16	0.99	0.89–1.11
	Friday	771	46,654	1,652.6	1.65	1.02	0.92–1.13	1.03	0.92–1.15
	Saturday	625	33,250	1,879.7	1.88	1.17*	1.05–1.30	1.38*	1.23–1.58
	Sunday	493	31,871	1,546.9	1.55	0.96	0.85–1.07	1.25*	1.10–1.42
	Monday	746	43,827	1,702.2	1.70	1.05	0.95–1.17	1.15*	1.03–1.29

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Acute hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, MELAA: Middle Eastern/Latin American/African, H: Odds ratios suppressed due to high mortality rates.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Table 10: Day-of-the-Week Mortality following Elective/Arranged/Waiting List Admission with One or More General Anaesthetics by Age Group, Gender, First ASA Score, Ethnicity, NZDep Decile and Charlson Comorbidity Index, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
General Anaesthetic									
Elective/Arranged/Waiting List									
Age Group	0–24 Years	106	268,704	39.4	0.04	0.27*	0.22–0.34	0.53*	0.42–0.66
	25–44 Years	88	200,909	43.8	0.04	0.30*	0.24–0.38	0.60*	0.47–0.76
	45–64 Years	394	270,397	145.7	0.15	1.00			
	65–79 Years	727	143,245	507.5	0.51	3.50*	3.09–3.95	2.01*	1.77–2.29
	80+ Years	477	34,354	1,388.5	1.39	9.65*	8.44–11.03	3.90*	3.36–4.51
Gender	Male	1,003	422,864	237.2	0.24	1.00		1.00	
	Female	789	494,743	159.5	0.16	0.67*	0.61–0.74	0.88*	0.80–0.97
First ASA Score	1–2	243	454,212	53.5	0.05	1.00		1.00	
	3	704	84,520	832.9	0.83	15.70*	13.56–18.16	4.43*	3.80–5.16
	4–5	445	8,391	5,303.3	5.30	104.62*	89.34–122.52	19.98*	16.87–23.66
	Not Stated	400	370,486	108.0	0.11	2.02*	1.72–2.37	2.33*	1.98–2.74
Ethnicity	European	1,394	666,961	209.0	0.21	1.00		1.00	
	Māori	240	118,241	203.0	0.20	0.97	0.85–1.11	1.32*	1.14–1.54
	Pacific	74	46,027	160.8	0.16	0.77*	0.61–0.97	0.92	0.71–1.17
	Asian/ MELAA/ Other	51	56,948	89.6	0.09	0.43*	0.32–0.57	0.70*	0.52–0.93
NZDep Decile	Deciles 1–2	206	166,673	123.6	0.12	1.00		1.00	
	Deciles 3–4	263	164,881	159.5	0.16	1.29*	1.08–1.55	1.15	0.95–1.38
	Deciles 5–6	376	181,642	207.0	0.21	1.68*	1.41–1.99	1.29*	1.08–1.53
	Deciles 7–8	453	201,056	225.3	0.23	1.83*	1.55–2.15	1.33*	1.12–1.57
	Deciles 9–10	485	201,115	241.2	0.24	1.95*	1.66–2.30	1.39*	1.17–1.66
Charlson Comorbidity Index	0	427	805,823	53.0	0.05	1.00		1.00	
	1+	1,365	111,786	1,221.1	1.22	23.32*	20.91–26.00	8.54*	7.54–9.67
Day of the Week	Tuesday	397	193,505	205.2	0.21	1.00		1	
	Wednesday	350	194,659	179.8	0.18	0.88	0.76–1.01	0.98	0.85–1.14
	Thursday	351	192,512	182.3	0.18	0.89	0.77–1.03	0.97	0.84–1.13
	Friday	275	155,604	176.7	0.18	0.86	0.74–1.00	0.98	0.83–1.15
	Weekend	94	10,617	885.4	0.89	4.34*	3.47–5.44	2.60*	2.04–3.31
	Monday	325	170,712	190.4	0.19	0.93	0.80–1.07	0.94	0.81–1.09

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: Elective/Arranged/Waiting list hospital admissions with one or more general anaesthetics listed in any of the first 90 procedures. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, MELAA: Middle Eastern/Latin American/African.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Transfers excluded

When admissions of patients who were either discharged to another hospital or admitted from another hospital were excluded from the analysis, the odds ratios for mortality in the first 30 days following an initial general anaesthetic were significantly higher for those patients aged over 64 years (vs 45–64 years), those with a first ASA score of 3–5 (vs ASA 1–2), Māori (vs European), those with domiciles in NZDep deciles 7–10 (vs 1–2), those with one or more comorbidities (vs none), those undergoing a procedure in the weekend (vs Tuesday) and those who were admitted acutely (vs elective admissions) (Table 11). Mortality odds ratios were significantly lower among those aged under 45 years (vs 45–64 years), females (vs males) and Pacific peoples (vs European). These differences occurred when the risk was adjusted for other socio-demographic factors and clinical factors.

Overall, excluding the patient transfers did not greatly alter the results of the multivariate analysis (odds ratios were similar in significance and magnitude when the transfers were excluded). This suggests that the weekend effect cannot be explained either by sicker patients being transferred into hospitals during the weekend, or by the loss of healthier patients being discharged for postoperative care to other hospitals.

Specific procedures (data not shown)

Mortality among patients undergoing specific procedures was examined to understand which patients may be affected the most by the 'weekend effect'. Procedures chosen were CABG, colorectal resection, hip and knee joint replacements, and a high-risk and a low-risk group of procedures. Univariate analyses showed there was a significant increase in mortality for patients admitted electively having colorectal resection, hip and knee joint replacements and the low-risk group of procedures; however, because the number of deaths among admissions for weekend procedures was so low, full analyses could not be undertaken.

Table 11: Day-of-the-Week Mortality following All Admissions with One or More General Anaesthetics and No Transfers by Age Group, Gender, First ASA Score, Ethnicity, NZDep Decile and Charlson Comorbidity Index, New Zealand 2009–2013

VARIABLE	CATEGORY	Number of Deaths	Number of Admissions	Mortality per 100,000 Admissions	Mortality per 100 Admissions (%)	Univariate OR	95% CI	Multivariate OR	95% CI
No Transfers									
All Admissions									
Age Group	0–24 Years	225	360,712	62.4	0.06	0.19*	0.17–0.22	0.45*	0.38–0.52
	25–44 Years	279	270,798	103.0	0.10	0.32*	0.28–0.36	0.59*	0.51–0.68
	45–64 Years	1,040	320,166	324.8	0.32	1.00		1.00	
	65–79 Years	1,837	166,111	1,105.9	1.11	3.43*	3.18–3.70	1.98*	1.82–2.16
	80+ Years	1,975	48,026	4,112.4	4.11	13.16*	12.20–14.20	4.04*	3.70–4.41
Gender	Male	2,841	555,425	511.5	0.51	1.00		1.00	
	Female	2,515	610,387	412.0	0.41	0.81*	0.76–0.85	0.92*	0.87–0.98
First ASA Score	1–2	501	630,069	79.5	0.08	1.00		1.00	
	3	1,793	109,769	1,633.4	1.63	20.87*	18.90–23.04	4.03*	3.61–4.49
	4	1,698	13,368	12,702.0	12.70	182.84*	165.22–202.34	15.73*	14.03–17.62
	5	267	481	55,509.4	55.51	H*	H	H*	H
	Not Stated	1,097	412,126	266.2	0.27	3.35*	3.02–3.73	3.70*	3.32–4.13
Ethnicity	European	4,157	825,167	503.8	0.50	1.00		1.00	
	Māori	661	164,015	403.0	0.40	0.80	0.74–0.87	1.15*	1.04–1.27
	Pacific	232	69,430	334.1	0.33	0.66	0.58–0.76	0.69*	0.59–0.80
	Asian/ MELAA/ Other	210	74,468	282.0	0.28	0.56	0.49–0.64	0.85	0.72–1.00
NZDep Decile	Deciles 1–2	700	203,689	343.7	0.34	1.00		1	
	Deciles 3–4	778	204,037	381.3	0.38	1.11	1.00–1.23	1.03	0.92–1.15
	Deciles 5–6	1,061	226,954	467.5	0.47	1.36*	1.24–1.50	1.07	0.96–1.19
	Deciles 7–8	1,364	254,769	535.4	0.54	1.56*	1.43–1.71	1.19*	1.08–1.31
	Deciles 9–10	1,412	271,516	520.0	0.52	1.52*	1.38–1.66	1.19*	1.08–1.32
Charlson Comorbidity Index	0	1,155	1,026,234	112.5	0.11	1.00		1.00	
	1–2	1,929	99,014	1,948.2	1.95	17.63*	16.39–18.97	5.25*	4.83–5.71
	3+	2,272	40,565	5,600.9	5.60	52.66*	49.02–56.56	11.43*	10.49–12.45
Day of the Week	Tuesday	904	231,612	390.3	0.39	1.00		1	
	Weekend	946	68,924	1,372.5	1.37	3.55*	3.24–3.89	1.36*	1.22–1.51
	Monday	859	207,153	414.7	0.41	1.06	0.97–1.17	1.08	0.98–1.20
	Wednesday	917	232,342	394.7	0.39	1.01	0.92–1.11	1.08	0.98–1.19
	Thursday	912	231,049	394.7	0.39	1.01	0.92–1.10	1.01	0.91–1.18
	Friday	818	194,733	420.1	0.42	1.08	0.98–1.18	1.00	0.90–1.11
Admission Type	Elective	1,395	899,249	155.1	0.16	1.00		1.00	
	Acute	3,961	266,542	1,486.1	1.49	9.71*	9.13–10.32	5.34*	4.98–5.72

Numerator: NMC: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: All hospital admissions without transfer in or out from another hospital. ASA score is first listed ASA score per admission.
CI: Confidence interval, OR: Odds ratio with confidence interval,*: Significantly different from reference category, MELAA: Middle Eastern/Latin American/African, H: Odds ratios suppressed due to high mortality rates.
Caution should be used in interpreting ORs where mortality exceeds 10% (see Appendix 2 for details).

Background: Day-of-the-week mortality following hospital admission with one or more general anaesthetics

Day-of-the-week mortality following hospital admission with one or more general anaesthetics by admission type

In New Zealand during 2009–2013, overall mortality rates were higher following acute admissions for procedures with one more general anaesthetics. However, within each admission type, the weekend mortality rate (Saturday and Sunday combined) was much greater than weekday mortality rate (all weekdays combined) among those admitted for elective procedures (Table 12). In other words, the weekend effect was more pronounced for elective procedures.

Table 12: Day-of-the-Week Mortality following Hospital Admission with One or More General Anaesthetics by Admission Type (Weekend and Combined Weekdays), New Zealand 2009–2013

ADMISSION TYPE	Deaths		Admissions		Mortality per 100 Admissions (%)	
	Weekdays (Combined)	Weekend	Weekdays (Combined)	Weekend	Weekdays (Combined)	Weekend
Day-of-the-Week Mortality following One or More General Anaesthetics						
Acute	3,845	1,118	228,629	65,121	1.68	1.71
Elective	1,698	94	906,992	10,617	0.18	0.89
Total	5,543	1,212	1,135,621	75,738	0.49	1.60

Numerator: NMC and NMDS: Thirty-day deaths following a general anaesthetic.
Denominator: NMDS: All hospital admissions with at least one general anaesthetic.

Perioperative Mortality for Previously Reported Clinical Areas

The following series of chapters present the key findings from clinical areas included in previous POMRC reports – reported here for the six-year period 2009–2014. This is part of the POMRC's approach to tracking perioperative mortality over time. These clinical areas include:

- cholecystectomy
- same or next day mortality following general anaesthesia
- hip arthroplasty
- knee arthroplasty
- colorectal resection
- coronary artery bypass graft (CABG)
- percutaneous transluminal coronary angioplasty (PTCA)
- mortality in admissions with an ASA score of 4 or 5
- mortality in elective admissions with an ASA score of 1 or 2.

Among these clinical areas, cholecystectomy is of continuing interest as it is a common procedure undertaken at a wide range of hospitals and is associated with a relatively high number of deaths. Deaths occurring on the same day as and following days after general anaesthesia are included as a general indicator of perioperative care close to the time of anaesthesia and surgery. Both hip and knee arthroplasty, presented in the POMRC's second report, are included again as the use of these procedures is increasing with the ageing population. CABG and PTCA are both included as the procedures are used relatively frequently to treat ischaemic heart disease and are associated with higher mortality rates compared to other procedures. Mortality in elective admissions with an ASA score of 1 or 2 continues to be of interest as these patients have a low risk of death and postoperative complications.

Mortality following Cholecystectomy

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following cholecystectomy. Consistent with the 2015 POMRC report, those procedures in which a cholecystectomy was conducted as a minor component of a more extensive operation have been removed from these analyses (approximately 450 cases).

