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Physical observations are recorded on patients in hospital in order to detect those whose conditions are deteriorating before a medical emergency, such as cardiac arrest, takes place. After heart surgery, the observations are often deranged, especially heart rate, and although rapid treatment is required it would be a significant burden on the medical emergency team to call a “code” in each case. We propose that it would likely be safe to adopt the New Zealand Early Warning Score system in our institution and to increase the heart rate parameter from 140 to 150 beats per minute.

Media accounts of unintentional child injury deaths in New Zealand: a teachable moment?
Bridget Kool, Savesh John

We reviewed media accounts of fatal child unintentional injury events reported in four leading New Zealand newspapers for their completeness and potential to deliver evidence-based injury prevention messages. Only 20% of accounts included clear prevention messages. Just over 33% of accounts included images and 66% were located within the first three pages. The low frequency of prevention messages in the media accounts reviewed highlights a missed opportunity for the dissemination of prevention messages to the New Zealand public.

BMI is a key risk factor for early periprosthetic joint infection following total hip and knee arthroplasty
Patrick Jung, Arthur J Morris, Sally A Roberts, Mark Zhu, Chris Frampton, Simon Young

This study has found BMI to be a key risk factor for developing surgical site infection following a total hip (THA) or knee (TKA) arthroplasty (replacement). Having a BMI in the morbidly obese category puts patients at a 5.6 times and 2 times increased risk of infection following THA and TKA respectively. Traditional methods to capture infection rates, such as joint registry data, have been shown to underestimate true infection rates. The New Zealand Surgical Site Infection Improvement programme more accurately captures this data and will be important in reducing infection by ensuring quality and safety markers are met.

Mental health service use by Asians: a New Zealand census
Cheok Soon Chow, Roger T Mulder

Asians are the third largest ethnic group in New Zealand. They have low rates of mental health service utilisation. Since those who use mental health services are no more severely ill than other ethnic groups this suggests that Asians have the lowest prevalence rates of mental disorder.
Estimated reduction in expenditure on hospital-acquired pressure injuries after an intervention for early identification and treatment

Heather Lewis, David Hughes, Dominic Madell, Christin Coomarasamy, Luis Villa, Brooke Hayward

Approximately 55,000 people a year in New Zealand experience a pressure injury, and these can cause constant pain, loss of function and mobility, financial difficulties, prolonged hospital stays, septicaemia and even death, as well as depression, distress and anxiety, embarrassment and social isolation. An intervention designed to reduce numbers of hospital-acquired pressure injuries was delivered in Counties Manukau Health hospitals from 2011 to 2015. Numbers of patients with different levels of pressure injuries were estimated across hospitals in Counties Manukau Health (Counties Manukau DHB) in these years. It was found that the estimated cost of treating pressure injuries in hospital patients was NZ$12,290,484 less in 2015 than in 2011, which was attributed to the intervention. It is concluded that strategies for managing hospital-acquired pressure injuries can lead to large financial savings for hospitals, as well as reducing the burden of managing this difficult condition for patients and staff.

The association between the first locating emergency ambulance being single crewed and cardiac arrest outcomes in New Zealand

Bridget Dicker, Paul Davey, Tony Smith

This was a retrospective analysis of St John New Zealand out-of-hospital cardiac arrest (OHCA) registry data for the period of 1 October 2013 to 30 June 2015. The study identified that patients first attended by a single-crewed ambulance had poorer survival to hospital discharge (12% survival) than those first attended by a double-crewed ambulance (17% survival). Although further investigation is required, it is likely that pursuing the use of double-crewed ambulances may positively impact OHCA survival rates in New Zealand.

Bionic balance organs: progress in the development of vestibular prostheses

Paul F Smith

Patients without functioning balance organs in the inner ear have poor quality of life. One solution is to implant an artificial vestibular system that can substitute for the missing inner ear function. This has been done in several parts of the world and has been relatively successful. This development is part of the growing field of artificial sensory systems.

The apprenticeship model of clinical medical education: time for structural change

Kate Rassie

The apprenticeship model, which forms the backbone of the current medical education system, has a strong historical precedent. However, its application to modern medicine is far from perfect, particularly with the breadth and complexity of current hospital systems. Demands on clinician resources, the sheer volume of knowledge our trainees must amass, short attachments and rigorous assessment schedules are all major challenges to a relatively simplistic educational system. Identifying and addressing these vulnerabilities is essential to enhancing the educational experiences of both undergraduate medical students and junior doctors in New Zealand: this article explores the issues, and poses possible solutions.
Rethinking apprenticeship
Tim J Wilkinson

One of my colleagues recently referred to their RMO (resident medical officer) as their random medical officer. This was no criticism of an individual but reflected the developments over the last decades where knowing exactly who's in one's clinical team has become less certain.

There was a time when, in hospital settings, a medical team comprised a senior doctor, registrar, RMO and sometimes a trainee intern—more importantly, that team remained relatively stable for weeks or months. They all got to know each other, they learned each other's strengths, weaknesses and foibles, and apprenticeship learning just sort of happened. Let's not forget the price of that continuity—long, unreasonable and unsafe working hours. Those days are gone. In this issue of the journal, Rassie wonders if the days of the old apprenticeship model are also gone.1 She calls for a structural change to the apprenticeship model. There certainly needs to be a rethink of apprenticeship—I'm less sure a structural change is the solution.

In either case, both she and my colleagues seem to agree that apprenticeship isn't quite right at the moment.

The pendulum is swinging around apprenticeship. It was once seen as the cornerstone of good medical education. It then fell into disfavour and was viewed by some as inefficient, at times exploitative, and often as a way of preserving the status quo—a way of ensuring “the way we do things around here” stays that way. Evidence-based practice, standardisation of education and wanting to be sure all learning objectives were learnt led to a period where apprenticeship was seen as too messy and uncontrolled. Then we rediscovered workplace learning and with that, began to understand what makes it work.2–4

Here's my view of what makes workplace learning work.

Let's start with supervision. It's easy to get this wrong. We can over-supervise or under-supervise—both have problems. When we over-supervise, we take too much control. We don't allow the trainees sufficient autonomy to make their own decisions. We end up just telling them what to do. This creates passivity in the trainee and they can become too scared to make any decisions without deferring to their supervisor. This just makes the supervisor even more controlling, and a vicious cycle is soon in play. When we under-supervise, we leave the trainee to it—“call me if you're worried” with the subtext of “don't really call me or if you do I'll consider you incompetent”.

The trainee may well learn a lot—often by making mistakes—and there are real concerns around patient safety. Neither of these scenarios is great for learning.

But judging the right amount of supervision to provide is also difficult because every trainee is different—made worse if there's a new trainee on the team every week or two. Likewise, every supervisor is different—each has his or her idiosyncrasies. As an example, I recall the wall of an orthopaedic ward covered with notices, each explaining how each orthopaedic surgeon liked their DVT prophylaxis to be given. None of the protocols was wrong, but they were all different. If a trainee did not know that and applied a different protocol, they might be chastised for doing it the wrong way. If they asked the surgeon how to give DVT prophylaxis they may fear being seen as ignorant—“didn't they teach you DVT prophylaxis in medical school?”

Herein lies the heart of the problem. Each trainee is different and each supervisor is different. Yet, if these are not understood by each party, how can trust develop? How can a supervisor know what it's safe to let a trainee do? How can a trainee know what they're allowed to do and what they should ask about? In the old days, people just worked it out because they had time to. Yes, the first weeks were tricky while each party got to know each other, but eventually it all settled down and a working and learning relationship ensued.

I suggest therefore that part of the solution to the new apprenticeship is a form of speed-dating. We need ways by which learner and supervisor can quickly get to know
each other and quickly learn each other’s strengths, weaknesses and idiosyncrasies. This establishes mutual trust and is a process change, not a structural change. What might this look like? It may be taking a few minutes whenever a new person joins the team, and call me old-fashioned here, to get to know each other; attending to the initiation part of the team building, not just doing the maintenance part. This needs to be two-way—making space to learn about the trainee’s strengths and weaknesses as well as making space for the trainee to learn about the supervisor’s strengths and weaknesses. This includes making it easy for each other to ask questions—“there’s no such thing as a stupid question in our team”. Rassie notes that assessment may undermine this—that may well be true, particularly if assessment aims to judge someone’s knowledge, but what if assessment were to judge someone’s curiosity? Suddenly, assessment might actually help—another simple process change. This speed-dating needs to occur every time a new person joins the team—for some, this may be every week. That would take time but we’d probably get better with practice.

It’s easy to get trapped into equating good supervision and good apprenticeship with good teaching, and then to think that good teaching equates with telling people what to do. Workplaces rarely work that way—they’re often too busy. Yet, this busy-ness is its strength. We recently undertook an ethnographic study of learning in a ward where two of the interesting findings were that the learning moments were often very short—the median duration was one minute with a range from 15 seconds to 21 minutes. Secondly, many of these moments went unnoticed. So, learning is occurring all the time, we just need to make it explicit.

Good apprenticeships foster good learning. Of course, we also want good teaching and good assessment. But for me, I’d start with a focus on ways to form quick and effective supervisor-trainee relationships within the first few minutes of someone joining the team—from that everything else follows.

Competing interests: Nil.

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Is the New Zealand Early Warning Score useful following cardiac surgery?
Kevin Niall Peek, Michael Gillham

**ABSTRACT**

AIMS: The rate of medical emergency team (MET) calling among post-cardiac surgery patients is unknown. We set out to determine what the call frequency would be if MET activation occurred in every instance that the early warning score (EWS) breached our local threshold, what the outcome was for these patients and what the calling rate might be if the proposed New Zealand EWS (NZEWS) system was implemented with 100% adherence.

METHODS: The clinical records of 400 consecutive post-cardiac surgery patients were examined. The number of times a patient's EWS reached the threshold which mandated a call to the MET was determined, as was the actual rate of calling, the occurrence of inpatient death and re-admission to the intensive care unit (ICU). The rate of calling was then determined using the NZEWS, and with a routine modification to the heart rate score.

RESULTS: There were 73 occasions (MET events) where the EWS reached the MET calling threshold. The MET was only called twice. There were no inpatient deaths and 12 ICU re-admissions in the study cohort. Nine ICU re-admissions were preceded by a MET event, two by cardiac arrest and one had neither. Re-scoring with NZEWS yielded 53 events. Eight of the 12 ICU admissions were preceded by a NZEWS event.

CONCLUSIONS: The rate of MET triggering EWS in patients post-cardiac surgery is high at 182/1,000 admissions. Using NZEWS could reduce the MET calling rate without significant risk to patient safety.

An early warning score (EWS) is a tool used by medical providers to identify those patients who are at risk of developing organ dysfunction and/or death. These scores are based on a set of physiological observations (parameters). In general, respiratory rate, heart rate, systolic blood pressure, temperature and level of consciousness are measured. But variation exists and some scores include peripheral pulse oximetry and volume of urine passed. Deviation from the reference range in each parameter contributes to an overall aggregate score. In many hospitals within New Zealand, when the EWS meets a threshold, a call for review by a medical emergency team (MET) or an experienced senior nurse is either recommended or mandated.¹-⁴

In a survey of district health boards in New Zealand a large variance was found, between which parameters were used to compose the EWS, the weighting and thresholds of each parameter and the response to an elevated score.⁵ The Auckland District Health Board's current EWS was developed as a composite of a pre-existing mandatory “Criteria for Code Red Call” and the Physiologically Unstable Patient (PUP) score.⁶,⁷ There is currently considerable focus on developing a national New Zealand Early Warning Score (NZEWS) similar to those systems developed in the UK.⁸,⁹

In general hospital cohorts, patients who trigger a MET review are at high risk of morbidity and death. However, there are little data concerning the use of an EWS in post-operative cardiac surgery patients.¹⁰ Post-operative cardiac surgery patients have a high rate of primary, rapid atrial fibrillation and are often being treated for heart failure with vasodilators such as angiotensin converting enzyme inhibitors.¹¹ Tachycardia and hypotension are frequent and can often be adequately managed by the ward staff without activation of the MET. Frequent MET activation in the absence of specific...
adequate funding for this service may have adverse effects on care delivery to patients within the intensive care unit.\textsuperscript{12}

We set out to determine what the call frequency would be if MET activation occurred in every instance that the EWS breached our local threshold, what the outcome was for these patients and further, what the calling rate might be if the proposed NZEWS system was implemented with 100\% adherence. As there have been no studies performed on this group of patients we decided to study a moderate number of (400) patients in the first instance.

Methods

Four hundred consecutive post-cardiac surgery patients who were discharged from the ICU to the cardiothoracic ward were identified retrospectively from our ICU database. Procedure and demographic information for each patient were collected from the clinical records. All physical observation charts from the time of admission to the cardiothoracic ward until discharge from hospital were examined by the principal investigator. Each set of observations was scored according to the hospital EWS criteria (Figure 1). Scores of 5 or higher, which

Figure 1: Auckland District Health Board Adult Observations Chart.

Each parameter is scored according to EWS scoring key and the total score for each set of observations tallied at the bottom of the page. A score of 5 or greater mandates a MET call (“code red”).

ARTICLE
should trigger a MET call, were considered ‘MET events’. For each MET event, the parameter(s) that was deranged, leading to the elevated score, was recorded. In order for more than one event to be recorded for an individual patient, the EWS must have fallen below 5 for at least one set of observations between MET events. The compliance with correctly recording the EWS after each set of observations was also determined in the first 100 patients.

The following outcomes were determined for each MET event: compliance with alerting the MET, review by the ICU team, re-admission to ICU and inpatient mortality.

The outcomes were determined by examining the clinical records including doctors’ and nurses’ notes, the electronic record system, admission and discharge records from ICU and the patient’s final hospital discharge summaries.