Key findings

In New Zealand during 2009–2014, following cholecystectomy:

- There were 146 deaths. The overall cumulative mortality was 0.37% of admissions.
- Mortality was higher when an open procedure was undertaken (3.53% of admissions) or when a laparoscopic procedure was converted to an open procedure (1.04% of admissions).
- Cumulative mortality rates were higher among acute admissions (0.70% of admissions) than elective/waiting list admissions (0.22% of admissions).

Findings were generally consistent with those from previous reports.

Mortality following cholecystectomy

In New Zealand during 2009–2014, the annual number of deaths following a cholecystectomy procedure varied between 16 and 30 deaths and annual mortality was 0.26%–0.46% of admissions (Table 13). The cumulative mortality for any cholecystectomy procedure during 2009–2014 was 0.37% of admissions.

Table 13: Mortality following Cholecystectomy by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	28	6,359	0.44
2010	16	6,211	0.26
2011	30	6,557	0.46
2012	21	6,606	0.32
2013	25	6,796	0.37
2014	26	6,551	0.40
Total	146	39,080	0.37
Acute Total	87	12,479	0.70
Elective/Waiting List Total	58	25,814	0.22

Numerator: NMC: Deaths occurring within 30 days of a cholecystectomy as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a cholecystectomy listed in any of the first 90 procedures.

Composite case 1: Elective cholecystectomy

Mrs AB was an ex-smoker, aged 55, with a high body mass index (BMI) and under treatment for high blood pressure with bendrofluazide. She had a past history of biliary colic and her ultrasound showed cholelithiasis (gallstones). When admitted to hospital, an endoscopic retrograde cholangio-pancreatograph (ERCP) was performed, after which Mrs AB was discharged, awaiting cholecystectomy. Liver function tests were settled post-ERCP, and she was assigned an ASA score of 2.

Mrs AB then returned for a laparoscopic cholecystectomy, which was difficult and took longer than usual because of adhesions, but otherwise was uneventful. The next morning (day 1) Mrs AB was noted to have needed treatment for vomiting and pain since return to the ward – in the six hours since her previously recorded observations, she had 100 ml of bile in a drain and a temperature of 37°C, and so the care plan was to monitor and continue intravenous (IV) fluids with sips of water as tolerated. The bile in the drain was attributed to spillage. Later that evening, Mrs AB was noted to be sleepier; this was ascribed to the pain relief medication, so the dosage was decreased. She was still needing IV fluids and her blood pressure was within normal limits, but lower than previously.

The following morning (day 2) at 8 am Mrs AB was noted to still be in pain with vomiting, hypotension and tachycardia, with an increased respiratory rate. A provisional diagnosis of septic shock was made, and she was taken to theatre for an urgent laparotomy that afternoon, where peritonitis with a perforated small bowel was discovered. She was transferred to the intensive care unit where, despite maximal therapy, she died of overwhelming septic shock two days later.

Key clinical practice points:

- **Severe postoperative sepsis has a high mortality (approximately 21% of patients who have had a procedure under general anaesthesia and develop severe postoperative sepsis die within 30 days of the procedure).**
- **Early recognition and management of causes of departure from the expected postoperative course is essential.**
- **Nurse surveillance is essential in timely recognition of a patient's deterioration postoperatively.**

Same or Next Day Mortality following General Anaesthesia

This chapter uses information from the NMDS (calculated using National Health Index data) and the NMC to review hospital admissions where one or more general anaesthetics were performed, as well as same and next day mortality following a general anaesthetic.

Key findings

In New Zealand during 2009–2014, following general anaesthesia on the same or next day:

- There were 1805 deaths (0.12% of admissions). Most of these deaths occurred among acute admissions and at public hospitals.
- Mortality was between 0.11% and 0.15% of admissions each year.
- These findings were consistent with those observed in previous reports.
- The proportion of admissions that have recorded an ASA score has steadily increased over the last six years. In 2014, 71.6% of admissions recorded an ASA score compared with 63.7% of admissions in 2009.

Same or next day mortality following one or more general anaesthetics

In New Zealand during 2009–2014, there were 1805 deaths on the same or next day after general anaesthesia. The overall mortality rate for the six-year period was 0.12% of admissions. The annual rate varied between 0.11% and 0.15% of admissions (Table 14).

Table 14: Same or Next Day Mortality following Hospital Admission with One or More General Anaesthetics by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	311	236,032	0.13
2010	260	237,815	0.11
2011	299	243,453	0.12
2012	275	244,317	0.11
2013	307	249,850	0.12
2014	353	237,575	0.15
Total	1,805	1,449,042	0.12
Acute Total	1,322	353,828	0.37
Elective/Waiting List Total	483	1,062,557	0.05

Data source: NMC: Same day (day 0) or next day (day 1) deaths following a general anaesthetic (as recorded in the NMDS).

Mortality following Hip Arthroplasty

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following a hip arthroplasty.

Key findings

In New Zealand during 2009–2014, following hip arthroplasty:

- There were 792 deaths. Six-year cumulative mortality was 1.53% of admissions.
- There were 716 deaths related to acute admissions;[9] cumulative mortality was 7.11% of admissions. Fifty-one deaths were related to elective/waiting list admissions; cumulative incidence was 0.12%.

These findings were generally consistent with previous reports.

Mortality following hip arthroplasty

In New Zealand in 2009–2014, mortality rates following hip arthroplasty varied between 1.38% and 1.68% of admissions (Table 15). The mortality cumulative incidence over the six-year period was 1.53% of admissions. The cumulative incidence was 7.11% for acute admissions and 0.12% for elective/waiting list admissions.

Table 15: Mortality following Hip Arthroplasty by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	123	8,219	1.50
2010	142	8,431	1.68
2011	131	8,326	1.57
2012	119	8,594	1.38
2013	149	8,960	1.66
2014	128	9,127	1.40
Total	792	51,657	1.53
Acute Total	716	10,065	7.11
Elective/Waiting List Total	51	41,033	0.12

Numerator: NMC: Deaths occurring within 30 days of a hip arthroplasty as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a hip arthroplasty listed in any of the first 90 procedures.

9 Patients admitted acutely commonly have hip arthroplasty to treat a fractured hip.

Composite case 2: Elective total hip joint replacement

Mr C was a smoker, aged 70 years with a BMI of 32, had chronic obstructive respiratory disease and was on inhalers at the time of surgery. He had a past history of prostate cancer, for which he had received a prostatectomy.

Mr C had severe osteoarthritis of the hip joint, causing very limited mobility and rest pain. He was assigned an ASA score of 2 and admitted electively to hospital for a total hip joint replacement under spinal anaesthesia. The procedure was uneventful, after which he was prescribed a standard postoperative course of thrombo-prophylaxis: 10 mg of rivaroxaban daily, starting at 8 pm on the day of surgery. Administration of the thrombo-prophylaxis continued over the next four days that he was in hospital.

In the postoperative period, Mr C was in more pain than usual for the procedure, and because of this he was slow to mobilise. He was discharged home on day 5 and his progress was slow but with no specific problems. Five days later he was found unconscious on the floor by his wife, apparently having collapsed. She called the ambulance and when it arrived Mr C was declared dead. A postmortem showed a massive pulmonary embolus in his pulmonary artery. It was noted that he had not continued with his thrombo-prophylaxis after discharge.

Key clinical practice points:

- **Consider continuing thrombo-prophylaxis post-discharge.**
- **Educate patients and caregivers about the importance of continuing thrombo-prophylaxis after discharge, and encourage patients to self-assess their risk.**
- **Optimising mobilisation of patients is crucial before and after discharge.**

Mortality following Knee Arthroplasty

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following knee arthroplasty.

Key findings

In New Zealand during 2009–2014, following knee arthroplasty:

- Mortality was low. There were 61 deaths, and cumulative mortality was 0.17% of admissions. Most admissions (98.3%) were elective, and the cumulative mortality was largely based on these admissions.
- The findings are consistent with previous reports, including data from 2005–2009.

Mortality following knee arthroplasty

In New Zealand during 2009–2014, there was a small and variable number of deaths each year. The annual mortality rates following knee arthroplasty varied between 0.07% and 0.22% of admissions. The overall cumulative mortality for the six-year period was 0.17% of admissions.

Table 16: Mortality following Knee Arthroplasty by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	10	5,547	0.16
2010	12	5,538	0.22
2011	12	5,771	0.21
2012	4	6,067	0.07
2013	8	6,311	0.13
2014	15	7,001	0.20
Total	61	36,235	0.17

Numerator: NMC: Deaths occurring within 30 days of a knee arthroplasty as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a knee arthroplasty listed in any of the first 90 procedures.

Mortality following Colorectal Resection

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following colorectal resection surgery.

Key findings

In New Zealand during 2009–2014, following colorectal resection:

- There were 816 deaths. Cumulative mortality was 3.92% of admissions.
- Cumulative mortality was higher among acute admissions (8.45%).
- These findings are generally consistent with previous reports. Cumulative mortality among acute admissions (8.45%) has slightly decreased when compared with 2005–2009 (9.80%).

Same or next day mortality following colorectal resection

In New Zealand during 2009–2014, there were between 127 and 150 deaths each year. The annual mortality rates following colorectal resection varied between 3.63% and 4.28% of admissions. The overall cumulative mortality for the six-year period was 3.92% of admissions.

Table 17: Mortality following Colorectal Resection by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	134	3,364	3.98
2010	150	3,505	4.28
2011	143	3,437	4.16
2012	127	3,503	3.63
2013	129	3,504	3.68
2014	133	3,509	3.79
Total	816	20,822	3.92
Acute Total	526	6,225	8.45
Elective/Waiting List Total	290	14,275	2.03

Numerator: NMC: Deaths occurring within 30 days of a colorectal resection as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a colorectal resection listed in any of the first 90 procedures.

Composite case 3: Elective colorectal resection

Mrs D was a female, aged 85, with controlled congestive cardiac failure, Parkinson's disease and non-insulin dependent diabetes mellitus. She was diagnosed with cancer of the rectum (no evidence of spread), for which she was admitted to hospital for anterior resection (with an ASA score of 3).

Mrs D's operation was uneventful. After her procedure, she had a prolonged stay in the post-anaesthetic care unit, due to problems controlling her pain.

Mrs D's postoperative care was in a busy ward environment. She was experiencing continued problems with pain, along with ongoing nausea and vomiting, and so her plan of care was nil by mouth, with sips of water and no naso-gastric tube. Because of this, she was not mobilising and was not taking her regular medication.

On day 3, her daughter said that Mrs D looked very tired and down, and the nurses noted that she was more lethargic. Over the next few days she continued to require oxygen therapy and her observations gradually worsened – her respiratory rate and pulse increased, her blood pressure decreased, and she had continuing nausea with occasional vomiting and pain, despite treatment.

By day 5 the team looking after Mrs D became increasingly concerned about her as she had a high respiratory rate and low oxygen saturation, despite continued oxygen therapy. She was diagnosed with probable pneumonia, probably secondary to aspiration of gastric contents, and complicated by exacerbation of her cardiac failure. After reviewing her 'not for resuscitation' status and discussing with family, the decision was made to proceed with palliative care and she died later that day.

Key clinical practice points:

- **Choice of operation (full, limited or palliative care) should take into account the impact of significant comorbidities and frailty on postoperative recovery, and should be discussed fully prior to surgery.**
- **Signs of postoperative complications can be masked in patients with significant comorbidities, so adequately resourced and staffed wards are important during their postoperative care.**
- **Early recognition and management of causes of departure from the expected postoperative course is essential.**
- **Normal medication should be maintained perioperatively.**

Mortality following Coronary Artery Bypass Graft (CABG)

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following CABG or as an inpatient.

Key findings

In New Zealand during 2009–2014, following CABG with an arterial or venous graft:

- There were 337 deaths. Cumulative mortality was 2.92% of admissions.
- Cumulative mortality was higher among acute admissions (4.89%).

Mortality following CABG

In New Zealand during 2009–2014, there were between 50 and 64 deaths each year. The annual mortality rates following CABG varied between 2.46% and 3.30% of admissions. The overall cumulative mortality for the six-year period was 2.92% of admissions.

Table 18: Mortality following CABG by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	57	1,812	3.15
2010	55	1,936	2.84
2011	58	1,902	3.05
2012	50	2,033	2.46
2013	64	1,940	3.30
2014	53	1,923	2.76
Total	337	11,546	2.92
Acute Total	148	3,029	4.89
Elective/Waiting List Total	184	8,166	2.25

Numerator: NMC: Deaths occurring within 30 days of a CABG as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a CABG listed in any of the first 90 procedures.

Composite case 4: Emergency CABG for unstable angina and coronary artery blockage not suitable for PTCA

Mr GH was 55 years old, with unstable angina caused by significant coronary artery disease including 90% blockage of the left main stem artery. The blockages were considered unsuitable for PTCA (non-surgical treatment). He had no other significant illnesses and had had no previous operations or anaesthetics. He was assessed as ASA 4E. An urgent CABG operation was planned.

On induction of anaesthesia, he collapsed with an unrecordable blood pressure and proceeded to full cardiac arrest with ventricular fibrillation. There was no evidence of a skin rash or bronchospasm. Prolonged resuscitation was undertaken, but it was unsuccessful. Blood test (serum tryptase) was taken at the time in case the collapse was due to anaphylaxis (acute drug reaction).