Finally, the physical observation charts for each MET event were examined again and re-scored using two alternative systems. First, using the proposed NZEWS criteria (Figure 2) and second, using the current EWS criteria but increasing the upper limit of heart rate as a single parameter MET trigger from 140 to 150 beats per minute (bpm). An analysis of the effect of these changes to the scoring criteria was performed.

This investigation (A+ 7186) was approved by the Auckland DHB Research Review Committee.

Figure 2: New Zealand Early Warning Score Adult Vital Signs Chart.
Table 1: MET Events—parameters that led to an EWS of 5 or higher.

<table>
<thead>
<tr>
<th>MET Events</th>
<th>73</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate &gt;140 bpm</td>
<td>30</td>
</tr>
<tr>
<td>Heart rate &gt;150 bpm</td>
<td>5</td>
</tr>
<tr>
<td>Heart rate &lt;40 bpm</td>
<td>6</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;80mmHg</td>
<td>18</td>
</tr>
<tr>
<td>Combination</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 2: Primary outcomes of MET events.

<table>
<thead>
<tr>
<th>Events</th>
<th>73</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET calls (%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Referred to ICU independent of a MET call (%)</td>
<td>11 (15%)</td>
</tr>
<tr>
<td>Re-admitted to ICU (%)</td>
<td>9 (12%)</td>
</tr>
<tr>
<td>Inpatient deaths</td>
<td>0</td>
</tr>
</tbody>
</table>

Results

In 400 consecutive patients (274 males, 126 females) discharged from the ICU to the cardiothoracic ward, 43 patients had a total of 73 MET events of EWS 5 or more. Two additional patients also had unheralded cardiac arrest. Thirty MET events were for isolated heart rate (HR) >140bpm, six for isolated HR <40bpm, 18 for isolated systolic blood pressure <80mmHg and 19 for a combination of deranged observations (Table 1).

Among the 73 MET events which mandated a MET call, there were only two MET calls made. The remaining 71 MET events were managed without alerting the MET (Table 2). The EWS was not recorded or recorded incorrectly in 1,462 of 4,480 sets of observations or 33% of the time.

In total, 12 patients in the 400 patient cohort were re-admitted to the ICU. Three patients had no preceding MET event. Two of these followed unheralded cardiac arrest and one was referred back and re-admitted without having a MET event. This patient had concerning hypoxia. Nine patients were re-admitted following a MET event, with only one having a MET call made and the other eight being referred to ICU independent of a MET call. There were no inpatient deaths.

When the MET events were re-scored using the proposed NZEWS chart, there were only 53 which mandated a MET call. There was one additional patient that did not meet MET criteria on the NZEWS chart who was subsequently re-admitted to ICU.

Re-scoring MET events with an increased upper limit of heart rate as a single parameter MET trigger from 140–150bpm as a modification to the current EWS resulted in 48 in which a MET call was required. This re-scoring led to one additional patient being missed who was subsequently re-admitted to ICU following a heart rate between 140–150bpm. Applying the same heart rate modification to NZEWS resulted in 28 MET calls and three patients missed who were re-admitted to the ICU (Table 3).

Discussion

We observed a high rate of deranged observations in this cohort of 400 post-cardiac surgery patients. There was poor adherence to alerting the MET to patients who breached the calling criteria at 3%. With complete adherence to the EWS system a MET activation rate of approximately 182 per 1,000 admissions can be expected. This rate is much larger than the typical rate of 20–40 per 1,000 admissions seen in general hospital cohorts.13 We have found that the most commonly deranged parameter mandating a MET call was isolated tachycardia (41%), and in most cases the rate was between 140–150bpm. This contrasts with general hospital cohorts.
Table 3: Frequency of MET events using current EWS, NZEWS and allowing isolated HR up to 150bpm.

<table>
<thead>
<tr>
<th>Events</th>
<th>Event rate (per 1,000 admissions)</th>
<th>ICU re-admissions without MET event</th>
<th>Reason for re-admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using current EWS</td>
<td>73</td>
<td>182</td>
<td>1</td>
</tr>
<tr>
<td>Current EWS but allowing isolated HR up to 150bpm</td>
<td>48</td>
<td>120</td>
<td>2</td>
</tr>
<tr>
<td>Using NZEWS</td>
<td>53</td>
<td>133</td>
<td>2</td>
</tr>
<tr>
<td>Using NZEWS and allowing isolated HR up to 150bpm</td>
<td>28</td>
<td>70</td>
<td>3</td>
</tr>
</tbody>
</table>

in whom the most common cause for MET activation is hypoxia.13

One of the principal aims of an EWS system is to identify those patients who are at risk of deteriorating to cardiac arrest and/or death. None of the 43 patients in our study with an EWS of 5 or higher progressed to either of these outcomes, and less than one-quarter (9/43) of these patients were re-admitted to the ICU.

A substantial increase in the number of MET calls can be expected should adherence to the current EWS system be absolute in post cardiac-surgery patients. Relaxing the threshold for isolated tachycardia as a single MET calling criterion from 140–150bpm may safely allow the initial investigation and management of fast atrial fibrillation to occur without involvement of the MET. If our current system were replaced by the proposed NZEWS, the calling rate would be lower but still high. It is unlikely that many significantly deteriorating patients would escape detection if the threshold for heart rate in isolation activating the MET were elevated to 150bpm. Patients who were causing significant concern can still be referred to the MET without attaining the requisite point score.

Our data indicates that calling rates in post-operative cardiac surgery patients will be high if the NZEWS system is introduced. This group of patients has very low in-patient mortality. Modification of the heart rate parameter to allow rates up to 150bpm before calling the MET will attenuate this to a degree but may result in more patients re-admitted to the ICU being ‘missed’ by the system. Hospital METs will need to be appropriately resourced to deal with the demand.

Competing interests:
Nil.

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The Convention on the Human Rights of the Child stipulates that countries have an obligation to take all necessary steps to protect children from all forms of injury.¹ Unintentional injury is the leading cause of death in children (1–14 years) in New Zealand; there are approximately 8.4 unintentional injury-related deaths per 100,000 children (aged 0 to 14) annually.² Ethnic and gender disparities are evident, with the unintentional injury mortality rate for children 3.5 times higher among Māori than non-Māori, and 1.6 times higher in male children compared to female children.³ A 2010 report by O’Dea and Wren estimated the economic cost of a child fatality at $8.05 million, significantly higher than that for an adult fatality ($5.74 million).⁴ The most recent United Nations International Children’s Emergency Fund (UNICEF) report on child poverty in rich countries, which includes injury data, indicates New Zealand has the highest rate of childhood fatal injury among 21 OECD countries,⁵ highlighting the need for renewed efforts to improve child safety to a level that is at least consistent with other high-income countries. Furthermore, a study comparing New Zealand child injury safety with 24 European countries found that New Zealand ranked 25th for Moped/motor scooter safety, 23rd for passenger/driver safety and 19th equal for pedestrian safety.⁶

A potential effective child injury prevention strategy is the provision of child safety messages via print and online news media. News media, unlike TV mass media advertising, has the advantage of not having to compete with commercial advertising for viewer attention,⁷ and is widely accessible with the potential to raise public awareness of childhood injuries and how to prevent them. A 2004 systematic review of the effectiveness of mass media campaigns...
for reducing alcohol-involved crashes found that a well-executed mass media campaign can contribute to a reduction in alcohol-related crashes. Similarly, a US study found that news media accounts played a significant role in a campaign to increase helmet usage among school-age children with rates increasing from 4% among children under 15 years to 54% among those ages five to nine years, and 38% among 10–14 year olds over 51 months.

A study by Kool et al of New Zealand fatal domestic fire-related child injury deaths found that all 14 fatal fire-events recorded by the fire service during a 10-year period were reported in the national newspaper with a high degree of detail and accuracy. However, only around one quarter of articles informed readers of specific measures that could prevent such events, suggesting a potential missed opportunity.

The potential of “teachable moments” for advocating for health behaviour change is well documented. Health professionals can potentially play an important role in promoting prevention messages to accompany media accounts of public health interest. For instance, the need for greater advocacy partnerships between the media and public health professionals for awareness of skin cancer prevention or in changing the way that motor vehicle crashes are framed.

The aim of this study was to review media accounts of fatal child unintentional injury events reported in leading New Zealand newspapers to explore the content of these reports and their potential for the delivery of evidence-based injury prevention messages. The findings have the potential to inform changes to the way in which print and other media outlets report serious child injury events and to ensure that public health professionals are more proactive in engaging with key media outlets (print, online and television) to promote child safety agendas.

**Method**

Using a content-analysis approach we examined New Zealand print media accounts of fatal unintentional child (0–14 years) injury events over a five-year period (1 January 2011 to 31 December 2015). New Zealand’s four largest daily newspapers (the New Zealand Herald [readership: 549,000], The Dominion Post [readership: 256,000], The Press [readership: 188,000] and The Otago Daily Times [readership: 93,000]) were searched for relevant articles. Two news clipping services (Media-Monitors and Isentia) accessed via Safekids Aotearoa were used to locate the relevant articles. Eligible articles included those that were published during the five-year period of interest and reported the death of a child or children (<15 years of age) as a result of unintentional injury. Treatment injuries were excluded. We only analysed accounts that were published in the immediate period following the injury event. In situations where the same event was mentioned by multiple sources the event was only counted once in the analysis.

Content analysis is the “systematic, objective, quantitative analysis of message characteristics”, and can be used to examine messages in a range of mediums, including: advertising, face-to-face human interactions, blogs, political speeches and news media.

For the purposes of this research, information extracted from each media account included: the newspaper/s which featured the media account, the date it appeared, prominence of the media account in the newspaper (page number, presence of a photograph) and presence or absence of prevention messages. Information specific to the injury event included: the date and location of the event, mechanism of injury, mention of prevention measures, and the age, gender and ethnicity of victims. The mechanism of injury was classified by members of the research team using the Centre for Disease Control’s International Classification of Diseases (ICD-10) external cause codes (V01-X59).

Prevention messages were classified into two categories for clarity: clear or ambiguous. ‘Clear’ messages were those that directly stated the prevention method, for example “police recommend parents keep children at arm’s length when in and around water”. Prevention messages commonly quoted sources such as the police or SafeKids Aotearoa. ‘Ambiguous’ messages were those that loosely referenced prevention or carelessness involved, for example a newspaper account where alcohol involvement in a road traffic crash that killed a child was noted, however there was no direct
mention of the known risks associated with driving under the influence of alcohol or the current legal blood or breath alcohol levels. In addition, as a proxy to assess the completeness of case ascertainment by the media accounts, the total number of injury deaths for the two leading causes of injury (transport [V01-V09] and drowning [W65-W74]) recorded in the National Injury Query System (NIQS) were compared with the number of deaths captured by the media accounts. The NIQS (http://psm-dm.otago.ac.nz/niqs/) is maintained by the University of Otago and is a simple online injury query system which allows the user to produce New Zealand non-fatal and fatal injury-related statistics based on data from national data collections maintained by the Ministry of Health (the Mortality Collection, and the National Minimum Dataset [NMDS], which consists of public hospital discharge data). Due to the lengthy coronial process in New Zealand, there is usually a two-year lag period before the public release of the mortality data. Therefore, we compared the media account data for the two most common causes of fatal unintentional child injury with the three most recent years of complete mortality data (2011–2013) contained in the NIQS.

Results

Over the five-year period reviewed, a total of 122 unique unintentional childhood fatal injury events covering 133 fatalities were reported by the four leading newspapers reviewed, an average of 47.6 per year. The four leading newspapers contained a total of 242 articles relating to these events. Of the four major papers, the New Zealand Herald reported the most articles relating to the events of interest (37.2%; n=90) while The Press produced the least (14.5%; n=35).

Aside from a peak in 2012, there appeared to be a downward trend in the number of fatal child injury-related media accounts reported in the four major newspapers in New Zealand for the five-year period reviewed (Figure 1).

Characteristics of fatal unintentional child injury events reported in the media

The leading mechanisms of injury in the newspaper accounts of unintentional child injury deaths were transport-related events (56.5%; n=69), followed by drowning (23.0%; n=28) (Table 1). Among the transport-related deaths, ‘car occupant’ events were the most common (n=26/69), followed by
The majority of the fatal child injury events reported in the newspapers were single fatality events (94.2%, n=115). There were seven multiple fatality events: five road traffic events resulting in 11 deaths, the Christchurch earthquake in 2011 accounted for four deaths, and a single poisoning event resulting in three deaths.

Table 1: Mechanism of injury of unintentional childhood injury fatal events reported by the four major New Zealand newspapers, 2011–2015 inclusive.

<table>
<thead>
<tr>
<th>Mechanism of injury (ICD-10 E-code)</th>
<th>Total number of events</th>
<th>Total number of fatalities</th>
<th>Number of media accounts (n=242)</th>
<th>NZ Herald</th>
<th>Dominion Post</th>
<th>Otago Daily Times</th>
<th>The Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>All transport (V01-99)</td>
<td>69</td>
<td>75</td>
<td>48</td>
<td>29</td>
<td>39</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Car occupant</td>
<td>26</td>
<td>30</td>
<td>17</td>
<td>8</td>
<td>14</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Pedestrian injured in collision with vehicle*</td>
<td>21</td>
<td>21</td>
<td>17</td>
<td>10</td>
<td>14</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>All-terrain vehicle occupant</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pedal cycle†</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Transport, water</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other transport†</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Drowning (W65-74)</td>
<td>28</td>
<td>28</td>
<td>21</td>
<td>14</td>
<td>10</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Other†</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Poisoning (X40-49)</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Victim of earthquake (X34)</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Caught crushed/jammed (W23)</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Fire/flame (X00-09)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Suffocation/strangulation (W75-76)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total n (%)</td>
<td>122 (100)</td>
<td>133 (100)</td>
<td>90 (37.2)</td>
<td>54 (22.3)</td>
<td>63 (26.0)</td>
<td>35 (14.5)</td>
<td></td>
</tr>
</tbody>
</table>

* ‘Pedestrian injured in collision with vehicle’ includes: pedestrian non-traffic vs car, bus, truck, ute; and pedestrian traffic vs car, motorbike.
† ‘Pedal cycle’ includes: pedal cycle non-collision, pedal cycle vs car, bus.
†† ‘Other transport’ includes: go-kart; plane crash; non-collision car passenger, van passenger; motorcycle non-traffic; passenger non-traffic.
‡ ‘Other’ includes: cutting/piercing, electrocution, fall, firearm, allergy to insects and arachnids, exposure to animate mechanical forces, forces of nature-excessive heat.