A full multi-disciplinary mortality review was undertaken. The cause was found to be anaphylaxis, probably due to the drugs given intravenously immediately before the collapse (confirmed by a very high serum tryptase level). As diagnosis of which drug was involved requires skin testing at least six weeks after the reaction, this was not possible.

Key clinical practice points:

- **Occasionally postoperative deaths are unavoidable; this can only be decided after a case review.**
- **Anaphylaxis to intravenously administered drugs (including anaesthetic agents and antibiotics) is very rare and can be unpredictable.**
- **Anaphylaxis should be included in the differential diagnosis of sudden collapse intra-operatively, especially if in temporal relation to IV drug administration.**

Mortality following Percutaneous Transluminal Coronary Angioplasty (PTCA)

This chapter uses information from the NMDS and the NMC to review mortality either in the first 30 days following PTCA or as an inpatient.

Key findings

In New Zealand during 2009–2013, following PTCA:

- There were 572 deaths. The cumulative mortality rate was 1.77% of admissions.
- Mortality was higher among acute admissions (2.43% of admissions).
- These findings are similar to those previously reported.

Mortality following PTCA

In New Zealand during 2009–2014, there were between 75 and 104 deaths each year. The annual mortality rates following PTCA varied between 1.49% and 1.88% of admissions. The overall cumulative mortality for the six-year period was 1.77% of admissions.

Table 19: Mortality following PTCA by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	75	5,049	1.49
2010	97	5,232	1.85
2011	98	5,313	1.84
2012	96	5,588	1.72
2013	104	5,749	1.81
2014	102	5,413	1.88
Total	572	32,344	1.77
Acute Total	487	20,065	2.43
Elective/Waiting List Total	85	11,889	0.71

Numerator: NMC: Deaths occurring within 30 days of a PTCA as recorded in the NMDS.
Denominator: NMDS: Hospital discharges with a PTCA listed in any of the first 90 procedures.

Mortality in Admissions with an ASA Score of 4 or 5

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following admissions that included a general anaesthetic or neuraxial block and were assigned an initial ASA score of 4 or 5. General anaesthetics or neuraxial blocks for maternity procedures were not included in the data set reviewed for this chapter.

Additional background information on ASA scores is provided in Appendix 2.

Key findings

In New Zealand during 2009–2014, for those admissions that were given an ASA score of 4 or 5 and who received a general anaesthetic or neuraxial block during their admission:

- There were 3032 deaths. The cumulative mortality rate was 12.62% of admissions.
- The cumulative mortality for admissions with an ASA score of 5 was 48.14% of admissions, and mortality was also higher among acute admissions (18.15%).
- The cumulative mortality is consistent with previous years.

Mortality in admissions with an ASA score of 4 or 5

In New Zealand during 2009–2014, annual mortality was between 460 and 538 deaths, and cumulative mortality was between 11.60% and 13.66% for those admissions that were given an ASA score of 4 or 5 and who received a general anaesthetic or neuraxial block during their admission (Table 20). The overall six-year cumulative mortality for 2009–2014 was 12.62% of admissions.

Table 20: Mortality following Admission with an ASA Score of 4 or 5 by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	489	3,833	12.76
2010	493	3,773	13.07
2011	538	3,938	13.66
2012	460	3,966	11.60
2013	534	4,167	12.81
2014	518	4,346	11.92
Total	3,032	24,023	12.62
Acute Total	2,510	13,833	18.15
ASA 5 Total	388	806	48.14
Elective/Waiting List Total	521	10,127	5.14

Numerator: NMC: Deaths occurring within 30 days of a general anaesthetic or neuraxial block or as an inpatient in those admitted with an ASA score of 4 or 5.
Denominator: NMDS: Admissions with an ASA score of 4 or 5 and either a general anaesthetic or a neuraxial block.

Mortality in Elective Admissions with an ASA Score of 1 or 2

This chapter uses information from the NMDS and the NMC to review mortality in the first 30 days following a general anaesthetic or a neuraxial block in those admitted electively or from the waiting list with a first ASA score of 1 or 2.

Key findings

In New Zealand during 2009–2014, for those admissions that were given an initial ASA score of 1 or 2, were admitted electively or from the waiting list, and who received a general anaesthetic or neuraxial block during their admission:

- There were between 38 and 75 deaths per annum. The cumulative mortality rate was 0.05%.
- Cumulative mortality has slightly reduced from previous years (down from 0.07% during 2006–2010).

Mortality in elective admissions with an ASA score of 1 or 2

In New Zealand during 2009–2014, annual mortality was between 38 and 75 deaths. The annual mortality rates varied between 0.04% and 0.08% for those admissions that were given an initial ASA score of 1 or 2, were admitted electively/from the waiting list, and who received a general anaesthetic or neuraxial block during their admission. Cumulative mortality over the six-year period was 0.05% of admissions.

Table 21: Mortality following Elective/Waiting List Admission with an ASA Score of 1 or 2 by Year, New Zealand 2009–2014

YEAR	Deaths	Admissions	Mortality per 100 Admissions (%)
2009	75	97,416	0.08
2010	51	99,619	0.05
2011	58	103,417	0.06
2012	42	105,780	0.04
2013	38	105,675	0.04
2014	56	110,579	0.05
Total	320	622,486	0.05

Numerator: NMC: Deaths occurring within 30 days of a general anaesthetic or neuraxial block in those elective admissions with an ASA score of 1 or 2.
Denominator: NMDS: Elective admissions with an ASA score of 1 or 2 and either a general anaesthetic or a neuraxial block.

Commentary and Recommendations from the Māori Caucus

In this report, 30-day mortality following one or more general anaesthetics was significantly higher for Māori admitted both acutely and electively, compared with Europeans and after adjusting for socio-demographic and clinical variables (Tables 4 and 5). We know from our knowledge of perioperative mortality rates (POMRs) that mortality following general anaesthesia is a broad indicator of the quality and safety of operative procedures, as well as an indirect measure of access to them. Lack of access can result in delayed presentation, which is reflected both in higher POMRs and fewer procedures per head of population (Watters et al 2014).

The reasons underlying the higher POMRs observed for Māori are complex and not well understood.[10] Māori show a pattern of high acute hospital admission rates and relatively low elective admission rates compared with Europeans. This pattern suggests poorer access to planned procedures, but there are numerous potential reasons for this: barriers to accessing primary care and health literacy can impact disease management and also delay diagnoses, resulting in later presentation for surgical intervention and with more severe illness. Presenting with more severe illnesses can limit the range of appropriate interventions and also directly impact postoperative mortality outcomes.

At the other end of the patient journey, once surgical intervention is accessed, there is the possibility that the quality of postoperative care differs for Māori. Again, there are multiple likely reasons for this including the cultural appropriateness of care and other barriers related to cultural differences which can impact how clinical staff interact with Māori and their whānau.

The POMRC recommends further research, particularly qualitative research, is undertaken to understand the context and the reasons for higher Māori POMRs. Research should focus on all aspects of the Māori patient journey in the surgical setting, from access to care right through to the quality of postoperative care. The developing local perioperative review system will also help deepen our understanding of these reasons by providing in-depth clinical information about diagnoses, severity of illness and perioperative care pathways among Māori.

The POMRC consulted with the Māori Caucus about the higher Māori POMRs following general anaesthesia. The Māori Caucus supports the need for further research to identify the underlying reasons and also recommends the POMRC explores strengthening its analyses in two ways:

1. Taking into account the younger age structure of the Māori population.
2. Using the Charlson Comorbidity Index (CCI) as an additional indicator of severity of illness.

The first of these recommendations is informed by research that shows relative mortality risk estimates can differ in magnitude and significance depending on the population used for age-standardisation[11] (Robson et al 2007). The second recommendation is driven by the need to better illuminate how much of the Māori POMRs might be explained by quality of care and access issues. Including the CCI in multivariate analyses, together with the ASA score, might provide a more robust adjustment for comorbidities and

10 For a discussion of the potential reasons underlying the Māori POMRs refer to the chapter on Māori Perioperative Mortality in the POMRC's previous report (POMRC 2015).

11 Age-standardisation is a statistical method that adjusts for variation in the age structures of different populations – it is useful when comparing rates between populations because it removes any bias in rates that are due to differences in the underlying population age distributions. In New Zealand, the Māori population has a younger age structure compared to the non-Māori population. The Ministry of Health adjusts for these differences when comparing mortality rates between Māori and non-Māori populations by standardising against the WHO World Standard Population (Ministry of Health 2015).

illness severity.[12] Having a robust adjustment for illness severity is important when comparing Māori POMRs because any increased risk that remains after adjusting shows the extent to which other non-patient factors contribute to them. This allows us to tease apart how much of the POMR might be explained by comorbidities and existing illnesses, and how much might be explained by access and postoperative care quality issues.

Recommendations

Further research and research funding:

- The reasons for increased perioperative mortality of Māori should be further investigated.

Recommendations from the Māori Caucus to the POMRC for better data analysis:

- The impact that the Māori population age structure has on analyses of Māori perioperative mortality should be investigated.
- The Charlson Comorbidity Index should be considered to strengthen future analyses and better understand how severity of illness impacts Māori perioperative mortality.

12 The CCI has been included in multivariate analyses to adjust for comorbidities in one study that showed Māori, when compared with NZ Europeans, had a 19% increased odds of readmission or death within 30 days of selected surgical procedures. This increased odds persisted (and only decreased slightly to 16%) after the CCI, socioeconomic position and other hospital variables were controlled for in the analysis (Rumball-Smith et al 2013).

Perioperative Mortality in New Zealand and International Comparisons

This chapter compares perioperative mortality rates in New Zealand with rates seen internationally for selected procedures and clinical areas that the POMRC tracks over time. Mortality rates for these procedures and clinical areas that were included in the two previous POMRC reports are summarised in Table 22, along with the rates for the two new clinical areas included in this report.

Comparing perioperative mortality in New Zealand with other published studies is challenging because the timeframe within which mortality is measured varies widely. Medium- and longer-term mortality rates are generally poorly reported at a national level in the literature (Jawad et al 2016) and some of the studies reviewed for this chapter either reported deaths within 48 hours, seven days, or in-hospital mortality before discharge. However, for some procedures, a significant proportion of patients die within 30 days or after discharge from hospital, from complications such as those related to infection and the quality of postoperative care in the time more distal to the operative procedure. This is why in-hospital rates are generally lower than 30-day mortality rates, and can actually underestimate 30-day perioperative mortality rates by up to 30% (Ariyaratnam et al 2015).

New Zealand is one of the few countries that is able to capture these perioperative deaths because the hospital administrative data set can be linked with mortality data using the National Health Index. Capturing these deaths is important because, for some procedures (eg, those involving shorter hospital stays), in-hospital mortality rates can only provide an indicator of the quality and safety of intra-operative care and the early stages of postoperative care.

Day-of-the-week mortality

A number of key studies, using population-based hospital administrative data sets, have demonstrated evidence of increased mortality following both acute and elective admissions occurring on the weekend (Saturday or Sunday). Aylin et al's (2010) analysis of all national emergency admissions to public hospitals in England for 2005–2006 showed the adjusted odds of in-hospital deaths was 10% higher following weekend emergency admissions compared to weekday admissions. The crude in-hospital mortality rates reported were 4.9% for weekday admissions and 5.2% for weekend admissions.

A subsequent study on all elective[13] surgical hospital admissions in England during 2008–2011 found a 44% and 82% higher adjusted odds of in- and out-of-hospital deaths within 30 days of procedures carried out on a Friday or a weekend respectively, compared with Monday (Aylin et al 2013). This additional mortality risk increased throughout the week, reaching a peak for weekend procedures. The mortality rate reported for all weekend elective surgical procedures was 7.4 per 1000 admissions (0.74%), and for Monday mortality was 5.5 per 1000 (0.55%). This is a similar result to a study of all national elective (and emergency) admissions in England during 2008–2009, which found a mortality rate of 0.77% for weekend elective admissions and 0.52% for weekday admissions (Mohammed et al 2012).

More recently, analysis of elective and emergency admissions (combined) from the Australian and New Zealand Surgical Mortality database found that early surgical mortality (death within 48 hours of procedure) was higher for those procedures carried out on weekends compared to weekdays (Singla et al 2015). A combined analysis of all hospital admissions in England also showed an association between increased 30-day mortality and weekend admissions (Freemantle et al 2015).

13 The study by Aylin et al (2013) was on all elective surgical procedures carried out in acute and specialist hospitals in England. An 'acute' hospital in England is the equivalent of a public hospital in New Zealand – they provide a combination of emergency treatment, routine and complex surgeries, diagnostic and therapeutic services, and specialist or consultant care, as well as a range of health care from allied professionals such as dieticians and physiotherapists (see the NHS website for further details: www.nrls.npsa.nhs.uk/resources/healthcare-setting/acute-hospital/).