Table 2: Completeness of reporting of unintentional fatal childhood injury events by injury type in leading New Zealand newspapers, 2011–2015 inclusive.

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>Total fatalities</th>
<th>Name reported</th>
<th>Age reported</th>
<th>Gender reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>75</td>
<td>63</td>
<td>73</td>
<td>71</td>
</tr>
<tr>
<td>Drownings</td>
<td>28</td>
<td>24</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Other*</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Poisoning</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Forces of nature—earthquake</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Caught/crushed or jammed</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fire/flame</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Suffocation/strangulation</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total n (%)</td>
<td>133</td>
<td>113 (85.0)</td>
<td>130 (97.7)</td>
<td>127 (95.5)</td>
</tr>
</tbody>
</table>

* ‘Other’ includes: cutting/piercing, electrocution, fall, firearm, allergy to insects and arachnids, exposure to animate mechanical forces, forces of nature-excessive heat.
Completeness of media accounts

The majority (85.0%; n=113) of child fatalities were identified by name in the media accounts reviewed (Table 2). Suffocation/strangulation events were least likely to report the child’s name (n=1/3). In almost all (97.7%; n=130) of the accounts, the victim’s age was reported, and in 95.5% (n=127) gender was reported. Ethnicity was reported for only six victims (5%) who were involved in four events (two drownings, one poisoning, and one fire/flame-related death).

For the three-year period reviewed where corresponding national mortality data was available (2011–2013), there was complete case ascertainment for the transport-related deaths (n=58) reported in the media, and all but one of the drowning deaths (n=27).

Prevention messages

Just under one half (46.3%; n=112) of the media accounts located included some form of prevention message, in 53.7% of accounts there were no prevention messages (n=130) (Table 3). Clear prevention messages were included in 20.3% of accounts (n=49) such as recommending parents stay within arm’s reach of accompany young children when playing in the water, checking the driveway before moving a vehicle or keeping cots away from curtain cords.

The New Zealand Herald had the highest proportion of media accounts with clear prevention messages included (26%; n=23), while The Otago Daily Times (ODT) had the least (14%; n=9). For the five leading injury mechanisms reported (transport, drowning, caught/crushed or jammed, fire/flame, poisoning), media accounts relating to poisonings were most likely to have clear prevention messages included (n=3/7), followed by drownings (n=14/53). Transport-related fatalities were the most commonly reported events, however, only 15.6% (n=21/134) of these accounts contained clear prevention messages. Of interest, there were no prevention messages included in any of the media accounts of electrocution deaths (n=4).

The majority of media accounts were considered to be in prominent locations within the newspaper, with 66% (n=158) appearing in the first three pages. Page three was the most common page for media accounts about unintentional fatal childhood injury events to appear. The mean page number where fatal injury media accounts appeared ranged from page 3.1 (the Press) to page 6.9 (ODT) (Table 4).

A total of 36 accounts (14.3%) of fatal child injury events appeared on the first page of the newspapers reviewed. When looking only at accounts which included prevention messages, the most common page number where the account appeared was page three, while the mean page number ranged from 3.2 (Dominion Post) to 9.4 (the ODT). Thirty-six articles (15%) were on the front page, with 12 of them including clear prevention messages.

Just over one third (36%; n=86) of media accounts included at least one picture (Table 4). The newspaper most likely to include a photo was the New Zealand Herald (49%; n=44), and the least likely was The Press (29%; n=10). Just over half of the accounts with prevention messages also included pictures with this most commonly occurring in the Dominion Post (n=9/11).

### Table 3: Presence or absence of prevention messages in media accounts of fatal child injury events in New Zealand’s four major newspapers, 2011–2015 inclusive (n=242).

<table>
<thead>
<tr>
<th>Newspaper</th>
<th>Total number of articles n (%)</th>
<th>Clear prevention message included n (%)</th>
<th>Ambiguous prevention message included n (%)</th>
<th>No prevention message n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand Herald</td>
<td>90 (37.1)</td>
<td>23 (25.6)</td>
<td>28 (31.1)</td>
<td>39 (43.3)</td>
</tr>
<tr>
<td>Dominion Post</td>
<td>54 (22.3)</td>
<td>11 (20.4)</td>
<td>14 (25.9)</td>
<td>29 (53.7)</td>
</tr>
<tr>
<td>Otago Daily Times</td>
<td>63 (26.0)</td>
<td>9 (14.2)</td>
<td>16 (25.4)</td>
<td>38 (60.3)</td>
</tr>
<tr>
<td>The Press</td>
<td>35 (14.5)</td>
<td>6 (17.1)</td>
<td>5 (14.3)</td>
<td>24 (68.6)</td>
</tr>
<tr>
<td><strong>Total n (%)</strong></td>
<td><strong>242</strong></td>
<td><strong>49 (20.3)</strong></td>
<td><strong>63 (26.0)</strong></td>
<td><strong>130 (53.7)</strong></td>
</tr>
</tbody>
</table>
Discussion

This analysis of media accounts of unintentional fatal child injury events in New Zealand reported in the four major newspapers during a five-year period found that while the cause of injury and demographic details of the victims were reported in most articles, only 20% included clear prevention messages, highlighting a missed opportunity for the dissemination of injury prevention messages. Among the most common causes of injury reported in the media accounts, fatal events as a result of poisoning were most likely to include prevention messages, followed by drowning and then transport-related events. Case ascertainment was high for the two most common causes of child fatal unintentional injuries reported, with all of the transport related deaths, and all but one of the drowning deaths captured by the NIQS (collates national mortality statistics) reported in the newspapers reviewed.

The strengths of this study include employing methods adapted from similar international studies. However, the findings need to be considered in light of some limitations. We only reviewed the four major daily papers; it is possible that newspapers with a more local distribution or those published in the weekend might report these events in a different way. There is the potential for misclassification bias in our coding of the mechanism of injury from the media accounts as we were limited to the information contained in those accounts. We acknowledge that some deaths classified as injury deaths may have in fact been intentional deaths (eg, assault, filicide or filicide-suicide). We were only able to investigate the completeness of case ascertainment in the media accounts for the first three years of the period being reviewed due to the two-year delay in mortality statistics being publicly available in New Zealand. Analysis of page numbers of articles can be affected by daily variations in thickness of the paper, and affected over time by redesigns in sectioning of the papers. We did not analyse the word count of each newspaper account, which may be of relevance to the prominence of the article. Despite these limitations, this study provides a contemporary snapshot of the state of media reporting of unintentional fatal child injury events in New Zealand.

The low frequency of prevention messages included in media accounts of fatal injury events found in this study is consistent with other published research. A US study of the presentation of injury deaths in the press found that clear prevention messages were reported in only 8% of articles. Another US study by Smith et al of newspaper coverage of residential fires found that 36% of deaths (all ages) were reported with accompanying prevention messages. A New Zealand study conducted in 2003, investigated the accuracy and public health relevance of the reporting of unintentional fire-related childhood deaths and found injury prevention messages were reported in 29% of news articles. This is higher than the 13% found in the present study for fire/flame related deaths.

Transport-related events were the leading mechanism of fatal child injuries reported over the five-year period reviewed in this study. Disappointingly, only 30% of these

### Table 4: Prominence of media accounts of fatal child injury events in New Zealand’s four major newspapers, 2011–2015 inclusive (n=242).

<table>
<thead>
<tr>
<th>Newspaper</th>
<th>Mean page number of accounts</th>
<th>Mean page number of accounts with clear prevention messages</th>
<th>Photographs included n (%)</th>
<th>Accounts with clear prevention messages accompanied by photographs n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand Herald</td>
<td>5.3</td>
<td>5.0</td>
<td>44 (49)</td>
<td>12 (52)</td>
</tr>
<tr>
<td>Dominion Post</td>
<td>3.3</td>
<td>3.2</td>
<td>24 (44)</td>
<td>9 (82)</td>
</tr>
<tr>
<td>Otago Daily Times</td>
<td>6.9</td>
<td>9.4</td>
<td>8 (13)</td>
<td>2 (22)</td>
</tr>
<tr>
<td>The Press</td>
<td>3.1</td>
<td>3.8</td>
<td>10 (29)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>All four papers</td>
<td>4.9</td>
<td>5.2</td>
<td>86 (36)</td>
<td>25 (51)</td>
</tr>
</tbody>
</table>
media accounts included clear prevention strategies. A US study investigating media accounts of fatal motor vehicle crashes, found only 20% of accounts mentioned the use or non-use of seatbelts.13 Drowning was the second most common cause of reported fatal child injury reported in the present study, however, only just over a quarter of these accounts included prevention messages.

Previous research has confirmed that the inclusion of photographs in media accounts draws attention to the text and encourages more extensive reading of the article.17 In the present study, media accounts with prevention messages were more likely to include photographs than those that did not (51% cf. 36%), which may have increased the likelihood of them being read and therefore provided a vehicle for prevention message dissemination.

A New Zealand study by Shepherd et al identified a number of evidence-based injury prevention policy and legislative actions that if implemented in New Zealand could result in a significant reduction in child injury mortality rates with the potential to result in an estimated 81 fewer child injury deaths every year.6 The authors highlight the prioritisation of vehicle passenger safety, pedestrian safety and water safety as “Do Now” policy recommendations. However, despite this, in the present study the inclusion of prevention messages in accounts of transport-related (16%) and drowning (26%) child fatalities was low.

The case ascertainment for the two most common causes of fatal child injury reported in the newspaper accounts reviewed (transport-related and drowning) against national mortality data (NIQS) was encouragingly high. For drowning events, there was almost complete case ascertainment (n=27/28), higher than the 57% found for child (0 to 14 years) drowning deaths reported in a Finnish study that compared the completeness of drowning reporting in newspapers with Statistics Finland data,19 and the 78% reported for drownings (<19 years of age) in a US study examining the accuracy of newspaper accounts with medical examiner reports.20 The high case ascertainment in the reporting of these injury types found in the present study may in part be due to the perceived newsworthiness of these events. This highlights the potential for the inclusion of evidence-based drowning prevention messages in media accounts.

Media accounts of fatal child injury events could be an effective means of disseminating prevention messages in New Zealand through the development of a set of media guidelines, which include appropriate rules for inclusion of appropriate evidence-based injury prevention messages. An international review of the guidelines for the reporting of violence against women found that most recommend the inclusion of local statistics to highlight the size of the problem.21

The association between unintentional child injury and socio-economic status is well established, with a range of risk factors identified, including: income, family structure, maternal education, accommodation-related factors.22 Injury risk is affected by socio-economic status in a range of ways such as in poor households parents may not be able to afford safety equipment (eg, smoke alarms, child car restraints, etc.) or they may be exposed to more hazardous environments (eg, fast moving traffic, lack of space for safe play, etc.). How the media presents child injury has an impact on “public attitudes”, with many arguing that journalists play a significant role in constructing what society considers acceptable or unacceptable.23,24 The UNICEF report on children’s rights and the media, recommends that all media accounts of children should portray children as subjects rather than objects, and avoid stereotypes or misconceptions in the reporting of the ethnicity of children from lower socio-economic communities.25

Gibson and Zillman in their study of perceptions of visual information in news reports in the US, found that photographic exemplification in media accounts of diseases of any given ethnic group increases the perceived risk to that group while exemplifying two groups equally produced similar estimates of risk for the groups.17 This underlines the importance of the careful choice of photographs to accompany media accounts to avoid the stigmatisation through the appropriate visual representation of ethnic groups.
This study only reviewed New Zealand's four major daily newspapers; future research could look at the reporting of fatal child injury events in community-specific papers to gain a more comprehensive view of media reporting of these events and to see what type of events are picked up nationally. In addition, an analysis of the headlines of media accounts of these events would provide an additional perspective on the discourse around events of this nature.

The findings of this study highlight the need for changes to the way in which print media outlets report serious child injury events. It emphasises the need for greater advocacy relationships between the media and public health professionals to promote appropriate prevention strategies, and the development of media guidelines for the responsible reporting of unintentional fatal child injury events.

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BMI is a key risk factor for early periprosthetic joint infection following total hip and knee arthroplasty

Patrick Jung, Arthur J Morris, Sally A Roberts, Mark Zhu, Chris Frampton, Simon W Young

ABSTRACT

AIM: To identify patient and surgical risk factors that are associated with periprosthetic joint infection (PJI), especially whether obesity is a risk factor following total hip arthroplasty (THA) and total knee arthroplasty (TKA).

METHODS: New Zealand Surgical Site Infection Improvement Programme data was analysed using deep infection within 90 days of the index procedure as the outcome. This was tested against surgical and patient factors for statistical associations in a multivariate model.

RESULTS: A total of 10,690 primary THAs and 9,481 primary TKAs were recorded by the NZSSIIP between 2013 and 2015. Multivariate analysis showed statistically significant associations with deep infections for BMI (BMI >40kg/m² OR 5.62, 95% CI 2.25–14.0), male gender (OR 1.7, 95% CI 1.05–2.74) and age greater than 75 for THAs (age <55 years OR 0.35, 95% CI 0.14–0.87). For TKAs, multivariate analysis showed statistically significant associations with deep infection for BMI (BMI >40kg/m² OR 1.94, 95% CI: 0.63–5.70) and male gender (OR 2.96, 95% CI 1.51–5.80).