These findings are strengthened by a recent international study that examined the association between 30-day in-hospital mortality and day of the week for emergency and elective patients, using hospital administrative data from 28 hospitals across England, Australia, the Netherlands and the US (Ruiz et al 2015b). In this study, after adjusting for patient case-mix, hospital characteristics and country, the odds of death at 30 days following emergency admissions on the weekend were higher among hospitals from all countries, except the six Australian hospitals.[14] For weekend elective surgery, the adjusted odds of 30-day death was higher for procedures carried out on Friday, Saturday and/or Sunday, compared with Monday (Ruiz et al 2015b).

The 'weekend effect'

The increased risk observed following weekend admissions and procedures conducted around the time of the weekend has become widely known as the 'weekend effect'. In addition to mortality, the effect has also been demonstrated using various quality care outcomes, with studies showing an association between weekend admissions, longer lengths of hospital stay (eg, Kothari et el 2015; Hoh et al 2010), reduced likelihood of receiving timely treatment (eg, Palmer et al 2012), and increased risk of developing postoperative complications (eg, Worni, Inge, Schudel et al 2012; Zapf et al 2015).

The weekend effect is not universally detected for all clinical diagnoses, procedures and admission types. Although studies demonstrating the effect show increased mortality risk following elective non-cardiac surgery (McIsaac et al 2014) and various elective surgical procedures, including colorectal resection (Vohra et al 2015), surgery for oesophageal cancer (Lagergren et al 2016) and hip arthroplasty (Illingworth et al 2015), other studies, particularly those on acute admission types, find no weekend effect. For example, researchers have reported no association between mortality and weekend admissions in studies on hip fractures (Boylan et al 2015; Daugaard et al 2012), stroke (Hoh et al 2010), laparoscopic appendectomy (Worni, Østbye et al 2012), acute upper gastrointestinal bleeding (Jairath et al 2011), oesophageal variceal haemorrhage (Myers et al 2009) and patients presenting to the emergency department for sepsis (Powell et al 2013).

Although research findings are slightly mixed[15] for acute and emergency admission types, with some studies showing a weekend effect (eg, Goldstein et al 2014) and others not, the comparative absence of the effect has led some to suggest that the impact of being admitted on or around the weekend might be greater in elective settings (eg, Basson 2007; Concha et al 2014). Further research is required to confirm this theory; however, it is supported by a national study on public hospital admissions in England during 2008–2009, which found weekend admissions were associated with a 9% increased odds of death for emergency admissions, but a much higher 32% increased odds of death for elective admissions (see Mohammed et al 2012).

Examining the quality of weekend care

Few studies have specifically examined the aspects of service provision that vary over the weekend, and how these might be associated with increased mortality.[16] Those studies that have looked into weekend service provision do show some diagnostic and treatment processes may be affected by weekend hospital organisation. Palmer et al (2012), for example, showed those admitted to public hospitals in England over the weekend for strokes during 2009–2010 had higher seven-day in-hospital mortality and were less likely to receive same day brain scans and thrombolysis treatment.

14 Thirty-day mortality following emergency admissions among the six Australian hospitals showed no significant variation by day of the week; however, seven-day post-emergency admissions did show a significantly higher adjusted odds of death on Saturday (Ruiz et al 2015b).

15 Findings for hip fractures, for example, are mixed – some show a weekend effect (eg, Thomas et al 2014), and others find no association between weekend hip fracture admissions and mortality (eg, Monem et al 2014). Some of the inconsistent findings could be explained by the fact that many of the studies showing no weekend effect are smaller single-site cohort studies; these may lack statistical power to detect any effect, since deaths after hospital admissions are relatively rare (Aylin 2015).

16 One recent study by Kothari et al (2015) examined whether various perioperative resources differed across a sample of 166 hospitals in Florida from 2007 to 2011 by comparing the resources in those hospitals that showed the weekend effect with those in hospitals that were able to overcome a weekend effect during the five-year study period. Key perioperative resources that were significant predictors for hospitals that were able to overcome the weekend effect included increased registered nurse-to-bed ratio, full implementation of electronic medical records, and having patient home health and pain management programmes as well as inpatient physical rehabilitation programmes available (Kothari et al 2015). Although length of stay was the outcome examined, the study provides some useful insights into potential service-related factors underlying the weekend effect.

In addition to delays in diagnosis and treatment, the 'weekend effect' may also impact the monitoring and management of patients after operative procedures. Ricciardi et al (2016) showed more hospital complications and adverse events occurred among non-elective patients admitted on weekends, suggesting responses to adverse events may be less effective. Similarly, Zapf et al (2015) showed patients admitted on weekends for urgent general surgical procedures had an increased risk of developing postoperative complications.

There is little evidence describing how weekend hospital staff configuration might explain the weekend effect. One recent study examined the national data set from Aylin et al (2013) and found that the increased mortality for elective procedures at the end of the week was still present after consultant surgeon experience[17] (and patient and hospital effects) were controlled for in their analysis (Ruiz et al 2015a). Another study by Ricciardi et al (2014) showed that patients admitted non-electively to hospitals in the US with more resident trainee staff on weekends had a higher risk of mortality. They noted that this was contrary to their hypothesis, and raised the possibility that it was due to inadequate supervision of resident trainee staff by physicians. In this study, lower staffing levels of nurses and physicians were both associated with increased mortality risk following weekend admission.

Improving our understanding of the 'weekend effect' with further research

The current body of evidence on the weekend effect, being based on retrospective observational studies, cannot give a clear picture of the timeline associated with increased mortality – that is, it is difficult to tell whether the effect is due more to factors preceding the operation, or to postoperative care factors. Similarly, it is difficult to discern how much of the increased mortality risk is due to patient factors and how much is due to the quality of weekend care. There is, however, some emerging evidence that the weekend effect differs for various clinical diagnoses and procedures, suggesting the relative contribution of patient and care-related factors may be context-specific (see Concha et al 2014).

Although it is increasingly accepted that the weekend effect is driven by the interplay of multiple patient- and care-related factors, further research is needed to understand how these factors impact patient outcomes (Lilford and Chen 2015). By identifying the most significant predictors of mortality following weekend admissions, policy-makers and hospital management can begin to implement more targeted interventions.

General anaesthesia

There is a small body of studies in the international literature that report population-based estimates on mortality following general anaesthesia. A meta-analysis that included 87 studies of perioperative and anaesthetic-related deaths in developed and developing countries found a perioperative mortality rate of 1176 per million (0.12%) in the 1990s–2000s (Bainbridge et al 2012). This was based on more than 21.4 million operative procedures where a general anaesthetic was administered for surgery. When comparing with New Zealand mortality following general anaesthesia, it is important to note that most of the 87 studies reported mortality over a short time period, usually within the first 48 hours of procedures; only four of the studies reported 30-day mortality (Bainbridge et al 2012). New Zealand's same or next day mortality rate following a procedure with one or more general anaesthetics (0.12% during 2009–2014) compares well with this international estimate.

Bainbridge et al (2012) also reported 'anaesthetic-related' mortality – based on deaths that were attributed solely to anaesthesia and deaths that were partially related to anaesthetic conduct (34 per million, or 0.0034% in the 1990s–2000s). Deaths due solely to anaesthesia, or partially related to anaesthetic conduct, are rare in developed countries,[18] and the POMRC reports on all-cause mortality, rather than separating out those with a significant anaesthesia component in causation. Anaesthetic-related mortality is reported triennially in the ANZCA publication *The Safety of Anaesthesia*. The latest report (2009–2011) gives a rate of anaesthesia-related deaths as 3.01 deaths per million population per annum (14.83% of all

17 Consultant experience was defined as the number of years of experience accumulated by each consultant from the year of entry to the General Medical Council specialist register up to the year of the patient's surgery (Ruiz et al 2015a).

18 Anaesthetic mortality is higher in developing countries because of a lack of professional training infrastructure, inadequate basic monitoring equipment and poor adherence to strict standards of care (Weisser and Gawande 2015).

deaths assessed) (ANZCA 2014). The data comes from five states in Australia, covering 70% of Australia's population, and is based on peer review of cases reported to the state mortality committees. The cases are then classified into those in which anaesthesia played some part, those in which anaesthesia played no part, and those that cannot be assessed. Anaesthetic-related mortality is also reported periodically as part of the Australian and New Zealand Audit of Surgical Mortality (ANZASM),[19] and anaesthetic was suggested as a significant factor in 1.4% (or 246) of the 17,431 surgical procedures resulting in death that were included in the 2014 audit (Royal Australasian College of Surgery and ANZASM 2015).

The Scottish Audit of Surgical Mortality (SASM) found mortality where anaesthetic contributed to death was 1.5% of all surgical admissions during 1996–2005 (McFarlane et al 2009). The SASM reviewed 92% of all deaths from surgical care occurring in public hospitals in Scotland over a 10-year period from 1996. Cumulative mortality among those surgical procedures where an anaesthetist was present was 0.6% of all surgical admissions (McFarlane et al 2009). The Western Australia Audit of Surgical Mortality (WAASM), modelled on the SASM, reported an overall surgical mortality rate of 24.6 per 100,000 population (0.025%) in Western Australia during 2011 (Azzam et al 2013).

Mortality rates reported by national audits are difficult to compare with New Zealand rates reported by the POMRC because audits rely on a case-reporting system, where structured information on surgical deaths are reported to a centralised database from participating hospital mortuaries, wards and consulting surgeons. These cases are then peer-reviewed externally by groups of surgeons and anaesthetists to identify areas of concern and other factors deemed to have contributed to the death. Thus, most national surgical mortality audits only capture in-hospital deaths, occurring within varied timeframes before discharge. Regardless, the rates observed in the SASM and WAASM are reasonably comparable to the New Zealand same or next day mortality rates observed following admissions with at least one general anaesthetic (see Table 22).

Thirty-day mortality

Very few countries have reported 30-day mortality following admissions with general anaesthesia. This is because 30-day mortality rates require data on post-discharge deaths, and New Zealand is one of the few countries with national mortality and hospital administrative systems that allow us to do this (through data linkage with unique identifiers). The National Surgical Quality Improvement Program (NSQIP)[20] in the US does collect information on 30-day postoperative mortality and morbidity. One analysis of patient data on 363,897 surgical procedures held in the NSQIP database from 2005 to 2007 found a post-surgical 30-day mortality rate of 1.76%. A large proportion of all post-surgical deaths included (23%) were those who died after discharge (Yu et al 2011). Similar 30-day post-surgical mortality rates using NSQIP data have been reported for all non-cardiac surgery (1.34% during 2005–2007) (Glance et al 2012). In a review of 3.7 million surgical procedures from national registry data in the Netherlands, all-cause perioperative mortality following surgery (including in-hospital deaths before discharge only) was reported as 1.85% during 1991–2005 (Noordzij et al 2010).

Pearse et al (2012) reported an in-hospital mortality rate of 4.0% following non-cardiac inpatient surgery in the European Surgical Outcomes Study (EuSOS) cohort study; this study included 46,539 elective and non-elective patients from 498 hospitals across 28 European nations. Patients in this cohort were followed up in hospital for a maximum of 60 days, or until discharge. The 4% mortality rate was higher than expected; however, rates varied widely between the countries included, and those countries with notably higher rates may have inflated the overall estimate. The mortality rates reported in this EuSOS study publication do not include post-discharge deaths,[21] and are slightly higher compared with the 30-day mortality rate for New Zealand presented in this report (0.56%).

19 The ANZASM was established to provide peer review of all deaths associated with surgical care, highlighting systems, process and surgical errors. Participating hospitals notify a regional centre every time a death occurs following surgery; surgeons and anaesthetists fill out a structured case-review form, which is then peer-reviewed externally. The purpose is to inform, educate others and improve the quality of practice in surgical settings. Almost all (99%) of Australian public hospitals (and about 76% of private hospitals) where surgery is conducted participate in the audit (Raju et al 2015).

20 The NSQIP was founded in the US in 1994, with the aim of developing a national system that could provide reliable risk-adjusted surgical outcomes data which could then be used to inform national quality improvement of surgical services. The NQSIP is able to be used to measure 30-day mortality outcomes that include deaths occurring after hospital discharge (see Khuri et al 2007).

21 The Swedish subset of the EuSOS study were able to follow up their patient cohort for one year and reported a 30-day mortality rate of 1.8% (95% CI: 1.0–2.6) after surgery; however, the study cohort was small (only 1314 surgical procedures, of which 303 patients were lost to follow-up), so this estimate should be interpreted with caution (Jawad et al 2016).

Cholecystectomy

The use of laparoscopic cholecystectomy procedures has increased internationally since the technology was introduced in the 1990s and is now the most commonly performed procedure in many countries including England (Sinha et al 2013), Denmark (Harboe and Bardram 2011) and the US (Ingraham et al 2010). Internationally, mortality rates are higher following open procedures, and acute or emergency admissions (Ingraham et al 2010; Sinha et al 2013). This is similar to New Zealand – laparoscopic procedures are the most common type performed (89% of all cholecystectomy admissions in 2007–2011), most deaths following cholecystectomy are from open procedures and acute admissions (POMRC 2014), and mortality rates are higher for acute admissions than elective/waiting list admissions (see Table 22).