CONCLUSIONS: These findings show that obesity is one of the most important modifiable patient factors in predicting PJI following THA and TKA.

Periprosthetic joint infection (PJI) is a devastating complication of total joint arthroplasty. It results in significant disability for the patient and burdens the healthcare system with significant costs.1–3 In New Zealand, each PJI adds an excess mean treatment cost of $40,121 and an additional 42 days in hospital, with an overall burden of $8 million per annum to the New Zealand healthcare system.4 In the last four decades, large strides have been made in improving surgical technique, theatre environment and prophylactic antibiotic use.5,6 Despite these efforts, the rate of PJI has not reduced and may have increased over the same time period.7,8 This finding may be due to changes in modifiable patient risk factors.9 One factor in particular is obesity—in New Zealand, 32% of adults are now obese.10 This figure is higher in patients undergoing THA and TKA and is expected to rise further in the coming years. Obesity has been linked in a number of studies to an increased risk of PJI.11,12 The majority of these studies rely on national joint registry data, which underestimates the true incidence of PJIs. A study of the New Zealand Joint registry found a sensitivity of only 63% in capturing PJI.13

The New Zealand Surgical Site Infection Improvement Programme (NZSSIIP) is a Health Quality and Safety Commission initiative to capture all inpatient infections within 90 days of the primary operation. Its reporting is independent of the New Zealand joint registry, and has high accuracy in capturing infections following THA and TKAs. Using NZSSIIP data, this study aims to identify patient and surgical risk factors that are associated with PJI: especially whether obesity is a risk factor following THA and TKA.
Methods

Patients
The NZSSIIP began in March 2013, and monitors surgical site infections following orthopaedic procedures across all 20 district health boards in New Zealand. It collects accurate data regarding infection within a 90-day follow-up period in THA and TKA patients.

All primary TKAs and THAs recorded by the NZSSIIP between July 2013 and September 2015 were analysed. Demographic details including age, gender, BMI, type of procedure, total risk score and ASA score were recorded. Four different BMI classifications were used in an attempt to determine which best stratified the differences in TKA outcomes: WHO classification, Dowsey, BMI greater or less than 30 and BMI greater or less than 35. Total risk score combines the patient’s ASA score with a surgical wound score and duration of the operation and is an indicator of prognosis. The following surgical details were also included in the study: surgical duration, prophylactic antibiotic type, prophylaxis timing, antibiotic dose and skin preparation type (Tables 1A and 2A).

Outcome
The NZSSIIP uses criteria from the Centre for Disease Control and Prevention (CDC) to group surgical site infections (SSIs) into superficial, deep and organ space. The outcome measured in this study was a deep or organ space infection (defined according to the CDC) that developed within 90 days of the index procedure. Deep and organ space SSIs were grouped together, as both constitute PJI infection in the context of hip and knee arthroplasty. Infection was recorded by Infection Prevention and Control practitioners specifically trained by the NZSSIIP in identifying perioperative infection using a predefined checklist using CDC criteria. Cases in which the diagnosis was not clear were reviewed by clinical microbiologists or infectious disease specialists. A 90-day cut off is used by the SSII programme, focusing on infections related to the initial surgical episode rather than late infection due to haematogenous spread.

Statistical analysis
The incidence of PJIs was calculated as a percentage for each of the patient and surgical factors. Association of these factors to deep/organ space infection was calculated as an odds ratio with 95% confidence intervals. A univariate analysis of p values, to determine whether associations were statistically significant, was conducted using a Pearson Chi Squared test. Variables with p values less than 0.05 were then initially forced into a multivariate model. Variables that were not found to be significant (p>0.05) in the multivariate model were removed and then a stepwise regression analysis of those remaining factors was performed.

Results

THAs
The overall PJI rate for THAs was 1.09%. The average age of patients was 70 years old. The average BMI was 30.7kg/m². Thirty-seven percent of THA patients were classified as obese (BMI >30kg/m²) Compared to the general New Zealand population, which has an obesity rate of 32%, obese patients are over represented in people requiring THA. On univariate analysis, BMI (all classifications), ASA and total risk score were associated with a statistically significant increase in risk of PJI following THA (Table 1A).

Using the WHO classification, which is the most widely used and accepted BMI classification, patients that were class III obese (BMI >40 kg/m²) had an odds ratio of 3.73 (95% CI: 1.57–8.82, p=0.0035) when compared to ‘normal weight’ patients (BMI <25kg/m²). Patients with a BMI greater than 35kg/m² were almost 2.5 times (OR: 2.33, 95% CI 1.41–3.81) more likely to develop PJI than patients with a BMI less than 35kg/m². Patients with a BMI greater than 30kg/m² were almost two times (OR: 1.83, 95% CI 1.15–2.91) more likely to develop PJI than patients with a BMI less than 30kg/m².
Table 1A: Univariate analysis of variables in relation to infection following THA.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Number of THAs</th>
<th>Deep/organ space infection (&lt;90 days)</th>
<th>Percentage (%)</th>
<th>Odds ratio (with 95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Body mass index (WHO)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (≤25)*</td>
<td>2,016</td>
<td>2,005</td>
<td>11</td>
<td>0.55</td>
<td>1.00</td>
</tr>
<tr>
<td>Overweight (25-30)</td>
<td>3,398</td>
<td>3,378</td>
<td>20</td>
<td>0.59</td>
<td>1.08 (0.52–2.26)</td>
</tr>
<tr>
<td>Obese I (30-35)</td>
<td>2,373</td>
<td>2,355</td>
<td>18</td>
<td>0.76</td>
<td>1.39 (0.66–2.96)</td>
</tr>
<tr>
<td>Obese II (35-40)</td>
<td>1,152</td>
<td>1,138</td>
<td>14</td>
<td>1.22</td>
<td>2.24 (1.01–4.96)</td>
</tr>
<tr>
<td>Obese III (≥40)</td>
<td>499</td>
<td>489</td>
<td>10</td>
<td>2.00</td>
<td>3.73 (1.57–8.82)</td>
</tr>
<tr>
<td>NR</td>
<td>1,252</td>
<td>1,243</td>
<td>9</td>
<td>0.72</td>
<td>1.32 (0.55–3.19)</td>
</tr>
<tr>
<td><strong>Body mass index (Dowsey)</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Normal* (≤25)</td>
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<td>Overweight (25–30)</td>
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<td>3,378</td>
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<td>1.08 (0.52–2.26)</td>
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<td>Obese (30–40)</td>
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<td>3,493</td>
<td>32</td>
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<tr>
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<td>10</td>
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<tr>
<td>NR</td>
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<td>1,243</td>
<td>9</td>
<td>0.72</td>
<td>1.32 (0.55–3.19)</td>
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<tr>
<td><strong>Body mass index (&lt; or &gt;35)</strong></td>
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<tr>
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<td>1,243</td>
<td>9</td>
<td>0.72</td>
<td>1.14 (0.56–2.33)</td>
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<td><strong>Body mass index (&lt; or &gt;30)</strong></td>
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<td>1.83 (1.15–2.92)</td>
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<tr>
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<td>1,243</td>
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<td>1.26 (0.60–2.65)</td>
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<td><strong>ASA</strong></td>
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<td>3,036</td>
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<td>3,431</td>
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<td>1.95 (1.25–3.06)</td>
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<td>257</td>
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<td><strong>Age</strong></td>
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<tr>
<td>&lt;55yr</td>
<td>1,273</td>
<td>1,266</td>
<td>7</td>
<td>0.55</td>
<td>0.76 (0.33–1.76)</td>
</tr>
<tr>
<td>55–64yr</td>
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<td>3,319</td>
<td>33</td>
<td>0.98</td>
<td>1.37 (0.82–2.30)</td>
</tr>
<tr>
<td>65–74yr</td>
<td>2,224</td>
<td>2,208</td>
<td>16</td>
<td>0.72</td>
<td>1.00 (0.54–1.87)</td>
</tr>
<tr>
<td>&gt;75yr*</td>
<td>3,613</td>
<td>3,587</td>
<td>26</td>
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<tr>
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<td>28</td>
<td>0</td>
<td>-</td>
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</tr>
<tr>
<td><strong>Gender</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Female*</td>
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<td>4,617</td>
<td>42</td>
<td>0.90</td>
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<td>0</td>
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<td><strong>Surgical duration</strong></td>
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<td>&lt;40mn</td>
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<td>121</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40–59mn*</td>
<td>1,405</td>
<td>1,394</td>
<td>11</td>
<td>0.78</td>
<td>1.00</td>
</tr>
<tr>
<td>60–89mn</td>
<td>4,703</td>
<td>4,672</td>
<td>31</td>
<td>0.66</td>
<td>0.84 (0.42–1.7)</td>
</tr>
<tr>
<td>90–119mn</td>
<td>3,230</td>
<td>3,203</td>
<td>27</td>
<td>0.84</td>
<td>1.1 (0.53–2.2)</td>
</tr>
<tr>
<td>120–180mn</td>
<td>1,102</td>
<td>1,091</td>
<td>11</td>
<td>1.0</td>
<td>1.3 (0.55–3.0)</td>
</tr>
<tr>
<td>&gt;180mn</td>
<td>98</td>
<td>96</td>
<td>2</td>
<td>2.1</td>
<td>2.7 (0.58–12)</td>
</tr>
<tr>
<td>NR</td>
<td>31</td>
<td>31</td>
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<td>-</td>
<td>-</td>
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Table 1A: Univariate analysis of variables in relation to infection following THA (continued).

<table>
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<tr>
<th>Prophylactic antibiotic type</th>
<th>9,825</th>
<th>9,747</th>
<th>78</th>
<th>0.79</th>
<th>1.00</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephazolin*</td>
<td>635</td>
<td>632</td>
<td>3</td>
<td>0.47</td>
<td>0.59 (0.19–1.9)</td>
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</tr>
<tr>
<td>Cefuroxime</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Flucloxacin</td>
<td>63</td>
<td>62</td>
<td>1</td>
<td>1.6</td>
<td>2.0 (0.28–15)</td>
<td></td>
</tr>
<tr>
<td>Gentamicin</td>
<td>34</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Vancomycin</td>
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<td>79</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Other</td>
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<td>52</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>78</td>
<td>79</td>
<td>1</td>
<td>0.76</td>
<td>1.24 (0.17–9.0)</td>
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</table>

Table 1B: Multivariate analysis of factors showing significant independent association to deep/organ space infection following THA.

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<thead>
<tr>
<th>Factor</th>
<th>Odds ratio (with 95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index (WHO) [stepwise]</td>
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<td></td>
</tr>
<tr>
<td>Normal (&lt;25)*</td>
<td>1.00</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Overweight (25–30)</td>
<td>1.12 (0.52–2.43)</td>
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</tr>
<tr>
<td>Obese I (30–35)</td>
<td>1.65 (0.75–3.62)</td>
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</tr>
<tr>
<td>Obese II (35–40)</td>
<td>3.03 (1.31–7.00)</td>
<td></td>
</tr>
<tr>
<td>Obese III (&gt;40)</td>
<td>5.62 (2.26–14.0)</td>
<td></td>
</tr>
<tr>
<td>Age (stepwise)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5yr</td>
<td>0.35 (0.14–0.87)</td>
<td>0.042</td>
</tr>
<tr>
<td>55–64yr</td>
<td>0.53 (0.28–1.01)</td>
<td></td>
</tr>
<tr>
<td>65–74yr</td>
<td>0.53 (0.30–0.95)</td>
<td></td>
</tr>
<tr>
<td>&gt;75yr*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Gender (stepwise)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female*</td>
<td>1.00</td>
<td>0.030</td>
</tr>
<tr>
<td>Male</td>
<td>1.70 (1.05–2.74)</td>
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</tr>
<tr>
<td>ASA (forced model)</td>
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</tr>
<tr>
<td>1–2*</td>
<td>1.00</td>
<td>0.424</td>
</tr>
<tr>
<td>3</td>
<td>1.33 (0.80–2.22)</td>
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</tr>
<tr>
<td>4–5</td>
<td>1.99 (0.46–8.66)</td>
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</tr>
</tbody>
</table>

*Reference category for odds ratio determination.
Table 2A: Univariate analysis of variables in relation to infection following TKA.

<table>
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<tr>
<th>Factor</th>
<th>Number of TKAs</th>
<th>Deep/organ space infection (&lt;90 days)</th>
<th>Percent-age (%)</th>
<th>Odds ratio (with 95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Body mass index (WHO)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (&lt;25)*</td>
<td>983</td>
<td>978</td>
<td>5</td>
<td>0.51</td>
<td>1.00</td>
</tr>
<tr>
<td>Overweight (25–30)</td>
<td>2,712</td>
<td>2,707</td>
<td>5</td>
<td>0.18</td>
<td>0.36 (0.10–1.26)</td>
</tr>
<tr>
<td>Obese I (30–35)</td>
<td>2,757</td>
<td>2,745</td>
<td>12</td>
<td>0.44</td>
<td>0.86 (0.30–2.45)</td>
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<tr>
<td>Obese II (35–40)</td>
<td>1,570</td>
<td>1,558</td>
<td>12</td>
<td>0.76</td>
<td>1.51 (0.53–4.31)</td>
</tr>
<tr>
<td>Obese III (&gt;40)</td>
<td>923</td>
<td>915</td>
<td>8</td>
<td>0.87</td>
<td>1.72 (0.56–5.27)</td>
</tr>
<tr>
<td>NR</td>
<td>536</td>
<td>534</td>
<td>2</td>
<td>0.37</td>
<td>0.74 (0.14–3.81)</td>
</tr>
<tr>
<td><strong>Body mass index (Dowsey)</strong></td>
<td></td>
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</tr>
<tr>
<td>Normal* (&lt;25)</td>
<td>983</td>
<td>978</td>
<td>5</td>
<td>0.51</td>
<td>1.00</td>
</tr>
<tr>
<td>Overweight (25–30)</td>
<td>2,712</td>
<td>2,707</td>
<td>5</td>
<td>0.18</td>
<td>0.36 (0.10–1.26)</td>
</tr>
<tr>
<td>Obese (30–40)</td>
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<td>4,303</td>
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<td>1.10 (0.42–2.88)</td>
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<tr>
<td>Obese morbid (&gt;40)</td>
<td>923</td>
<td>915</td>
<td>8</td>
<td>0.87</td>
<td>1.72 (0.56–5.27)</td>
</tr>
<tr>
<td>NR</td>
<td>536</td>
<td>534</td>
<td>2</td>
<td>0.37</td>
<td>0.74 (0.14–3.81)</td>
</tr>
<tr>
<td><strong>Body mass index (&lt; or &gt; 35)</strong></td>
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<td>NR</td>
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<td>149</td>
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<td>1.97</td>
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<td>5,942</td>
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<td>1.53 (0.76–3.09)</td>
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<td>60–89mn</td>
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<td>4,282</td>
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<td>0.30</td>
<td>0.56 (0.20–1.6)</td>
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<td>990</td>
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<td>0.91</td>
<td>1.7 (0.60–5.1)</td>
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<tr>
<td>&gt;180mn</td>
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<td>70</td>
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<td>1.4</td>
<td>2.7 (0.31–23)</td>
</tr>
<tr>
<td>NR</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Patients with an ASA score of 3 had an odds ratio of 2.04 (95% CI: 1.27–3.31); scores of 4–5 had an odds ratio of 4.20 (95% CI: 1.28–13.8); p=0.006, when compared to patients with ASA score 1–2. Male gender was associated with an increase in risk of PJI (OR: 1.36, 95% CI 0.88–2.10) while age less than 55 had a slightly lower risk (OR: 0.76, 95% CI 0.33–1.76).

The variables BMI, ASA score, age and gender were analysed using a multivariate model. BMI, age and gender all showed significance. In a stepwise multivariate analysis with ASA removed, BMI continued to show a strong association with PJI. ‘Obese III’ patients had an odds ratio of 5.62 (95% CI: 2.25–14.0) compared to ‘normal weight’ patients with a p-value less than 0.0001. After adjusting for BMI and age, men were 1.7 (1.05–2.74) times more likely to develop PJI than women. Patients younger than 75 were found to have approximately half the risk of PJI for patients older than 75 (Table 1B).

**TKAs**

The overall PJI rate was 0.46%. The average age of patients was 70 and the average BMI was 30.7kg/m². Fifty-five percent of TKA patients were classified as obese. On univariate analysis BMI, total risk score, age and gender were associated with a statistically significant increase in risk of PJI following TKA (Table 2A).

Using the WHO classification, patients that were class III obese (BMI >40kg/m²) had an odds ratio of 1.72 (95% CI: 0.56–5.27, p=0.028) when compared to ‘normal weight’ patients (BMI <25 kg/m²). In absolute terms, 8 out of 923 (0.87%) class III obesity patients developed PJI compared to 5 out of 983 (0.51%) ‘normal weight’ patients. Patients with a BMI greater than 35kg/m² were over twice as likely (OR: 2.36 with 95% CI 1.28–4.34) to develop PJI than patients with a BMI less than 35kg/m². The results were similar using the greater or less than 30kg/m² stratification (OR: 2.26, 95% CI 1.11–4.60).

<table>
<thead>
<tr>
<th>Prophylactic antibiotic type</th>
<th>Cephalzin</th>
<th>Cefuroxime</th>
<th>Flucoxacilln</th>
<th>Gentamcin</th>
<th>Vancomycin</th>
<th>Other</th>
<th>NR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8,759</td>
<td>8,717</td>
<td>42</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Prophylactic antibiotic dose</td>
<td>0.48</td>
<td>1.0</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2g*</td>
<td>1,312</td>
<td>1,307</td>
<td>5</td>
<td>0.38</td>
<td>1.0</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>2g ≤ x &lt;3g</td>
<td>7,771</td>
<td>7,735</td>
<td>36</td>
<td>0.46</td>
<td>1.2 (0.48–3.1)</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>≥3g</td>
<td>306</td>
<td>303</td>
<td>3</td>
<td>0.98</td>
<td>2.6 (0.61–11)</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>92</td>
<td>92</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Prophylactic antibiotic timing</td>
<td>0–60 minutes before incision*</td>
<td>8,959</td>
<td>8,918</td>
<td>41</td>
<td>0.46</td>
<td>1.0</td>
<td>0.17</td>
</tr>
<tr>
<td>&gt;1h before incision</td>
<td>131</td>
<td>129</td>
<td>2</td>
<td>1.5</td>
<td>3.4 (0.81–14)</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>After incision</td>
<td>82</td>
<td>82</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>309</td>
<td>308</td>
<td>1</td>
<td>0.32</td>
<td>0.71 (0.097-5.2)</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Skin preparation</td>
<td>7,465</td>
<td>7,427</td>
<td>38</td>
<td>0.51</td>
<td>1.0</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Chlorhexidine + alcohol*</td>
<td>1,832</td>
<td>1,826</td>
<td>6</td>
<td>0.33</td>
<td>0.64 (0.27-1.5)</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Povidone iodine + alcohol</td>
<td>31</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Aqueous chlorhexidine</td>
<td>72</td>
<td>72</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Aqueous povidone iodine</td>
<td>81</td>
<td>81</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Reference category for odds ratio determination.
Males had an almost three-fold (OR = 2.79, 95% CI: 1.46–5.34, p-value = 0.0012) greater risk of PJI than females. Age was also shown to be a significant factor. Fifty-five to 64 year-olds had an OR of 1.53 (95% CI: 0.76–3.09) when compared with patients older than 75. Patients with ASA scores 4–5 were greater than four times more likely to develop PJI than patients with scores 1–2.

Surgical duration, antibiotic dose, type, timing and skin preparation did not provide statistically significant results in the univariate analysis and were, therefore, not included in the multivariate analysis.

BMI, ASA score, age and gender were analysed using a multivariate model (Table 2B). Using this model, BMI and gender remained statistically significant but ASA and age did not. In a stepwise multivariate analysis with ASA and age removed, BMI showed a strong association with PJI.

‘Obese III’ patients had an odds ratio of 1.94 (95% CI: 0.63–5.70, p=0.015) compared to ‘normal weight’ patients. Patients who were classed as overweight and obese I showed a reduced risk of developing PJI with odds ratios of 0.31 and 0.73 respectively. After adjusting for BMI, men were 2.96 (1.51–5.80, p=0.002) times more likely to develop PJI than women.

**Discussion**

Infection is a major cause of failure in TKA and THA, accounting for up to 24% of early (within 24 months) failures.17 There is strong international evidence that accurate data to inform and monitor efforts to reduce PJI is beneficial. A Norwegian group reported a 57% reduction in SSIs over an 11-year period after the implementation of a surveillance system.18 The French ISO-RAISIN system (Infection du Site Opératoire—Réseau Alerte Investigation Surveillance des Infections)

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**Table 2B: Multivariate analysis of factors showing significant independent association to deep/organ space infection following TKA.**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds ratio (with 95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body mass index (WHO)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (&lt;25)*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Overweight (25–30)</td>
<td>0.31 (0.09–1.09)</td>
<td>0.015</td>
</tr>
<tr>
<td>Obese I (30–35)</td>
<td>0.73 (0.25–2.12)</td>
<td></td>
</tr>
<tr>
<td>Obese II (35–40)</td>
<td>1.44 (0.50–4.16)</td>
<td></td>
</tr>
<tr>
<td>Obese III (&gt;40)</td>
<td>1.94 (0.63–5.97)</td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.96 (1.51–5.80)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>ASA (forced model)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–2*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.54 (0.78–3.02)</td>
<td>0.268</td>
</tr>
<tr>
<td>4–5</td>
<td>3.64 (0.47–28.4)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (forced model)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤55yr</td>
<td>0.54 (0.12–2.54)</td>
<td>0.138</td>
</tr>
<tr>
<td>55–64yr</td>
<td>1.13 (0.50–2.56)</td>
<td></td>
</tr>
<tr>
<td>65–74yr</td>
<td>0.45 (0.19–1.10)</td>
<td></td>
</tr>
<tr>
<td>&gt;75yr*</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

*Reference category for odds ratio determination.
A study in New Zealand and overseas found that the average age of patients undergoing arthroplasty was 67.4 years, which did not show an association with age for PJI. This contrasts with a study based on data from the Korean Nosocomial Infection Surveillance System (KONIS), which showed an odds ratio of 1.75 and 1.64 for age 60–69 for THAs and TKAs respectively. In our study, the risk of PJI in patients with age greater than 70 was almost two times higher in THAs, but no association with age was found in TKAs. The average age of patients undergoing arthroplasty procedures is around 70 years old. This is an important factor to consider as, if indeed the rate of PJI is higher in older patients, this will represent a larger proportion of the arthroplasty population.

Reducing PJI following arthroplasty first requires an accurate understanding of the factors important in its incidence. This study, using data from the NZSSIIP, found patient factors including an elevated BMI and gender to be strongly associated with early infection following both TKA and THA. The use of data from a targeted national infection surveillance program, rather than a national joint registry, is relevant as PJI infection surveillance program, rather than registries both in New Zealand and overseas. Zhu et al found the New Zealand Joint Registry (NZJR) has a sensitivity of only 63% for reporting PJI when compared to an audit of hospital records. The NZSSIIP supports more vigilant surveillance and therefore reduces the likelihood of both missed reports and missed diagnoses. In this study, the overall 90-day infection rate for TKAs was 0.46%, compared to NZJR data revision rates for PJI of TKAs of 0.16% at six months and 0.28% (at 12 months). This highlights the benefit of a targeted surveillance programme, as true PJI rates can be recorded and the effectiveness of any measures to reduce PJI rates can be monitored.

We found an increased risk of PJI in males for both THAs (OR=1.70) and TKAs (OR=2.96). This association has been previously reported in a number of large registry studies. Namba et al found that males had a 1.89 higher risk of PJI than females following TKA. Tayton et al similarly reported a 1.78 times higher risk in males. However, the reason for this association is unclear. There may be a number of potential confounding variables, such as smoking and diabetes, that may contribute. However, male gender may also be an independent risk for the development of PJI and the strength of the association seen in this study would support this hypothesis.

There is debate whether age is an independent risk factor for PJI. Namba et al studied a population with an average age of 67.4 years, which did not show an association with age for PJI. This contrasts with a study based on data from the Korean Nosocomial Infection Surveillance System (KONIS), which showed an odds ratio of 1.75 and 1.64 for age 60–69 for THAs and TKAs respectively. In our study, the risk of PJI in patients with age greater than 70 was almost two times higher in THAs, but no association with age was found in TKAs. The average age of patients undergoing arthroplasty procedures is around 70 years old. This is an important factor to consider as, if indeed the rate of PJI is higher in older patients, this will represent a larger proportion of the arthroplasty population.
BMI greater than 40 kg/m², 1.5 more people will develop PJI compared to the equivalent number of normal BMI patients, and just 0.4 more for TKA based on this data set. Should an infection threshold be clearly defined, a weight reduction intervention, even bariatric surgery, before TKA or THA may have a role although data is mixed. Werner et al reported that bariatric surgery prior to TKA resulted in reduced post-operative complications. However, Inacio et al reported no significant association with prior bariatric surgery and improved surgical outcomes.

The overall PJI rate in THAs was 1.06% compared to 0.46% in TKAs, a significant difference. This could be associated with the prevalence of abdominal obesity, which affects the hips more than the knees. While abdominal obesity is important in abdominal surgery, there are no studies that have specifically investigated the impact of abdominal obesity on orthopaedic surgery.

There are a number of limitations to this study. Firstly, The NZSSIIP does not record data on some factors that may have a correlation to increasing rates of PJI, in particular patient smoking and diabetes. The use of a multivariate analysis aims to limit confounding, but without data on these factors this was not possible. However, our findings are consistent with previous registry-based studies where data on these factors was available, and BMI appears to be an independent risk factor in PJI causation. Werner et al reported that bariatric surgery prior to TKA resulted in reduced post-operative complications. However, Inacio et al reported no significant association with prior bariatric surgery and improved surgical outcomes.

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This study has shown that male gender and BMI are key risk factors in the development of early periprosthetic joint infection following THA and TKA. PJI has significant impacts on patient mortality and morbidity and also resource expenditure by the public healthcare system. The NZSSIIP will be important in the future by ensuring that quality and safety markers are met and allowing the accurate reporting of the SSI rate following interventions aimed at its reduction.

Competing interests: Dr Morris is the Clinical Lead for the NZ Surgical Site Infection Improvement Programme.

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REFERENCES:


Mental health service use by Asians: a New Zealand census
Cheok Soon Chow, Roger T Mulder

ABSTRACT

BACKGROUND: Asians are the third largest ethnic group in New Zealand. Little is known about their use of mental health services and the psychiatric diagnoses they receive in these services.

AIM: To study rates of mental health service use and the prevalence of mental disorders in mental health services among New Zealand Asians compared to European, Māori and Pacific peoples.

METHODS: Data from PRIMHD (Program for the Integration of Mental Health Data) was collected over a five-year period from 1 July 2008 to 30 June 2013.

RESULTS: There were 229,874 individuals who had contact with mental health services. Asians were less likely to use mental health services compared to European, Māori or Pacific people. Asian clinical diagnoses were similar to other ethnic groups. The major differences were lower rates of substance-related disorders and personality disorders.

CONCLUSION: Asians have low rates of mental health service utilisation. There is no evidence they are more severely ill when using mental health services. This suggests Asians may have lower prevalence rates of mental disorder than other ethnic groups in New Zealand.