Cumulative mortality following cholecystectomy in New Zealand was 0.37% of all cholecystectomy admissions during 2009–2014 (Table 13). Similar 30-day mortality rates have been reported in other countries. In the US, a review of 65,511 cholecystectomy patients from the NSQIP database found a 30-day mortality rate of 0.53% during 2005–2008 (Ingraham et al 2010). In Sweden, 30-day day mortality after cholecystectomy between 2007 and 2010 was 0.15% (Sandblom et al 2015). This rate is comparable to New Zealand rates because both in-hospital and post-discharge deaths within 30 days of the procedure are included (obtained by linking data from 47,912 cholecystectomy procedures in the national Swedish Register for Cholecystectomy, with data from the Swedish Death Register). In Denmark, a review of deaths of 20,307 patients included on the Danish Cholecystectomy Database found a 30-day mortality rate of 0.27% from 2006 to 2009 (Harboe and Bardram 2011). When this information was linked with clinical information from surgeons completing the procedure, 91.2% of all primary procedures were reported as laparoscopic, only 1.3% were open, and 7.5% of procedures were converted to open.

In England, analysis of national hospital administrative records from 2000 to 2009 found an in-patient mortality rate for all cholecystectomy procedures of 0.2%. Although 30-day mortality was not reported, researchers were able to include post-discharge deaths by linking the data set with national statistics, and estimated a one-year mortality rate of 1.0% (Sinha et al 2013). This finding highlights the importance of understanding longer-term mortality outcomes from cholecystectomy because, although mortality is low in hospital, a significant proportion of patients die after discharge. Yu et al (2011) reviewed the NSQIP data and found that 25.3% of all deaths that occurred within 30 days of cholecystectomy in the US took place after discharge from hospital.

Hip arthroplasty

In New Zealand, mortality is higher among acute admissions for hip arthroplasty and significantly associated with age and poorer physical health (higher ASA scores). In 2009–2014, there were 716 deaths related to acute admissions (7.11% of admissions) and 51 deaths related to elective/waiting list admissions (0.12% of admissions) (Table 22). These were similar to the rates reported by the POMRC during 2005–2009 (POMRC 2011). New Zealand mortality rates for hip arthroplasty procedures are similar to those observed in other developed countries. Internationally, there is an overall declining trend in mortality rates following hip arthroplasty, despite increasing comorbidities among patients (Berstock et al 2014; Hunt et al 2013; Liu et al 2009). A recent meta-analysis of 32 published studies on 30-day or 90-day mortality following total hip replacement estimated a pooled 30-day mortality rate of 0.30% (95% CI: 0.22–0.38) (Berstock et al 2014). A systematic review of 80 published studies on mortality following all hip arthroplasty procedures (total and partial) found a pooled mortality rate of 0.63% (Singh et al 2011).

New Zealand mortality rates are similar to others reported internationally, although much of the international literature reports mortality rates by procedure type (eg, total hip replacements) as opposed to by admission type (acute vs elective). Most acutely admitted patients for hip arthroplasty present to hospital with hip fractures, and New Zealand acute mortality rates are similar to those reported internationally. Analysis of all patient data in New South Wales (Australia) showed an estimated 30-day mortality rate of 8.6% (95% CI: 0.4–8.9) for hip fracture fixation and 0.5% (95% CI: 0.4–0.5) for total hip replacements. The majority (92%) of hip fracture fixation procedures took place in public hospitals, whereas just over 40% of hip replacements took place in public hospitals (Harris et al 2012).

In the US, a review of the NSQIP database found there were 17,640 patients who underwent total hip arthroplasty from 2006 to 2011, and the 30-day mortality rate was 0.35%. Age, cardiac disease, renal

insufficiency, ASA score >3 and male sex were strong predictors of developing postoperative complications (Belmont, Goodman, Hamilton et al 2014). Analysis of the US National Hospital Discharge Survey from 1990 to 2004 found the number of total hip arthroplasty procedures performed has increased, but the in-hospital mortality rate has remained relatively low, at 0.32% during 1990–2004 (Liu et al 2009). Analysis of US hospital discharge data from 508,150 primary total hip arthroplasties contained in the National Inpatient Sample database (excluding acetabular fracture patients) revealed an inpatient mortality rate of 0.13% during 2007–2008 (Illingworth et al 2015). Data from the National Joint Registry on 409,096 primary hip replacements for osteoarthritis in England and Wales between 2003 and 2011 showed a 90-day mortality rate of 0.29% in 2011 (Hunt et al 2013).

Knee arthroplasty

Mortality following knee arthroplasty in New Zealand is similar to mortality observed in other developed countries. Singh et al (2011) reported an overall pooled mortality rate of 0.29% following all primary knee arthroplasty procedures in their systematic review of published studies.

In the US, Belmont, Goodman, Waterman et al (2014) reported a 30-day mortality rate of 0.18% from a national review of 15,321 patients contained in the NSQIP database who had a unilateral total knee arthroplasty between 2006 and 2010. Patient age and diabetes were independent predictors of mortality, and an ASA score >3 was predictive of developing postoperative complications (along with increased operative time, age and higher BMI). In the United Kingdom, a review of 341,749 knee arthroplasty procedures from the National Joint Registry in England and Wales during 2003–2012 found 30-day cumulative mortality was higher among those who had a total knee replacement (0.24%, 95% CI: 0.19–0.29) compared to those who had a partial/unicompartmental knee replacement (0.06%, 95% CI: 0.03–0.12). Those who had total knee replacements were more likely to be readmitted within the first year of their procedure and were more likely to have complications such as thromboembolism, myocardial infarction and stroke during their procedure (Liddle et al 2014).

Coronary artery bypass graft (CABG)

In New Zealand, mortality following CABG is higher among those admitted acutely, 4.89% of admissions (Table 22), than those admitted electively, and is significantly associated with older ages and higher ASA scores. These patterns are seen in other countries, with age and emergency/unplanned procedure status being particularly strong predictors of mortality following CABG (D'Errigo et al 2013; Hansen et al 2015; Thorsteinsson et al 2015). A declining mortality trend over time has been reported in many countries, including Denmark (Hansen et al 2015; Thornsteinsson et al 2015) and the US (ElBardissi et al 2012).

New Zealand mortality rates and patterns are similar to those observed internationally. In the US, a review of studies using national registry data between 1997 and 2001 showed the mortality rate following CABG averaged between 2% and 5% for acute patients and about 1.0% for elective patients (Aranki et al 2014). A review of the Society of Thoracic Surgeon's database from 2000 to 2009 found almost 1.5 million patients underwent primary isolated CABG. Cumulative mortality during this time was 2.4% and researchers noted a decrease in mortality from 2.4% in 2000 to 1.9% in 2009 (ElBardissi et al 2012).

In Italy, a multi-centre study of 41,303 patients (from 68 hospitals) who underwent isolated CABG found a 30-day postoperative mortality rate of 2.5%. Emergency procedures were associated with increased risk of mortality (D'Errigo et al 2013). Researchers also conducted a meta-analysis of data from published studies on postoperative mortality following CABG, finding a total pooled 30-day mortality rate of 0.9% among those aged under 50 years.

In Denmark, a nationwide analysis of all 38,830 patients who underwent CABG surgery during 1996–2012 showed a cumulative mortality rate of 3.0%. Although patient age had increased over time, patients also had more comorbidities at the time of surgery and mortality appeared to have decreased over time (Thorsteinsson et al 2015). A similar declining mortality trend was observed by Hansen et al (2015) over 12 years from 1999 to 2012. In their analysis of 25,602 CABG patients from the Western Denmark Heart Registry, 30-day mortality decreased from 4.07% during 1999–2000 to 2.44% during 2011–2012.

In Japan, the Japanese Cardiovascular Surgery Database (a national database containing all cardiovascular surgical patients) was reviewed during 2005–2007. There were 36,780 isolated CABG procedures conducted during this time, and 30-day mortality was 2.5%, but the rates associated with emergency/unexpected procedures were very high (20.7%) (Miyata et al 2011). Analysis of annual survey data collected by the Japanese Association for Thoracic Surgery showed a cumulative mortality rate of 2.15% for all those who underwent a CABG procedure during 2005–2009. Mortality was higher for those who underwent emergency CABG procedures (8.69% across 12,663 patients) compared to those who underwent elective procedures (1.12% across 72,937 patients) (Sakata et al 2012).

Percutaneous transluminal coronary angioplasty (PTCA)

Most of the international literature refers to percutaneous coronary intervention (PCI), which is the contemporary name given to all types of interventions that involve inserting a catheter into the coronary arteries through a puncture in the skin, then using various methods (eg, balloons and stents) to re-open the vessel and improve blood flow. In New Zealand, mortality following PTCA shows similar patterns to CABG, with higher rates observed among those admitted acutely. Mortality is lower following PTCA compared to CABG since it is a non-operative procedure (see Table 22).

New Zealand trends in mortality following PTCA are similar to those following PCI reported internationally. There has been a declining trend in mortality rates over time and procedures are increasingly being performed on older patients (Pandya et al 2016). There is evidence that very early discharge (<48 hours) after PCI is associated with higher 30-day mortality rates (Swaminathan et al 2015) and women experience more complications and higher mortality risk after PCI than men, particularly younger women (Lichtman et al 2014).

In the US, a large prospective cohort study involving 10,144 patients registered for PCI across 55 hospitals nationwide showed a 30-day mortality rate of 0.50% (51 patients died within 30 days) (Stolker et al 2011). It should be noted that their mortality rate may underestimate the actual rate because their method of following up deaths among patients after discharge relied on secondary information from patients' physicians.

Another US study reviewed over 500,000 PCI procedures from the National Cardiovascular Registry and found that total 30-day in-hospital mortality was 1.27%. Mortality ranged from 0.65% to 4.81% depending on whether patients presented with ST-elevated myocardial infarction (STEMI) or not – rates for those with STEMI ranged from 4.69% to 4.81% and non-STEMI rates ranged from 0.60% to 0.69% (Peterson et al 2010). Other large US studies using the National Cardiovascular Registry report in-hospital mortality rates of 1.0% (Lichtman et al 2014) and 1.4% (Brennan et al 2013); mortality is much higher for those admitted acutely with shock and recent cardiac arrest (up to 65.9%) compared to those admitted electively (0.2%) (Brennan et al 2013).

Colorectal resection

Similar to the trends seen with cholecystectomy procedures, internationally there has been increasing use of laparoscopic colorectal resection since the early 2000s (Burns et al 2014; Iversen et al 2014; Taylor et al 2013). Laparoscopic colorectal resection is associated with lower mortality and postoperative morbidity compared to open colorectal resection procedures (Mamidanna et al 2012; Panis et al 2011). Laparoscopic procedures are less likely to be used in those with advanced disease, those with severe comorbidities, and those who undergo unplanned or emergency procedures (Taylor et al 2013). The use of laparoscopic techniques for rectal cancer can be more complex, depending on the location of tumours (Biondi et al 2013).

As in New Zealand, the international literature shows age, male gender, obesity, prior cardiovascular disease and ASA scores >3 are all significant risk factors for developing complications during and after colorectal surgery (Kirchoff et al 2010). Internationally reported mortality rates following colorectal resection are similar to those reported in New Zealand. Few studies report rates for acute or emergency procedures separately and many studies focus on outcomes following procedures for cancer (the most common reason for the procedure).

Analysis of all 138,735 patients undergoing elective colorectal resection procedures in England between April 2001 and March 2008 showed 30-day in-hospital mortality was 3.3% (Mamidanna et al 2012). Thirty-day mortality was significantly higher following open procedures (3.4%) compared to laparoscopic

procedures (1.7%). Laparoscopic procedures were also associated with significantly lower risk of postoperative complications, including cardiorespiratory complications and venous thromboembolism (Mamidanna et al 2012). An analysis of mortality following all public colorectal surgical procedures (elective and emergency combined) using national data in England from April 2001 to February 2007 showed 30-day mortality was 8.5% and 90-day mortality was 11.3%. Extending mortality reporting to 90 days is important to consider for national reporting as higher 90-day mortality correlates strongly with increased longer-term mortality occurring in the year following colorectal surgery (Byrne et al 2013).

In the US, nationwide analysis of 65,716 patients who underwent elective colorectal operations during 2006–2011 (from the NSQIP database) showed cumulative mortality was 1.7% (Gabre-Kidan et al 2014). The most common diagnoses were cancer (51.3%) and diverticular disease (31.8%). Increased risk of mortality was associated with existing congestive heart failure and dialysis history, high BMI, higher ASA scores and open procedures.