Methods

The Program for the Integration of Mental Health Data (PRIMHD) is a Ministry of Health single national mental health and addiction information collection of service activity and outcomes data for health consumers in New Zealand. The data is collected from district health boards (DHBs) and non-governmental organisations (NGOs) across New Zealand’s public mental health sector. PRIMHD records contain demographics, including gender, age and ethnicity. This study uses data from PRIMHD over a five-year period from 1 July 2008 to 30 June 2013.

The ethnic data divides patients into four major groups: European, Māori, Pacific and Asian. The Asian group is further subdivided into four groups: Chinese, Indian, South East Asian and ‘Other Asians’. ‘Other Asians’ cover a wide geographical region including: Sri Lanka, Nepal, Bangladesh, Afghanistan, Pakistan, Japan and Korea.
Service utilisation is derived by counting the number of individual patients who presented at least once to public mental health services over the five-year period in the PRIMHD database. We then calculated the odds ratio of Asians having accessed mental health services with other ethnicities. The odds ratios were calculated using the number of people who accessed services as the numerator and the number of people who did not access services as the denominator. The denominator was derived from the 2013 census data. We have used Europeans as the reference group (OR=1).

The prevalence of the recorded mental disorders in the PRIMHD database is presented using the ICD-10 diagnostic grouping per 100 patients over the five-year period.

Tests of statistical significance were not used since this data is a census of the New Zealand population.

**Results**

There were a total of 320,896 referrals to specialist mental health services, but 91,022 were not seen by a mental health service during these five years. This study is based on the remaining 229,874 patients.

**Demographics**

The age range of service users from 2012 to 2013 is between 0–101. In general, most service users fall within the age group of 20–39. Europeans have the highest percentage of service users age 60 and above (7.81%) compared to other ethnic groups. Europeans and Asians share a similar age distribution with a slightly higher proportion of service users age 60 and above. Māori and Pacific peoples have lower proportion of service users aged 60 and above. The mode age is similar across all ethnic groups. Pacific peoples have a higher percentage of male service users (64.74%) compared to other ethnic groups. Otherwise, the proportion of male and female service users appear evenly distributed across European, Māori and Asian ethnic groups.

**Service utilisation**

Asians were much less likely to have accessed public mental health services over the five-year period when compared to other ethnic groups. The odds ratio compared to Europeans was 0.389 (95% CI=0.381–0.397). Māori have the highest rate of access with an odds ratio of 1.615 (95% CI=1.597–1.632) compared to Europeans. Pacific peoples have comparable service utilisation to Europeans with an odds ratio of 1.022 (95% CI=1.005–1.041).

<table>
<thead>
<tr>
<th>Table 1: Demographics including age and sex.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age groups</td>
</tr>
<tr>
<td>European N (%)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>0–19</td>
</tr>
<tr>
<td>20–39</td>
</tr>
<tr>
<td>40–59</td>
</tr>
<tr>
<td>60–79</td>
</tr>
<tr>
<td>80 and above</td>
</tr>
<tr>
<td>Mode age</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
</tbody>
</table>
All Asian sub-groups were less likely to present to mental health services compared to Europeans. South East Asians were least likely to access service (OR = 0.192, 95% CI = 0.188–0.216), followed by Chinese (OR = 0.296, 95% CI = 0.284–0.307), Indians (OR = 0.424, 95% CI = 0.41–0.439) and Other Asians who were most likely to utilise service among Asian sub-groups (OR = 0.548, 95% CI = 0.525–0.572).

**Figure 1:** Odds ratio of having accessed public mental health services over a five-year period among Māori, Pacific and Asian.

**Figure 2:** Odds ratio of having accessed public mental health services over a five-year period among Chinese, Indian, South East Asian and Other Asian.

The reference group (odds ratio=1) is the European group.
Clinical diagnoses

In general, clinical diagnoses in mental health services were similar across ethnic groups. Differences were that Asians had lower rates of substance-related disorders when contrasted with other ethnic groups and lower rates of personality disorders except in contrast to Pacific peoples. Asian rates of adjustment disorders were also somewhat higher than other ethnic groups. Europeans had higher rates of mood disorders and anxiety disorders, but lower rates of schizophrenia/psychotic disorders.

Diagnoses across Asian sub-groups were also similar. Chinese and ‘Other Asians’ had higher rates of delirium and dementia and lower rates of substance-related disorders.

Table 2: Prevalence of commonly diagnosed mental disorders measured in number of diagnoses per 100 people over a five-year period.

<table>
<thead>
<tr>
<th>DSM-IV and ICD-10 classifications</th>
<th>Māori (n=47,308)</th>
<th>European (n=149,857)</th>
<th>Pacific (n=15,251)</th>
<th>Asian (n=9,549)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mood disorders</td>
<td>14.63</td>
<td>23.46</td>
<td>8.21</td>
<td>17.72</td>
</tr>
<tr>
<td>Substance-related disorders</td>
<td>21.96</td>
<td>15.26</td>
<td>10.77</td>
<td>5.64</td>
</tr>
<tr>
<td>Anxiety disorders</td>
<td>6.42</td>
<td>11.60</td>
<td>3.46</td>
<td>6.46</td>
</tr>
<tr>
<td>Schizophrenia/psychotic disorders</td>
<td>10.98</td>
<td>6.40</td>
<td>8.60</td>
<td>9.67</td>
</tr>
<tr>
<td>Infancy/childhood/adolescence disorders</td>
<td>6.42</td>
<td>6.70</td>
<td>3.02</td>
<td>3.37</td>
</tr>
<tr>
<td>Personality disorders</td>
<td>2.40</td>
<td>2.96</td>
<td>0.80</td>
<td>1.21</td>
</tr>
<tr>
<td>Adjustment disorders</td>
<td>4.30</td>
<td>5.39</td>
<td>3.10</td>
<td>6.13</td>
</tr>
<tr>
<td>Delirium/dementia/amnestic/cognitive disorders</td>
<td>1.55</td>
<td>5.12</td>
<td>2.68</td>
<td>3.18</td>
</tr>
<tr>
<td>Eating disorders</td>
<td>0.35</td>
<td>1.52</td>
<td>0.15</td>
<td>1.10</td>
</tr>
<tr>
<td>Mental disorders due to medical condition</td>
<td>3.02</td>
<td>2.55</td>
<td>0.75</td>
<td>1.19</td>
</tr>
</tbody>
</table>

* SEA = South East Asians; ** OA = Other Asians.

Table 3: Prevalence of commonly diagnosed mental disorders measured in number of diagnoses per 100 people over a five-year period.

<table>
<thead>
<tr>
<th>DSM-IV and ICD-10 classifications</th>
<th>Chinese (n=2,611)</th>
<th>Indian (n=3,405)</th>
<th>SEA* (n=788)</th>
<th>OA** (n=2,176)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mood disorders</td>
<td>19.26</td>
<td>15.86</td>
<td>19.54</td>
<td>17.78</td>
</tr>
<tr>
<td>Substance-related disorders</td>
<td>2.87</td>
<td>7.72</td>
<td>4.31</td>
<td>5.79</td>
</tr>
<tr>
<td>Anxiety disorders</td>
<td>6.47</td>
<td>5.52</td>
<td>6.47</td>
<td>7.49</td>
</tr>
<tr>
<td>Schizophrenia/psychotic disorders</td>
<td>11.26</td>
<td>8.25</td>
<td>11.17</td>
<td>9.10</td>
</tr>
<tr>
<td>Infancy/childhood/adolescence disorders</td>
<td>4.06</td>
<td>3.02</td>
<td>3.05</td>
<td>3.08</td>
</tr>
<tr>
<td>Personality disorders</td>
<td>1.26</td>
<td>1.12</td>
<td>1.27</td>
<td>1.15</td>
</tr>
<tr>
<td>Adjustment disorders</td>
<td>6.05</td>
<td>6.61</td>
<td>6.09</td>
<td>5.74</td>
</tr>
<tr>
<td>Delirium/dementia/amnestic/cognitive disorders</td>
<td>5.09</td>
<td>3.20</td>
<td>2.28</td>
<td>1.70</td>
</tr>
<tr>
<td>Eating disorders</td>
<td>1.57</td>
<td>0.59</td>
<td>0.38</td>
<td>1.29</td>
</tr>
<tr>
<td>Mental disorders due to medical condition</td>
<td>0.88</td>
<td>1.35</td>
<td>1.14</td>
<td>0.92</td>
</tr>
</tbody>
</table>
Comorbidity
We also studied the total number of diagnoses in different ethnic groups. Asian and Pacific ethnic groups were less likely to have two or more diagnoses. Rates for two or more diagnoses were as follows: European (21.42%), Māori (19.65%), Pacific (9.43%) and Asian (12.9%) (Details available on request).

Discussion
These data are a census of Asian patterns of mental health service use since there are no significant private facilities available in New Zealand. The results clearly show Asians are much less likely to use mental health services compared with other ethnic groups. The odds ratio of Asians using services was 0.39 compared to Europeans. South East Asians are the least likely to utilise services (OR=0.20) among the Asian sub-groups. This low level of mental health service utilisation was consistent with other international studies. The reasons for the low service use are less clear.

One explanation is cultural factors. Many Asians have a different cultural explanatory model of mental illness, which does not necessarily conform to a traditional Western concept. For some there is intense shame and stigma associated with being mentally ill. Asians may be more likely to seek help outside traditional mental health services. For example, a study by Dolly et al reported that 35% of Asian-Americans with a lifetime mental disorder seek help with religious/spiritual advisors, which was a similar rate to seeking help from a psychiatrist.

However, our data did not support a model of delayed help seeking when mentally ill due to language and cultural barriers. If this were so then we would expect to see higher rates of severe mental illness among Asians who present to mental health services. Our data did not support this hypothesis. Asians have the highest rates of adjustment disorders of any ethnic group, which is generally considered the most benign mental disorder. While Asian rates of psychotic disorders are higher than European and Pacific groups, they are lower than Māori and are still only present in around one-tenth of patients. In addition, Asians have relatively low rates of comorbidity, which may be seen as a proxy measure of severity.

An alternative hypothesis for the low use of mental health services is that Asians have better mental health than other ethnicities. This might reflect the high standards screened for in Asian immigrants or protective factors related to their family and community functioning. There is evidence from other countries that migrant communities begin to suffer higher rates of mental disorders as they acculturate to their host population. There is some weak evidence that mental illness appears to be more common in second and third generation migrants than in overseas born migrants in New Zealand. Overall, the relationship between migration and mental illness is inconsistent. A meta-analysis reported that migration was an important risk factor for development of schizophrenia but other studies have reported a lower risk of other psychiatric disorders such as alcohol and drug misuse, major depression, dysthymia, mania and anxiety disorders in immigrant populations.

The study has limitations. First, the study relies on clinical diagnoses, which are not standardised. Second, it is possible clinicians may have cultural bias when diagnosing mental disorders in different ethnic groups. Third, we are unable to determine the country of birth in our study sample and therefore unable to evaluate factors such as immigration status or length of stay in New Zealand. Fourth, the ‘Other Asians’ group is poorly defined with individuals from vastly different countries with contrasting beliefs, languages and cultures. Fifth, data collected by PRIMHD is sometimes incomplete due to the inconsistent data collection process. For example, PRIMHD mainly captures data from mental health and addiction services but data on psychogeriatric services are incomplete. The age of patients are also determined by date of birth, which makes it less reliable especially for older patients. Clinical diagnoses are not always reported in PRIMHD. Therefore, rates of clinical diagnoses do not reflect absolute rates but comparative rates among ethnic groups. Sixth, Kumar et al have argued against a study of service utilisation due to different help seeking pathways in Asians and other language and cultural barriers. However, we believe data which universally represents the mental health needs of diverse groups of Asians in New Zealand is difficult to attain.
Therefore, this study serves as a starting point despite its limitations.

**Conclusion**

Asian New Zealanders are now a significant proportion of New Zealand society. There has been virtually no study of their mental health needs. Asian populations will need to be oversampled in future studies to compensate for the lack of reliable community samples. Asians are less likely to use mental health services, but when using them do not appear to be significantly more unwell than other ethnic groups. It is likely that Asian demand for mental health services will increase both due to an increase in number of New Zealand Asians and the possibility that their rates of mental disorder will increase as they acculturate to New Zealand.

**Competing interests:**
Nil.

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**REFERENCES:**


Estimated reduction in expenditure on hospital-acquired pressure injuries after an intervention for early identification and treatment

Heather Lewis, David Hughes, Dominic Madell, Christin Coomarasamy, Luis Villa, Brooke Hayward

ABSTRACT

AIM: An intervention designed to reduce numbers of hospital-acquired pressure injuries was delivered in Counties Manukau Health hospitals. An audit of a sample of patients was carried out to estimate the cost savings that would have been acquired across the district health board (DHB) due to a reduction in pressure injuries.

METHOD: The pressure injury intervention was delivered from 2011 to 2015. A monthly prospective audit of patients with stages 1, 2, 3 and 4 pressure injuries was carried out. This involved a random sample of five patients per ward in all hospitals in Counties Manukau DHB.

RESULTS: It was found that the annual estimated cost of treating pressure injuries in hospital patients was NZ$12,290,484 less in 2015 than in 2011.

CONCLUSION: Implementation of strategies for managing hospital-acquired pressure injuries can lead to potentially large financial savings for hospitals, as well as reducing the burden of managing this difficult condition for patients and staff.

Localised injuries to the skin and/or underlying tissue that usually develop over bony parts of the body due to sustained pressure, or pressure combined with shear are known as pressure injuries. These can develop in hospitals where patients have health conditions that make it difficult to move, especially where patients are confined to a bed, sitting for long periods of time or undergoing lengthy surgical procedures. Pressure injuries are categorised into stage 1: non-blanchable erythema of intact skin, stage 2: partial thickness skin loss, stage 3: full thickness skin loss, and stage 4: full thickness tissue loss with exposed bone, tendon, muscle or cartilage, as well as ‘unstageable: depth unknown’ and ‘suspected deep tissue injury: depth unknown’ classifications. Further explanation of the National Pressure Ulcer Advisory Panel and European Pressure Ulcer Advisory Panel (NPUAP/EPUAP) pressure injury classifications can be found in the 2014 NPUAP/EPUAP and Pan Pacific Pressure Injury Alliance (PPPIA) Quick Reference Guide.