In previous years, there were some major differences in mortality rates following colorectal cancer surgery between European countries, with rates in Denmark being about twice as high compared to those in Norway, Sweden and Scotland. National registry data for Denmark showed 30-day mortality rates during 2001–2008 were 6.2% for elective surgical procedures and 22.1% for emergency procedures (Iversen 2012). The development of national guidelines to improve management of colorectal cancer, along with improved diagnostic technology and the use of laparoscopic procedures, have seen more recent rates decline in Denmark (Iversen 2012; Iversen et al 2014). Nationwide analysis of Danish patients who underwent elective colorectal resection for cancer during 2001–2011 found the 30-day mortality rate had decreased significantly, from 7.3% in 2001–2002 to 2.8% in 2011. This declining mortality trend was associated with increased use of laparoscopic procedures, although laparoscopic procedure use was only associated with reduced mortality risk in patients with colon cancer, but not rectal cancer (Iversen et al 2014).

Table 22: Perioperative Mortality in New Zealand: Selected Tracking Procedures and Clinical Areas, 2007–2014

TRACKING PROCEDURES AND CLINICAL AREAS	Proportion – Up to 30 days post-surgery			Rate – Cumulative 30-day mortality per 100,000			International Comparisons
	2007–2011	2008–2012	2009–2014	2007–2011	2008–2012	2009–2014	
General Anaesthesia: Same or Next Day Mortality	1465 deaths/ 1,167,573 anaesthetics	1436 deaths/ 1,181,670 anaesthetics	1805 deaths/ 1,449,042 anaesthetics	125.47 (0.13%)	121.5 (0.12%)	124.6 (0.12%)	NZ same or next day mortality rates are similar to the rate obtained in meta-analysis of perioperative mortality (0.12% across 87 studies, most of which reported mortality following surgical procedures within the first 24–48 hours of procedure) (Bainbridge et al 2012).
Cholecystectomy	118 deaths/ 30,157 admissions	113 deaths/ 30,901 admissions	146 deaths/ 30,080 admissions	975 (0.98%) acute 151 (0.15%) elective/ waiting list	821.7 (0.82%) acute 181.8 (0.18%) elective/ waiting list	695 (0.69%) acute 214 (0.21%) elective/ waiting list	NZ overall rate is similar to 30-day mortality rates observed in other countries: • US – 0.53% (Ingraham et al 2010). • Sweden – 0.15% (Sandblom et al 2015). • Denmark – 0.27% (Harboe and Bardram 2011).
Hip Arthroplasty 45+ Yrs	Numbers not reported	568 deaths/ 8106 admissions – acute 55 deaths/ 32,208 admissions elective/ waiting list	716 deaths/ 10,065 admissions – acute 51deaths/ 41,033 admissions elective/ waiting list	6608.9 (6.61%) acute 180.5 (0.18%) elective/ waiting list	7098.0 (7.10%) acute 171.0 (0.17%) elective/ waiting list	7113.8 (7.11%) acute 124.3 (0.12%) elective/ waiting list	**Reviews – hip replacements:*** Pooled 30-day rate from meta-analysis all total hip arthroplasty procedures (0.30%) (Berstock et al 2014). Pooled mortality rate of 0.63% for total and partial hip replacements (Singh et al 2011). NZ elective rates are similar to mortality rates following total hip replacements* reported internationally: • US – 0.35% (Belmont, Goodman, Hamilton et al 2014); 0.13% (Illingworth et al 2015). • UK – 90-day mortality, 0.29% (Hunt et al 2013).
Knee Arthroplasty 45+ Yrs: Elective/ Waiting List		46 deaths/ 27,714 admissions	61 deaths/ 36,235 admissions		142.8 (0.14%)	168.3 (0.17%)	NZ 30-day mortality rates are similar to pooled international 30-day mortality rate of 0.29% for all knee arthroplasty procedures (Singh et al 2011). NZ mortality rates are similar to those reported by other countries, including those observed in: • US – 0.18%, total knee arthroplasty (Belmont, Goodman, Waterman et al 2014). • UK – 0.24%, total knee replacements (Liddle et al 2014).

TRACKING PROCEDURES AND CLINICAL AREAS	Proportion – Up to 30 days post-surgery			Rate – Cumulative 30-day mortality per 100,000			International Comparisons
	2007–2011	2008–2012	2009–2014	2007–2011	2008–2012	2009–2014	
Coronary Artery Bypass Graft (CABG)		134 deaths/ 5436 admissions total	337 deaths/ 11,546 admissions total 148 deaths/ 3029 admissions acute		2465.0 (2.47%) total	2918.8 (2.92%) total 4886.1 (4.89%) acute	NZ 30-day mortality rates are similar to those observed internationally: • US – 2.0%–5.0% for acute procedures in a review of published studies on perioperative and in-hospital mortality following CABG surgery (Aranki et al 2014); total mortality 2.4% (ElBardissi et al 2012). • Denmark – total mortality 2.44% (Hansen et al 2015); 3.0% (1.0% in those aged <65 years and 8.0% in those aged >80 years (Thorsteinsson et al 2015). • Italy – total mortality 2.50% (D'Errigo et al 2013). • Japan – 2.15% for all CABG, 8.69% acute/emergency CABG, 1.12% elective CABG (Sakata et al 2012); 2.5% for all CABG (20.7% for emergent/unexpected CABG) (Miyata et al 2011).
Percutaneous Transluminal Coronary Angioplasty (PTCA)			572 deaths/ 32,344 admissions total 487 deaths/ 20,065 admissions acute			1768.5 (1.77%) total 2427.1 (2.43%) acute	NZ mortality rates are similar to those observed internationally: • US – total in-hospital mortality 1.0% (Lichtman et al 2014) and 1.27% (Peterson et al 2010), depending on admission status (higher rates for acute procedures) (Lichtman et al 2014; Brennan et al 2013; Peterson et al 2010).
Colorectal Resection 45+ Yrs	555 deaths/ 16,760 admissions		816 deaths/ 20,822 admissions	8456 (8.46%) acute 1700.6 (1.70%) elective/ waiting list		8449.8 (8.45%) acute 2031.5 (2.03%) elective/ waiting list	NZ 30-day mortality rates are similar to those observed internationally: • UK – 3.3% for elective colorectal resection (in-hospital mortality only) (Mamidanna et al); 8.5% for acute/elective procedures combined (Byrne et al 2013). • US – 1.7% following elective colorectal resection (Gabre-Kidan et al 2014). • Denmark – 2.8% in 2011 (elective procedures for colorectal cancer) (Iversen et al 2014).
	2007–2011	2008–2012	2009–2013	2007–2011	2008–2012	2009–2013	
General Anaesthesia: 30-day Mortality			6755 deaths/ 1,211,359 anaesthetics			557.6 (0.56%)	NZ rate slightly lower than those reported in: • US – 1.76% (Yu et al 2011); 1.34% for all non-cardiac surgery (Glance et al 2012). • Netherlands – 1.85% (Noordzij et al 2010). Only the US rates include post-discharge deaths.

TRACKING PROCEDURES AND CLINICAL AREAS	Proportion – Up to 30 days post-surgery			Rate – Cumulative 30-day mortality per 100,000			International Comparisons
	2007–2011	2008–2012	2009–2013	2007–2011	2008–2012	2009–2013	
Day-of-the-Week Mortality			**Acute admissions:** Weekdays 3845 deaths/ 228,629 admissions Weekends 1118 deaths/ 65,121 admissions **Elective/ Waiting list admissions:** Weekdays 1698 deaths/ 906,992 admissions Weekends 94 deaths/ 10,617 admissions			**Acute admissions:** Weekdays 1681.7 (1.68%) Weekends 1716.8 (1.71%) **Elective/ Waiting list admissions:** Weekdays 187.2 (0.18%) Weekends 885.3 (0.89%)	NZ 30-day mortality rates are slightly lower than those observed internationally. **Acute/Emergency admissions:** • England (in-hospital mortality) – 5.2% for weekend emergency inpatient admissions and 4.9% for weekday admissions (Aylin et al 2010); 6.53% for weekday public hospital emergency admissions and 7.06% for weekend admissions (Mohammed et al 2012). Ruiz et al's (2015b) multi-national study estimated 30-day in-hospital mortality following emergency admissions in: • Netherlands – 4.6% for Saturday or Sunday admissions and 4.1% for Monday admissions. • US – 2.9% for Saturday admissions, 3.0% for Sunday admissions and 2.6% for Monday admissions. • Australia – 3.6% for Saturday or Sunday admissions and 3.6% for Monday admissions (ie, no weekend effect). **Elective admissions:** • England – 30-day mortality (in-hospital and post-discharge) of 0.74% for weekend admissions and 0.82% for Friday admissions, compared to 0.55% for Monday admissions (Aylin et al 2013); in-hospital mortality of 0.52% for weekday public hospital elective admissions and 0.77% for weekend admissions (Mohammed et al 2012). Ruiz et al's (2015b) multi-national study estimated 30-day in-hospital mortality following elective surgical admissions in: • Netherlands – 1.88% for Saturday and 1.35% for Sunday admissions compared to 0.57% for Monday admissions. • US – 1.31% for Saturday and 1.66% for Sunday admissions compared to 0.33% for Monday admissions. • Australia – 1.31% for Saturday and 1.32% for Sunday admissions compared to 0.32% for Monday admissions.

* Mortality rates for total hip replacements are presumed to mostly represent elective procedures, and rates for hip fractures are presumed to represent acute admissions.

Developing World Health Organization (WHO) Metrics in New Zealand

In 2009, the WHO published the *WHO Guidelines for Safe Surgery 2009*, in which it proposed a set of standardised public health metrics for the routine surveillance of surgical care (WHO 2009). The WHO metrics incorporate both systems-level surveillance measures and patient-level surveillance measures for assessing both access to, and the quality of, surgical care (WHO 2009).

Reporting using the WHO metrics is increasingly being adopted by other countries throughout the world. This chapter describes the POMRC's work to date in applying the WHO metrics for routine surveillance of surgical safety in New Zealand.

WHO metrics

There are increasing efforts to improve the standardisation of data collection and reporting and, therefore, enable international comparisons with other jurisdictions. The WHO (2009) has proposed a set of standardised public health surveillance metrics for surgical care. The POMRC has focused on two of these metrics: day-of-surgery deaths and postoperative inpatient deaths (Table 23). The day-of-surgery death ratio can be equated with the analysis of same or next day general anaesthesia deaths, as presented in the POMRC's previous reports.

Table 23: WHO's Proposed Standardised Public Health Metrics for Surgical Care Analysed by the POMRC (WHO 2009)

WHO METRIC	Definition	Rationale for use
Day-of-surgery death ratio	Number of deaths on the day of surgery, regardless of cause divided by number of surgical procedures in a given year or period, reported as a percentage.	This ratio allows health care systems to assess performance and have a snapshot of the health status of a population.
Postoperative in-hospital death ratio	Number of deaths in hospital following surgery, irrespective of cause and limited to 30 days, divided by the number of surgical procedures done in a given year, reported as a percentage.	Understanding this ratio provides an understanding of the risks associated with surgical interventions.

Table 24 presents results to describe the total number of inpatient surgical procedures provided in New Zealand (2009–2014), the proportion of same-day fatalities and the proportion of inpatient deaths related to the admissions. The number of inpatient surgical procedures is defined in relation to admissions where patients have undergone at least one general anaesthetic during their inpatient stay.

Table 24: WHO Metrics and Perioperative Mortality by Year, New Zealand 2009–2014

YEAR	Deaths on Same Day as Operation *(Deaths within one day of general anaesthetic)*	Day of Surgery Mortality Rate per 100,000 (% all admissions) *(Deaths within one day of general anaesthetic)*	Admissions	Deaths as Inpatient	Inpatient Mortality Rate per 100,000 (% all admissions)
2009	311	131.76 (0.13%)	236,032	1173	496.97 (0.50%)
2010	260	109.33 (0.11%)	237,815	901	378.87 (0.38%)
2011	299	122.82 (0.12%)	243,453	989	406.24 (0.41%)
2012	275	112.56 (0.11%)	244,317	893	365.51 (0.37%)
2013	307	122.87 (0.12%)	249,850	920	368.22 (0.37%)
2014	353	148.58 (0.15%)	237,575	936	393.98 (0.39%)
Total	1,805	124.57 (0.12%)	1,449,042	5,812	401.09 (0.40%)

Appendices

Appendix 1: Thirty-Day Mortality Rates in New Zealand Resident Population

Table 25: Thirty-Day Mortality Rates in New Zealand Resident Population

AGE GROUPS (FIVE-YEAR BLOCKS)*	Male 30-Day Mortality/100,000	Female 30-Day Mortality/100,000
0	44.88	36.00
1	2.38	1.89
5	0.58	0.66
10	1.40	1.15
15	6.25	2.71
20	7.40	3.04
25	6.00	3.53
30	8.14	4.27
35	9.53	5.92
40	13.81	9.29
45	19.48	13.97
50	29.75	21.04
55	46.60	30.16
60	70.60	49.07
65	117.29	81.12
70	191.34	129.04
75	332.14	215.10
80	581.51	415.73
85	1011.37	801.21
90	1841.84	1722.66

* The age interval relates to a five-year period except for age 0 (which relates to a one-year period), age 1 (which relates to a four-year period), and age 90, which relates to remaining life span.

Based on Statistics New Zealand Life Tables 2009–11.