Patients at increased risk of developing pressure injuries include those with mobility limitations, poor nutrition, health conditions that disrupt the blood supply or make the skin more vulnerable to injury and damage, aging skin, urinary or bowel incontinence and those who have serious mental health conditions (NHS, 2014). Approximately 55,000 people a year in New Zealand experience a pressure injury, and these can cause constant pain, loss of function and mobility, increased financial burdens, prolonged hospital stays, septicaemia and even death,
as well as depression, distress and anxiety, embarrassment and social isolation. The Northern Regional Alliance ‘First, Do No Harm’ point prevalence survey in 2014 found an overall prevalence rate of 4.7% pressure injuries in their DHB hospitals, while the Central Region DHBs 2014 study showed a prevalence range of 8.3%.

According to Bennet, Dealey and Posnett (2004), the mean cost of treating a hospital or long-term care setting pressure injury in the UK in 2004 was £1,064 (NZ$1,856.56) for stage 1 pressure injuries, £4,402 (NZ$7,681.00) for stage 2, £7,313 (NZ$12,760.37) for stage 3 and £10,551 (NZ$18,410.33) for stage 4 (currency converted on 22/02/2017). Adjusting for inflation, the cost at the end of 2016 of treating a stage 1 pressure injury would be NZ$2,395.36, for stage 2 would be NZ$9,101.36, for stage 3 would be NZ$16,463.12 and for stage 4 would be NZ$23,753.24 (Reserve Bank of New Zealand, 22/02/2017). These costs include nurse time, dressings, antibiotics, diagnostic tests, support surfaces and inpatient days (the authors state that “The cost of support surfaces assumes equipment is purchased rather than rented (which is generally more expensive)” (p.230).

A prospective audit of hospital-acquired pressure injuries was carried out at Counties Manukau Health hospitals from 2011–2015, during an intervention to reduce the incidence of these. The results of this audit were used to estimate cost savings that might have been acquired across all five Counties Manukau Health hospitals in the intervention period.

Method

Annual pressure injury audits started in 2009 with all in-patients at Middlemore Hospital, Manukau Surgery Centre, Auckland Spinal Rehabilitation Unit, Pukekohe and Franklin hospitals being assessed for pressure injuries using a standardised single-sheet assessment on a given day. Due to the high prevalence rate, a pressure injury working group was established to implement new initiatives and identify areas for improvement. From February 2011, regular monthly prospective audits of a sample of five randomly chosen patients per ward commenced in all Counties Manukau Health hospitals to ensure a consistent approach to identifying prevalence trends. In these audits, the number of patients with stage 1, 2, 3, and 4 and unstageable pressure injuries were recorded with the highest stage of injury recorded for each patient. The number of patients with pressure injuries were recorded rather than the number of pressure injuries that occurred, as it was expected that treating a single patient with multiple pressure injuries would not cost as much as treating the same number of pressure injuries across multiple patients, as in the former case only one bed is needed to treat multiple injuries simultaneously. Risk assessments were standardised across the organisation with the expectation the assessment is completed within six hours of admission, and associated bundles of care implemented based on the assessment score, and clinical judgement.

Nurse wound care champions were identified in each ward/unit who participated in the monthly audits and completed a full pressure injury risk assessment, including a full visual skin check, documentation review and recording of any pressure relieving equipment in use. The nurse champions also provided support and education to the ward nursing teams and feedback on the outcomes of the audits to identify areas for improvement. Education packages, including ward resource folders, a pressure injury website, e-learning packages and patient information leaflets were developed. These were aimed primarily at nursing staff and promoted by pressure injury champions.

A review of pressure injury rental equipment and a staff survey was carried out with nursing and allied health staff. A survey was sent out at the start of June 2012 and 73 responses were received. The information collected was intended to identify themes to help the pressure injury working group understand requirements relating to pressure injuries. This showed there were several suppliers of pressure-relieving equipment, in addition to Counties Manukau Health-owned equipment. It also pointed to the need for clarity and transparency on equipment use, ordering systems and costs. In response, a streamlined pressure-relieving equipment decision tree was implemented in 2014 that aligned risk assessment findings with equipment orders.
Results

Table 1 shows the numbers of patients with pressure injuries found in the sample participating in monthly audits, across the intervention implementation period. As there were few patients with stages 3, 4 and unstageable pressure injuries, it was decided to collapse these categories before using the figures to extrapolate numbers of pressure injuries across hospitals (Table 2). For example, in 2013 there were no stage 4 pressure injuries as compared to four in 2012. Although this was only a small difference in the absolute number of stage 4 pressure injuries, when the percentage was multiplied by the tens of thousands patients admitted to Counties Manukau Health hospitals annually (see Table 2), this small change in percentage would have a dramatic, and possibly disproportionate, effect on the overall estimate of the number of stage 4 pressure injuries across the hospitals.

Table 2 shows the cost of pressure injuries across Counties Manukau Health hospitals from 2011 to 2015, based on estimates of the percentage of patients with pressure injuries from the monthly audit shown in Table 1. Stages 3, 4 and unstageable pressure injuries were costed as stage 3 pressure injuries, based on clinical advice in the case of unstageable injuries, and also to be conservative when making estimates on savings made due to pressure injury reduction from 2011–2015.

Table 1: Number of patients with pressure injuries found in monthly audit.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total patients in audit sample</th>
<th>Stage 1 (Total patients)</th>
<th>Stage 1 (% of total patients)</th>
<th>Stage 2 (Total patients)</th>
<th>Stage 2 (% of total patients)</th>
<th>Stage 3 (Total patients)</th>
<th>Stage 3 (% of total patients)</th>
<th>Stage 4 (Total patients)</th>
<th>Stage 4 (% of total patients)</th>
<th>Unstageable (Total patients)</th>
<th>Unstageable (% of total patients)</th>
<th>Stage 3, 4 and unstageable collapsed (Total patients)</th>
<th>Stage 3, 4 and unstageable collapsed (% of total patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2,078</td>
<td>101 (4.86%)</td>
<td>31 (1.49%)</td>
<td>8 (0.38%)</td>
<td>4 (0.19%)</td>
<td>4 (0.19%)</td>
<td>16 (0.76%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>2,065</td>
<td>69 (3.4%)</td>
<td>22 (1.07%)</td>
<td>3 (0.15%)</td>
<td>4 (0.19%)</td>
<td>5 (0.24%)</td>
<td>12 (0.58%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>2,375</td>
<td>74 (3.12%)</td>
<td>23 (0.97%)</td>
<td>3 (0.13%)</td>
<td>0 (0%)</td>
<td>2 (0.08%)</td>
<td>5 (0.21%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>2,057</td>
<td>50 (2.43%)</td>
<td>28 (1.36%)</td>
<td>2 (0.1%)</td>
<td>4 (0.19%)</td>
<td>6 (0.29%)</td>
<td>12 (0.58%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>2,353</td>
<td>32 (1.36%)</td>
<td>29 (1.23%)</td>
<td>3 (0.13%)</td>
<td>0 (0%)</td>
<td>4 (0.17%)</td>
<td>7 (0.30%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Estimated cost of pressure injuries 2011–2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total patients admitted to Counties Manukau hospitals (without babies)</th>
<th>Estimated numbers of patients with pressure injuries</th>
<th>Estimated cost of pressure injuries across hospitals (NZ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total patients admitted to Counties Manukau hospitals (without babies)</td>
<td>Stage 1</td>
<td>Stage 2</td>
</tr>
<tr>
<td>2011</td>
<td>67,701</td>
<td>3,291</td>
<td>1,010</td>
</tr>
<tr>
<td>2012</td>
<td>68,278</td>
<td>2,281</td>
<td>727</td>
</tr>
<tr>
<td>2013</td>
<td>68,761</td>
<td>2,142</td>
<td>666</td>
</tr>
<tr>
<td>2014</td>
<td>70,575</td>
<td>1,715</td>
<td>961</td>
</tr>
<tr>
<td>2015</td>
<td>69,601</td>
<td>947</td>
<td>858</td>
</tr>
<tr>
<td>TOTAL</td>
<td>344,916</td>
<td>10,376</td>
<td>4,222</td>
</tr>
</tbody>
</table>
Table 2 shows that the estimated total cost of pressure injuries generally decreased between 2011 and 2015. However, there was an increase in the total cost of pressure injuries in 2014 as compared with 2012, 2013 and 2015, which is due to an increase in stages 2 and 3, 4 and unstageable pressure injuries in this year. Nevertheless, the estimated cost of pressure injuries in hospital patients was $12,290,484 less in 2015 than in 2011.

Discussion

Findings from our audit show reductions in the incidence of pressure injuries have been made at Counties Manukau Health hospitals by implementation of interventions to manage this issue. We have attempted to estimate the potential financial savings that may have been made by extrapolating findings from an audit that sampled one in six patients in hospital wards, and have noted considerable potential savings over the course of the intervention.

Our findings are congruent with those found in the literature. For example, Sullivan and Schoelles (2013) reviewed studies of initiatives to prevent pressure injuries in acute and long-term care settings in the US. Findings from 26 studies, where data was collected at least six months after initiatives had been implemented, suggested that reduced pressure injury rates could be achieved through: “simplification and standardisation of pressure ulcer-specific interventions and documentation, involvement of multidisciplinary teams and leadership, use of designated skin champions, ongoing staff education and sustained audit and feedback” (p.410).

In addition, Spetz, Brown, Aydin and Donaldson (2013) also assessed cost savings related to using nurses in preventing hospital-acquired pressure injuries. They described approaches to prevention, including the “use of specially designed support surfaces, frequent repositioning of patients, attention to patient nutrition, and management of moisture and incontinence” (p.236), as well as “risk screening upon admission, systematic assessment and reassessment of individual risk factors along with skin inspections, implementation of a skin care regimen and repositioning of patients” (p.236). They found improvements in pressure injury rates across 78 hospitals that contributed data to the Collaborative Alliance for Nursing Outcomes from 2003 to 2010 (258,456 patients), and suggested a Return on Investment rate of 1.61, with net savings of $127.51 per patient (savings were estimated from published literature).

We accept that the assessment of savings made due to reduction in pressure injuries is very approximate, especially as the estimate of the cost of treating pressure injuries is taken from background literature rather than using recorded costs, which were not available in sufficient detail to be used. A proper cost analysis would rely on recording costs fully, including equipment, staff time and other resources used for managing pressure injuries. However, we are confident that our study does at least indicate that savings can be made by implementation of interventions such as ours to manage pressure injuries in hospitals. Furthermore, we were conservative in our estimate of the costs of stage 4 and unstageable pressure injuries, which lends weight to this assertion. In conclusion, we suggest that implementing strategies to manage hospital-acquired pressure injuries can lead to potentially large financial savings for hospitals, as well as reduce the burden of managing this difficult condition for patients and staff.
Competing interests:
Nil.

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REFERENCES:
The association between the first locating emergency ambulance being single crewed and cardiac arrest outcomes in New Zealand

Bridget Dicker, Paul Davey, Tony Smith

ABSTRACT

**AIM:** This study investigated the association between the first locating emergency ambulance being single crewed on outcomes following out-of-hospital cardiac arrest in New Zealand.

**METHOD:** Using data from the St John cardiac arrest registry for the period of 1 October 2013 to 30 June 2015, cases were included if a resuscitation attempt was made and the patient was an adult. Logistic regression modelling was used to account for confounding factors. The primary outcome was survival to hospital discharge.

**RESULTS:** A total of 2,347 cases were included. There was no difference in the rate of return of spontaneous circulation sustained to hospital handover in patients attended by either single-crewed (27%) or double-crewed ambulances (32%); p=0.059. However, patients were significantly less likely to survive to hospital discharge when attended by single-crewed (12%) compared to double-crewed ambulances (17%) with an OR of 0.533, 95% confidence interval 0.320–0.888 and p=0.016.

**CONCLUSION:** Patients had lower survival to hospital discharge outcomes when the first locating ambulance was single crewed than those where the first locating ambulance was double crewed.

Sudden out-of-hospital cardiac arrest (OHCA) is a significant health burden in New Zealand. During the one-year period from 1 July 2014 to 30 June 2015, St John attended 4,298 OHCAs. The majority of patients (98%) attended were adults greater than or equal to 16 years of age, with an incidence of 132.8 per 100,000 person-years. Of the adult patients with OHCA attended by St John during this period, 1,996 (48%) had a resuscitation attempt initiated by the attending emergency ambulance crews.

St John operates a two-tiered response system for responding to OHCA in New Zealand. The two-tiered response system involves response of the fire service crewed with basic life support first responders, dispatch of the closest two ambulances and an intensive care paramedic (ICP) if possible. The usual standard for an ambulance crew is to be staffed with two trained responders. New Zealand is in a relatively unique situation in that some ambulances may be staffed with a single trained responder. If an ambulance is staffed with two trained responders, the crew composition may include a mix of ICP, paramedic (PARA) or emergency medical technician (EMT). However, the ideal skill composition and number of crew that attend an OHCA is unknown.¹

There are various models of ambulance response to OHCA, ranging from one- or two-tier systems, different numbers of crew and different skill compositions.¹ ² A limited number of studies have shown that a larger number of crew may not have an effect on patient outcomes.³ ⁴ Primarily
these studies make comparisons between a double crew (DC) to a crew of three or more. There are few ambulance services, other than in New Zealand, where an ambulance response can consist of a single crew (SC) outside of the context of a being a first tier or non-transporting response. As such, there are no studies that compare a DC ambulance response to a SC ambulance response.

As New Zealand is unique in that a portion of the ambulance crews may be staffed with a single responder, this study sought to investigate if there was any association between attendance by a single-crewed ambulance and cardiac arrest outcomes in New Zealand.