Appendix 2: Methods

The data sources and methods employed in this report for chapters that have been published before are consistent with those used for previous reports unless otherwise stated. Methods related to new chapters are outlined below.

Data sources

Hospital admission data was obtained from the NMDS and compared with Estimated Resident Population counts from Statistics New Zealand (projected from 2008). Inpatient procedures were assessed in relation to the 6th Edition of the Australian Classification of Health Interventions (ACHI) (National Centre for Classification in Health 2008). Mortality rates were sourced from NMC data and compared to NMDS admissions counts.

The following data was obtained for the two new clinical areas included in this report:

- **Thirty-day mortality following operations and procedures under general anaesthesia**

  All hospital admissions were included with a general anaesthetic (ICD-10-AM ACHI Version 6: 92514XX) listed in the first 90 procedure codes as recorded in the NMDS. Mortality rates of those who died (within 30 days following a general anaesthetic) were sourced from NMC data and compared to NMDS admissions counts where a general anaesthetic was administered.

- **Day-of-the-week mortality**

  All hospital admissions were included with a general anaesthetic (ICD-10-AM ACHI Version 6: 92514XX) listed in the first 90 procedure codes as recorded in the NMDS. Mortality rates of those who died (within 30 days following a general anaesthetic) were sourced from NMC data and compared to NMDS admissions counts where a general anaesthetic was administered. Day-of-the-week information was sourced from the NMDS.

  The first procedure that involved a general anaesthetic during a hospital admission was used as the index procedure and the date of this procedure was obtained from information included in the NMDS. The day of the week for the occurrence of the index procedure was assigned on the basis of the date for the procedure. Deaths within 30 days were assessed in relation to the day of the week of the index procedure. The analyses followed the methodology employed by Aylin et al (2010 and 2013). The methods applied to the 30-day mortality chapter were also followed with these analyses. In some analyses, information related to procedures on Saturday and Sunday were combined and assessed as weekend procedures.

  Tuesday was used as the reference day for all multivariate analyses as it was considered relatively representative of other weekdays. Exploratory analyses were conducted for all hospital admissions following one or more general anaesthetics, to see how day-of-the-week mortality varied using other weekdays as the reference day (presented below). These showed a significant increase in the mortality odds ratios for weekend procedures (a 'weekend effect') regardless of the weekday that was chosen as the reference day.

Table 26: Additional Analyses Exploring Day-of-the-Week Mortality for All Hospital Admissions with One or More General Anaesthetics, Using Other Weekdays as the Reference Day, New Zealand 2009–2013

DAY OF THE WEEK	OR	95% CI
Monday as reference day		
Weekend	1.292	1.177–1.418
Tuesday	0.931	0.851–1.019
Wednesday	0.991	0.906–1.085
Thursday	0.912	0.833–0.998
Friday	0.938	0.855–1.029
Tuesday as reference day (included in the report)		
Weekend	1.387	1.265–1.521
Monday	1.074	0.981–1.175
Wednesday	1.065	0.974–1.164
Thursday	0.98	0.896–1.071
Friday	1.007	0.919–1.104
Wednesday as reference day		
Weekend	1.303	1.189–1.428
Monday	1.009	0.922–1.104
Tuesday	0.939	0.859–1.027
Thursday	0.920	0.842–1.006
Friday	0.946	0.864–1.036
Thursday as reference day		
Weekend	1.416	1.292–1.552
Monday	1.096	1.002–1.200
Tuesday	1.021	0.934–1.116
Wednesday	1.087	0.994–1.188
Friday	1.028	0.938–1.127
Friday as reference day		
Weekend	1.377	1.255–1.512
Monday	1.066	0.972–1.17
Tuesday	0.993	0.906–1.088
Wednesday	1.057	0.965–1.158
Thursday	0.973	0.888–1.066

CI: Confidence interval, OR: Odds ratio with confidence interval.

In relation to the specific tracking procedures and clinical areas included in this report, the following data was obtained:

- **Cholecystectomy**

  Hospital admissions were included with a cholecystectomy listed in the first 90 procedure codes (ICD-10-AM ACHI Procedure Codes, Version 6: 3044300, 3044500, 3044600, 3044800, 3044900, 3045401, 3045500). In a small proportion of cases (n=485), other more complex procedures were undertaken at the same time as the cholecystectomy (for example, liver resections). In such cases where a cholecystectomy was performed as part of a more complex procedure, the risk of mortality is likely to have been significantly higher than if a cholecystectomy was either the main or the only procedure undertaken at the time of the operation. These admissions were not included in the analyses. Mortality rates of those who died following a cholecystectomy were sourced from NMC data (with cases being selected from the cohort of those undergoing cholecystectomy, as identified in the NMDS) and compared to NMDS admissions where a cholecystectomy was listed in any of the first 90 procedure codes.

- **General anaesthesia (same or next day)**

  All hospital admissions were included with a general anaesthetic (ICD-10-AM ACHI Version 6: 92514XX) listed in the first 90 procedure codes as recorded in the NMDS. Mortality rates of those who died (on the same day or the day following a general anaesthetic) are sourced from NMC data and compared to NMDS admissions counts where a general anaesthetic was administered.

- **Hip arthroplasty**

  All hospital admissions were included with a hip arthroplasty listed in the first 90 procedure codes (ICD-10-AM ACHI Procedure Codes, Version 6, Blocks: 1489 and 1492) as recorded in the NMDS. Mortality information was sourced from the NMC and as recorded in the NMDS.

- **Knee arthroplasty**

  All hospital admissions were included with a knee arthroplasty listed in the first 90 procedure codes (ICD-10-AM ACHI Procedure Codes, Version 6, Blocks: 1518, 1519, 1523 and 1524) as recorded in the NMDS. Mortality information was sourced from the NMC and as recorded in the NMDS.

- **Mortality in elective admissions with an ASA score of 1 or 2**

  All elective or waiting list hospital admissions were included in those with a first ASA score of 1 or 2 that included a general anaesthetic (ICD-10-AM ACHI Procedure Code Version 3: 92514-XX) or neuraxial block (ICD-10-AM ACHI Procedure Code Version 3: 92508-XX). Deaths related to elective/waiting list admissions with an ASA score of 1 or 2 were included where mortality occurred within 30 days of the first general anaesthetic or neuraxial block.

- **Colorectal resection**

  Hospital admissions with a colorectal resection listed in the first 90 procedure codes (ICD-10-AM ACHI Blocks, Version 6: 913, 934, 935, 936) were obtained from the NMDS. Mortality information was sourced from the NMC and as recorded in the NMDS.

- **CABG**

  All hospital admissions were included with a CABG procedure listed in the first 90 procedure codes (ICD-10-AM ACHI Procedure Codes, Version 6, 3849700, 3849701, 3849702, 3849703, 3849704, 3849705, 3849706, 3849707, 3850000, 3850300, 3850001, 3850301, 3850002, 3850302, 3850003, 3850303, 3850004, 3850304, 9020100, 9020101, 9020102, 9020103, 3863700) as recorded in the NMDS. Mortality information was sourced from the NMC and as recorded in the NMDS.

- **PTCA**

  All hospital admissions were included with an angioplasty procedure listed in the first 90 procedure codes (ICD-10-AM ACHI Procedure Codes, Version 6, 3530400, 3530500, 3531000, 3531001, 3531002) as recorded in the NMDS. Mortality information was sourced from the NMC and as recorded in the NMDS.

- **ASA score 4 or 5**

  All hospital admissions were included for those with an ASA score of 4 or 5 that included a general anaesthetic (ICD-10-AM ACHI Procedure Code Version 6: Block 1910, 92514-XX) or neuraxial block (ICD-10-AM ACHI Procedure Code Version 6: Block 1909, 92508-XX). Deaths related to the admissions with an ASA score of 4 or 5 were included where mortality occurred within 30 days of the general anaesthetic or neuraxial block.

Notes on interpretation

The following notes describe the data definitions used for analyses included in this report.

1. Hospital admission types and hospital readmissions

The following occurrences, unless otherwise stated, have been dealt with in the same way as in previous reports.

Acute, arranged (semi-acute) and elective/waiting list admissions

The analyses included in this report used the hospital admissions typology specified in the NMDS Data Dictionary (National Health Board 2014). An acute admission is defined as an unplanned admission occurring on the day of presentation, while an arranged admission is a non-acute admission with an admission date less than seven days after the date the decision was made by the specialist that the admission was necessary. Similarly, waiting list admissions arise when the planned admission date is seven or more days after the date the decision was made that admission was necessary.

These definitions, however, are inconsistently used by private hospitals uploading their data to the NMDS, with a significant proportion of private hospital admissions being coded as arranged when in reality they meet the criteria for a waiting list admission as outlined above. As a result, in the report all arranged private hospital cases have been included in the waiting list/elective category, while arranged admissions occurring in public hospitals have been included in the public hospital semi-acute admission category. Thus, unless otherwise specified, acute and elective/waiting list admissions include both public and private cases, while semi-acute admissions are confined to public hospitals only.

Private and public hospital admissions

The NMDS contains near-complete information on all publicly funded inpatient events occurring in public hospitals. In contrast, private hospital events include a mix of publicly funded and privately funded cases. DHB-funded events occurring in private hospitals are usually reported to the NMDS by the DHB contracting the treatment, and thus are mostly complete in the data set. As NMDS reporting is not legally mandated for New Zealand health care providers, however, many private surgical or procedural day-stay or outpatient hospitals, facilities or in-rooms do not report any events to the NMDS.

The Ministry of Health is unable to provide any estimate of the extent to which the NMDS undercounts private surgical or procedural day-stay or outpatient hospitals, facilities or in-room events, although it notes that the data most likely to be missing is privately funded or Accident Compensation Corporation (ACC) funded events, or publicly funded long-stay geriatric cases. Thus, in this report it must be remembered that the data presented is likely to undercount some private hospital events, with the magnitude of this undercount being difficult to quantify (although it is assumed to be significant).

Readmissions

Both first-time procedures and revisions of previous procedures were included in the analyses, with a small number of individuals appearing more than once in the data. In such cases, if a second procedure occurred within 30 days of the initial procedure, it was considered to be a revision, arising as a complication of the first procedure, and, in such cases, the outcomes arising from the second procedure were attributed to the first. These readmissions were not included in the denominator used to calculate mortality rates by procedure. If a readmission occurred more than 30 days from the original procedure, however, this was considered to be a new procedure in the calculation of mortality rates.

2. Chapter-specific notes

The following information relates to chapters on the two new clinical areas that have not been presented in previous reports.

Thirty-day mortality following operations and procedures under general anaesthesia

While in the majority of cases only one general anaesthetic was performed per hospital admission, in approximately 2.5% of admissions, two or more general anaesthetics were performed, with the maximum number of general anaesthetics performed during any one admission being 70. Further, in a number of cases, two or more admissions that included a general anaesthetic occurred within 30 days of the death, resulting in more than one death being eligible for inclusion in the numerator and more than one admission being eligible for inclusion in the denominator. As a result of these complexities, mortality rates have been calculated per 100 admission events where one or more anaesthetics were performed, rather than per 100 anaesthetics (that is, the denominator is the number of admission events rather than the number of anaesthetics). Where two eligible admissions occurred within 30 days of death, both admission events have been counted in the denominator (number of hospital admissions) but the death has only been counted once, in the most recent admission event prior to the death.

Day-of-the-week mortality

The first procedure that involved a general anaesthetic during a hospital admission was used as the index procedure and the date of this procedure was obtained from information included in the NMDS. The day of the week for the occurrence of the index procedure was assigned on the basis of the date for the procedure. Deaths within 30 days were assessed in relation to the day of the week of the index procedure. The methods applied to the 30-day mortality chapter were also followed with these analyses. In some analyses information related to procedures on Saturday and Sunday were combined and assessed as weekend procedures.

3. Socio-demographic and clinical covariates

Charlson Comorbidity Index score

The Charlson Comorbidity Index is a method of categorising comorbidities of patients based on the International Classification of Diseases (ICD) diagnosis codes found in administrative data, such as hospital admission data. Each comorbidity category has an associated weight, based on the adjusted risk of mortality, and the sum of all the weights results in a single comorbidity score for an admission. The index has been validated in a variety of clinical settings and has been updated to enable it to be used with ICD10 administrative data in New Zealand (Quan et al 2011).

NZDep decile

Analysis of NZDep information in this report is based on 2013 NZDep data.

Other socio-demographic and clinical occurrences, unless otherwise stated, have been dealt with in the same way as in previous reports.

ASA SCORE	Description
1	A normal healthy patient
2	A patient with mild systemic disease
3	Patient with severe systemic disease that limits activity
4	Patient with severe systemic disease that is a constant threat to life
5	A moribund patient who is not expected to survive longer than 24 hours without surgical intervention
6	A declared brain-dead patient whose organs are being removed for donor purposes
9	No documented ASA score

EMERGENCY	Modifier Description
0	Procedure being performed as an emergency
9	Non-emergency or not known

Unless otherwise specified, the ASA status referred to throughout this report is the ASA status derived from the first anaesthesia code for each admission event (with the order of procedure codes being determined by the diagnosis sequence variable within the NMDS). In the case of multiple anaesthetics, it is likely that this first ASA status reflects most closely the ASA status of the patient at the time of admission. However, in Table 6 the ASA status and emergency status of the last listed anaesthesia code has been used, in order to better reflect the factors associated with the last anaesthetic prior to death (with the order of procedure codes again being determined by the diagnosis sequence in the NMDS).

4. Interpreting multivariate analyses: Odds ratios and rate ratios

This report used logistic regression for multivariate analysis. A limitation of logistic regression is that the results generated are expressed as odds ratios (the odds of an event occurring in an exposed group versus the odds of it occurring in an unexposed group) as opposed to rate ratios such as relative risk (the risk of an event occurring in an exposed group relative to the risk of it occurring in the unexposed group).

Odds ratios provide a close estimate of relative risk for rare outcomes. However, for non-rare outcomes, odds ratios become biased away from the null, resulting in a tendency to over-estimate the magnitude of any effect.

In this report, consistent with previous reports, all odds ratios derived from figures where the mortality rate exceeds 20% have been suppressed (as indicated by an H). Interpreting any odds ratios where the associated mortality is in the 10%–19% range should also be interpreted with caution because of the tendency for odds ratios to slightly overestimate rate ratio (and the magnitude of effect).

Appendix 3: Previous report recommendations – progress summary

The following tables present the POMRC's progress on recommendations made in the previous four reports.

Table 27: Progress Summary of Fourth Report Recommendations

RECOMMENDATIONS OF FOURTH REPORT (MARCH 2015)	PROGRESS TO DATE (MARCH 2016)
The POMRC recommends that: Further work should be undertaken to reduce the risk of thromboembolic disease. Consideration should be given to continuing prophylaxis after discharge from hospital including engaging patients in the ways they can reduce their risk.	Safe Surgery NZ and the College of Surgeons were notified of this recommendation.
The POMRC should continue to participate in the development and evaluation of WHO metrics for monitoring and strengthening global surgery and anaesthesia.	POMRC data has been provided to the Royal Australasian College of Anaesthetists for presentation of Oceania metrics.
All providers (public and private) should contribute data on health care to the National Minimum Dataset.	The last year has seen an increase in provider reporting.
The ASA status should be recorded for all patients for all procedures (including all procedures that do not involve an anaesthetist).	There has been a slight improvement in the recording of ASA status. The Health Quality & Safety Commission (the Commission) surgical teamwork and communication programme rolled out this year has made ASA status a requirement on the 'time out' component of the Surgical Safety Checklist. This recommendation is repeated for 2016.
Given the high mortality associated with severe postoperative sepsis, further investigation into prophylaxis, early detection, diagnosis and management should be undertaken.	According to Safe Surgery Outcome measure data, sepsis quarterly rates experienced a significant increase during Q1 2009 to Q4 2012. This upward trend continued for another three quarters before the effect of the programme started to be shown in Q4 2013. The upward trend started bending to flat since Q4 2013 till the end of Q3 2015. However, it is still too early to see a significant shift; more time is needed to tell if the flattening out is sustained.
A targeted evaluation of the mortality rate of Māori patients undergoing CABG should be undertaken.	The mortality rates of Māori patients undergoing CABG highlighted in the 2015 POMRC report were brought to the attention of the Health Research Centre to consider how future research in this area could be supported.
Local multidisciplinary mortality review committees should be developed. Review should not be limited to patients viewed as low risk, as investigation of higher risk patients (older, high ASA status, acute) who died may help prevent future deaths by identifying common factors and determining preventable strategies or more appropriate treatment pathways.	The POMRC along with a working group has designed a Tier 1 form which is to be trialled by six pilot sites to look at causality and preventability themes.
The Māori Caucus recommends that: Further research should be undertaken to identify ways to improve Māori access to cardiac treatments, including screening, early detection and addressing barriers to service uptake.	The mortality rates of Māori patients undergoing CABG highlighted in the 2015 POMRC report were brought to the attention of the Health Research Centre to consider how future research in this area could be supported.

Table 28: Progress Summary of Third Report Recommendations

RECOMMENDATIONS OF THIRD REPORT (MARCH 2014)	PROGRESS TO DATE (MARCH 2016)
Recommendations for *improving perioperative care*: The ASA Physical Status Classification for each patient should be collected and communicated to all theatre staff. The Committee considers this is best done in the time out part of the WHO Surgical Safety Checklist.	The need for ASA recording as part of the checklist has been highlighted by the Perioperative Harm Advisory Group. The proportion of ASA recording is improving but far from complete. This recommendation will be repeated.
A continuing focus on promotion of formal and timely assessment of the risk of venous thromboembolism (VTE) is warranted, including with acutely admitted patients, given the apparent minor increase in pulmonary embolism mortality.	The Commission is partnering with the International Society on Thrombosis and Haemostasis, highlighting a systematic approach to assessment and prophylaxis of VTE. Help for introducing hospital VTE prevention programmes was included in a 2012 Commission-sponsored project to establish a national policy framework for VTE. As the most recent year reported on is 2012, no effect would yet be seen.
Recommendations for *system development*: The Committee should work with health care providers to develop recommendations for standardised perioperative mortality reporting and reviewing.	All DHB and private providers have been surveyed as to how they undertake local perioperative mortality review. Areas that are doing it well have been identified, and the Lead Coordinator for POMRC has undertaken site visits collecting information as to what best practice looks like. Recommendations will then be drawn up as to how best to undertake a standardised local perioperative mortality review.
Recommendations for *further analysis*: The proposed WHO measures of surgical care should be incorporated into perioperative mortality analysis and reporting.	The 2015 report has focused on two of the WHO proposed standardised public health surveillance metrics: day-of-surgery and postoperative inpatient deaths.
A standard out-of-hospital death notification process should be explored as a mechanism to identify deaths that occurred within 30 days of an operative procedure but after discharge.	This process is under development.
The Commission should consider developing a resource on hospital standardised mortality ratios.	Under investigation.

Table 29: Progress Summary of Second Report Recommendations

RECOMMENDATIONS OF SECOND REPORT (MARCH 2013)	PROGRESS TO DATE (MARCH 2016)
All patients should be formally assessed preoperatively for risk of VTE and appropriate thromboprophylaxis implemented, taking into account the individual risk/benefit profile	Raising the profile of VTE risk is part of the Commission's *Open for better care* campaign and promoted by the Reducing Perioperative Harm group.
All health care professionals should participate actively in the WHO Surgical Safety Checklist, including the question on thromboprophylaxis.	The Perioperative Harm Advisory Group of the Commission is actively promoting the use of the checklist to improve teamwork and communication.
To assist informed consent, information should be available for patients concerning the risk of dying within 30 days of any procedure that has significant risk of mortality.	Reports of this Committee (reporting mortality on a five-year rolling basis starting from 2006) will shape the development of informed consent resources for patients. This will be developed in conjunction with the Consumer Engagement team of the Commission. Data from the reports has been used in clinical teaching.
Non-operative care pathways should be developed and used when surgical procedures are deemed inappropriate because of excessive risk.	This has been raised with the Royal Australasian College of Surgeons and the Australian and New Zealand College of Anaesthetists and is supported.
Case studies are developed to highlight current good practice or recommend practice change.	Case studies are used in the annual POMRC workshops.
Psychosocial issues contributing to mortality following procedures require further investigation.	Close communications are maintained with the Suicide Mortality Review Committee.
Given the relative mortality of acute (1.0%) and elective (0.16%) cholecystectomy, further research is conducted into the management of acute cholecystitis.	Analysis included in the 2015 report.
Mortality following acute surgery for those aged over 80 years needs further assessment and discussion with health care professionals so that optimal health care can be planned.	Analysis included in the 2015 report.
There is a continuing focus on ASA 1 and 2 elective surgery mortality (as, for these patients, a positive outcome was anticipated).	Further analysis included in the 2015 report.

Table 30: Progress Summary of Inaugural Report Recommendations

RECOMMENDATIONS OF INAUGURAL REPORT (FEBRUARY 2012)	PROGRESS TO DATE (MARCH 2016)
A whole-of-system perioperative mortality review process should be developed which builds on the NMDS and the NMC. This would include the accurate and systematic recording of patient and procedure details from all health care facilities and practitioners.	An integrated data entry process is being developed to collect data across all health care facilities.
Key components • The enhancement and standardisation of existing data collections and current mortality review processes to ensure a uniform, efficient and meaningful national methodology.	An integrated data entry process is being developed to collect data across all health care facilities. Identification of 'all perioperative processes' in the NMDS remains problematic and will be addressed by the data entry process being developed. Private hospital coverage is still incomplete, particularly private day-stay providers.
• A coding mechanism that recognises both procedures and deaths within the remit of the Committee. This will require investigation to determine optimal methodology.	See above. Comments from previous reports remain.
• The development of a national standardised perioperative mortality review form that will be common to all health care facilities and practitioners. This form will enable and facilitate additional data collection and peer review processes.	This will be an electronic data only process, which is under development.
• Secure national data storage hosted by, and under the guardianship of, the Commission.	Completed.
• The ability to carry out whole-of-system and focused (sub-group) analysis of both qualitative and quantitative data.	Under development.
• The ability to report at a number of levels (national, regional, within health care facility) and to a variety of audiences, including consumers and the wider community.	A data entry process is being developed to enable national, regional and local reporting.
• The ability to generate evidence-based, peer-reviewed recommendations for reinforcing current 'good practice' or system improvements leading to practice change.	In progress.
• Formalised Memorandum of Understanding between the POMRC and Coronial Services to enable enhanced and standardised data access.	A change in Chief Coroner has slowed the process, but progress is being achieved. The Memorandum of Understanding is in development and is expected to cover all the mortality review committees.
• Work with the National Health Board to ensure that the NMDS and NMC collections are enhanced and standardised by: – ensuring that the ASA score is recorded for all procedures – separately identifying existing conditions from those acquired during that admission – ensuring that the immediate cause of death can be identified from the data collections.	The National Health Board and mortality review committees have worked together to improve data capture. This remains an iterative process as data collection and reporting systems are further developed.
• Submission of data to the NMDS is mandatory for all health care facilities.	Following sector consultation, this recommendation has been well received by both the public and private sectors. Despite this, there are some private facilities still not submitting data to the NMDS.

Appendix 4: POMRC Progress 2010–2016

Table 31: POMRC Progress since Committee Establishment, 2010–2016

ESTABLISHMENT PHASE		IMPLEMENTATION PHASE			
Year 1 July 2010–June 2011	**Year 2 July 2011–June 2012**	**Year 3 July 2012–June 2013**	**Year 4 July 2013–June 2014**	**Year 5 July 2014–June 2015**	**Year 6 July 2015–June 2016**
POMRC establishment	Inaugural report published (February 2012)	POMRC at full membership	Publication of progress report (March 2014)	Publication of progress report (June 2015)	Publication of progress report (June 2016)
Sector engagement/ consultation	Sector engagement/ consultation	Sector engagement/ consultation	Publication of further national perioperative mortality data (June 2014)	Publication of fourth report (June 2015)	Publication of fifth report (June 2016)
Data scoping	Developing data analysis methodology	Publication of second report	Second workshop (June 2014)	Third workshop (June 2015)	Fourth workshop (June 2016)
Determine reporting focus	Reviewing additional data modalities	Endoscopy Working Group established	Endoscopy case review		
Transition from Ministry of Health to Health Quality & Safety Commission		Inaugural workshop (June 2013)	Integrated review form piloted internally and externally	Review of existing local mortality review processes	
		Development of integrated perioperative mortality review form	National perioperative mortality data collection infrastructure developed		

List of Abbreviations

ACC	Accident Compensation Corporation
ACHI	Australian Classification of Health Interventions
ANZASM	Australian and New Zealand Audit of Surgical Mortality
ANZCA	Australian and New Zealand College of Anaesthetists
ASA	American Society of Anesthesiologists
BMI	Body mass index
CABG	Coronary artery bypass graft
CCI	Charlson Comorbidity Index
CI	Confidence interval
COPD	Chronic obstructive pulmonary disease
DHB	District health board
ERCP	Endoscopic retrograde cholangio-pancreatograph
EuSOS	European Surgical Outcomes Study
ICD	International Classification of Diseases
IV	Intravenous
MELAA	Middle Eastern/Latin American/African
NMC	National Mortality Collection
NMDS	National Minimum Dataset
NSQIP	National Surgical Quality Improvement Program
NZDep	New Zealand Deprivation Index
OR	Odds ratio
PCI	Percutaneous coronary intervention
POMR	Perioperative mortality rate
POMRC	Perioperative Mortality Review Committee
PTCA	Percutaneous transluminal coronary angioplasty
SASM	Scottish Audit of Surgical Mortality
STEMI	ST-elevated myocardial infarction
VTE	Venous thromboembolism
WAASM	Western Australia Audit of Surgical Mortality
WHO	World Health Organization

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