Method

Study design
This was a retrospective analysis using St John OHCA registry data for the period of 1 October 2013 to 30 June 2015. The data variables held within the registry are inclusive of all OHCA attended by St John in New Zealand, regardless of whether a resuscitation attempt was initiated or not. It includes dispatch data, on-scene data collected by the ambulance personnel in attendance and mortality data from district health boards or the New Zealand National Health Index. The dispatch data includes time of answering the emergency call in the ambulance clinical control centre, time of arrival of an ambulance at the scene, the level of qualification of the attending crew, the number of crew attending and whether the first locating vehicle was an emergency transporting ambulance or a non-transporting vehicle such as a car.

The St John OHCA registry covers the areas of New Zealand that are serviced by St John. This includes all of New Zealand with the exception of the Greater Wellington Region, which is serviced by Wellington Free Ambulance. The registry encompasses 90% of the New Zealand population (approximately 4.1 million people) and 97% of New Zealand.

Variables
Variables included were ambulance crew number (SC or DC), gender, age, ethnicity, OHCA witnessed status, performance of bystander cardio-pulmonary resuscitation (CPR), defibrillation prior to ambulance arrival, shockable presenting rhythm, aetiology, location, incident region, service area (urban, rural or remote), minutes to scene, highest clinical level in attendance, ROSC on handover at hospital and discharged alive.

Ethics approval
Ethical approval for research using non-identifiable OHCA data was obtained from the Auckland University of Technology Ethics Committee (13/367) and the New Zealand Health and Disabilities Ethics Committee (13/STH/192/AM02).

Statistical methods
All data was entered into an IBM SPSS database (Version 23.0 IBM Corporation). Patient demographics, case characteristics and patient outcomes were compared between SC and DC groups using the Chi-squared test for categorical data and the Mann-Whitney-U test for numerical data. Binary logistic regression analysis of patient demographics and case characteristics were performed to select variables significant at the p<0.10 level for adjusted multivariate regression models.

Outcomes
Survival to hospital discharge was the primary outcome. Survival to hospital discharge was defined as having either a known date of being discharged alive from hospital or survival to 15 days post-event.

Results

Included cases
During the 21-month study period, St John attended 7,005 OHCA of which 3,446 had resuscitation attempted. After excluding OHCA where age was less than 16 years, fire service or a non-transporting rapid response vehicle such as a car were the first locating vehicle and emergency response ambulances with greater than 2 crew; a total of 2,347 OHCA cases were included for analysis (Figure 1).

Study population
Of the 2,347 cases, 337 were attended by SC (14%) and 2,010 were attended by DC (86%). Gender and age were similar between SC and DC groups. A lower proportion of patients attended by SC were European, Pacific Peoples or Other ethnicity and a higher proportion were Māori (Table 1).
Figure 1: Flow diagram of included cases.

All OHCA events
1/10/2013 to 30/06/2015
n=7,005

No resuscitation attempted
n=3,559

Resuscitation attempted
n=3,446

Children < 16 years old
n=135

Adult ≥16 years old
n=3,311

Fire arrived on scene >1 min ahead of ambulance
n=331

Non-transporting response vehicle arrived first
n=372

Transporting emergency response
ambulance arrived on scene first
n=2,608

Greater than 2 crew
n=261

Single or double crew
n=2,347

Single crew
n=337

Transported to hospital
n=102

ROSC on handover
n=90 (27%)

Survival to discharge
n=39 (12%)

Double crew
n=2,010

Transported to hospital
n=722

ROSC on handover
n=640 (32%)

Survival to discharge
n=340 (17%)
### Table 1: Characteristics of OHCA by crew level.

<table>
<thead>
<tr>
<th></th>
<th>Single crew, n=337</th>
<th>Double crew, n=2,010</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><strong>Study population</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender male</td>
<td>240</td>
<td>71%</td>
<td>1,389</td>
</tr>
<tr>
<td>Age in years, median (IQR)</td>
<td>67 (54–78)</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>149</td>
<td>54%</td>
<td>1,034</td>
</tr>
<tr>
<td>Māori</td>
<td>109</td>
<td>40%</td>
<td>387</td>
</tr>
<tr>
<td>Pacific Peoples</td>
<td>8</td>
<td>3%</td>
<td>148</td>
</tr>
<tr>
<td>Other ethnicity</td>
<td>8</td>
<td>3%</td>
<td>122</td>
</tr>
<tr>
<td><strong>OHCA characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witnessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By a bystander</td>
<td>172</td>
<td>51%</td>
<td>1,008</td>
</tr>
<tr>
<td>By ambulance staff</td>
<td>63</td>
<td>19%</td>
<td>374</td>
</tr>
<tr>
<td>Bystander-performed CPR</td>
<td>194</td>
<td>58%</td>
<td>1,157</td>
</tr>
<tr>
<td>Defibrillation prior to ambulance arrival</td>
<td>20</td>
<td>6%</td>
<td>89</td>
</tr>
<tr>
<td>Shockable presenting rhythm</td>
<td>121</td>
<td>37%</td>
<td>749</td>
</tr>
<tr>
<td><strong>Aetiology</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Presumed cardiac</td>
<td>262</td>
<td>78%</td>
<td>1,525</td>
</tr>
<tr>
<td>Other non-cardiac</td>
<td>62</td>
<td>19%</td>
<td>373</td>
</tr>
<tr>
<td>Traumatic</td>
<td>11</td>
<td>3%</td>
<td>94</td>
</tr>
<tr>
<td><strong>Ambulance response</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>53</td>
<td>17%</td>
<td>357</td>
</tr>
<tr>
<td>Home</td>
<td>230</td>
<td>73%</td>
<td>1,290</td>
</tr>
<tr>
<td>Aged care facility</td>
<td>8</td>
<td>3%</td>
<td>66</td>
</tr>
<tr>
<td>Health care facility</td>
<td>4</td>
<td>1%</td>
<td>40</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern</td>
<td>54</td>
<td>16%</td>
<td>832</td>
</tr>
<tr>
<td>Central</td>
<td>245</td>
<td>73%</td>
<td>624</td>
</tr>
<tr>
<td>South Island</td>
<td>38</td>
<td>11%</td>
<td>554</td>
</tr>
<tr>
<td>Service area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>114</td>
<td>34%</td>
<td>1,577</td>
</tr>
<tr>
<td>Rural</td>
<td>204</td>
<td>61%</td>
<td>382</td>
</tr>
<tr>
<td>Remote</td>
<td>19</td>
<td>6%</td>
<td>43</td>
</tr>
<tr>
<td>Minutes to scene, median (IQR)</td>
<td>9</td>
<td>(6–14)</td>
<td>8</td>
</tr>
<tr>
<td><strong>Highest clinical level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMT</td>
<td>42</td>
<td>13%</td>
<td>62</td>
</tr>
<tr>
<td>PARA</td>
<td>68</td>
<td>20%</td>
<td>271</td>
</tr>
<tr>
<td>ICP</td>
<td>227</td>
<td>67%</td>
<td>1,677</td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROSC on handover at hospital</td>
<td>90</td>
<td>27%</td>
<td>640</td>
</tr>
<tr>
<td>Discharged alive</td>
<td>39</td>
<td>12%</td>
<td>340</td>
</tr>
</tbody>
</table>

Table 2: Univariate logistic regression model for survival to hospital discharge.

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crewing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crewing DC (reference)</td>
<td>0.642</td>
<td>(0.451–0.914)</td>
<td>0.014</td>
</tr>
<tr>
<td><strong>Study population</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (reference)</td>
<td>0.832</td>
<td>(0.651–1.063)</td>
<td>0.141</td>
</tr>
<tr>
<td>Age in years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.989</td>
<td>(0.983–0.995)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European (reference)</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Māori</td>
<td>0.511</td>
<td>(0.374–0.699)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pacific Peoples</td>
<td>0.729</td>
<td>(0.461–1.152)</td>
<td>0.176</td>
</tr>
<tr>
<td>Other ethnicity</td>
<td>0.488</td>
<td>(0.275–0.865)</td>
<td>0.014</td>
</tr>
<tr>
<td><strong>OHCA characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witnessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unwitnessed (reference)</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>By a bystander</td>
<td>4.816</td>
<td>(3.297–7.033)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>By ambulance staff</td>
<td>8.428</td>
<td>(5.614–12.652)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Bystander CPR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bystander CPR (reference)</td>
<td>0.877</td>
<td>(0.703–1.095)</td>
<td>0.247</td>
</tr>
<tr>
<td>Defib. prior to ambulance arrival</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No defib. prior to ambulance arrival (reference)</td>
<td>3.245</td>
<td>(2.161–4.872)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Presenting rhythm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-shockable (reference)</td>
<td>12.900</td>
<td>(9.541–17.439)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Aetiology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac (reference)</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Non-cardiac</td>
<td>0.487</td>
<td>(0.348–0.682)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Traumatic</td>
<td>0.269</td>
<td>(0.117–0.619)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Ambulance response</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public (reference)</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Home</td>
<td>0.374</td>
<td>(0.283–0.494)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Aged care facility</td>
<td>0.131</td>
<td>(0.041–0.427)</td>
<td>0.001</td>
</tr>
<tr>
<td>Health care facility</td>
<td>2.841</td>
<td>(1.508–5.352)</td>
<td>0.001</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern (reference)</td>
<td></td>
<td></td>
<td>0.038</td>
</tr>
<tr>
<td>Central</td>
<td>0.765</td>
<td>(0.590–0.993)</td>
<td>0.044</td>
</tr>
<tr>
<td>South Island</td>
<td>1.081</td>
<td>(0.823–1.418)</td>
<td>0.577</td>
</tr>
<tr>
<td>Service area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban (reference)</td>
<td></td>
<td></td>
<td>0.222</td>
</tr>
<tr>
<td>Rural</td>
<td>0.832</td>
<td>(0.640–1.082)</td>
<td>0.169</td>
</tr>
<tr>
<td>Remote</td>
<td>0.624</td>
<td>(0.281–1.384)</td>
<td>0.246</td>
</tr>
<tr>
<td>Minutes to scene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes to scene</td>
<td>0.987</td>
<td>(0.970–1.004)</td>
<td>0.132</td>
</tr>
<tr>
<td>Highest clinical level at scene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMT (reference)</td>
<td></td>
<td></td>
<td>0.128</td>
</tr>
<tr>
<td>PARA</td>
<td>2.089</td>
<td>(0.995–4.382)</td>
<td>0.051</td>
</tr>
<tr>
<td>ICP</td>
<td>2.034</td>
<td>(1.015–4.075)</td>
<td>0.045</td>
</tr>
</tbody>
</table>

OHCA characteristics
OHCA characteristics were similar between SC and DC groups (see Table 1). Approximately 50% were witnessed by a bystander and 19% were witnessed by ambulance staff, 58% had CPR performed by a bystander, less than 10% had defibrillation prior to ambulance arrival, nearly 40% had a shockable presenting rhythm and the majority had a presumed cardiac aetiology (approximately 80%).

Ambulance response
A higher proportion of events attended by SC ambulances were in the Central Region (73%), a higher proportion of events were in rural areas (61%), the median response time for the SC group was longer and they were less likely to have the highest qualified responder in attendance being an ICP (67%) (Table 1).

Outcomes
The univariate analysis of ROSC sustained to hospital handover showed there was no difference in the rates of ROSC sustained to hospital handover in patients attended by either SC ambulances or DC ambulances (OR 0.779, 95% CI 0.602–1.010, p=0.059). However, patients were significantly less likely to survive to hospital discharge when attended by SC ambulances compared to those attended by DC ambulances (Table 2, Figure 2). After adjustment for confounders there remained a significant difference between SC and DC groups with patients attended by SC ambulances having a lower odds of survival (Figure 2).

Discussion
This retrospective analysis of data from the St John New Zealand OHCA registry has clearly shown that attendance by a SC ambulance was associated with a reduction in the odds of survival to hospital discharge when compared to attendance by a DC ambulance. There was no difference in rates of ROSC on hospital handover between patients attended by a SC or DC ambulance.

Due to the retrospective observational nature of this study, potential causes for the associated reduction in survival to hospital discharge with attendance by a SC ambulance cannot be drawn. It is possible that factors such as patient characteristics, CPR quality, pre-shock and post-shock pauses, defibrillation mode and responder fatigue may be implicated.

During the first few minutes of a cardiac arrest, the quality of CPR is critical to achieving survival. The chest compression fraction, or the percentage of time that chest compressions are performed during resuscitation, has been previously identified as an independent predictor of survival. It may be that in the setting of attendance by a SC ambulance the chest compression fraction is less than that with attendance by a DC ambulance. With a SC ambulance a lone responder would need to perform multiple tasks such as performing chest compressions, attaching defibrillation pads and using the defibrillator, whereas in the case of a DC ambulance, one of the two responders would perform continuous compressions.

Figure 2: Odds ratio (OR) of survival to hospital discharge for patients attended by SC ambulances vs DC ambulances.
while the other responder completed all of the other tasks.

Chest compression rate and depth have also been identified as elements of high-quality CPR. Both have been shown to deteriorate over time with responder fatigue.\textsuperscript{12–13} To ameliorate the observed deterioration in chest compression quality over time, the resuscitation guidelines recommend that the responder performing chest compressions should change every two minutes.\textsuperscript{14} In the case of attendance by a SC ambulance the lone responder may either continue compressions for longer than the recommended two-minute period or may potentially recruit an untrained lay-responder to continue the compressions. Both situations have the potential to compromise the quality of compressions.

Although it was not able to be investigated in this study, it is possible that in the context of attendance by a SC ambulance that the defibrillator may be used more frequently in an advisory mode. The use of a defibrillator in the advisory mode has been shown to be associated with longer interruptions in CPR and lower rates of ROSC compared to using a defibrillator in manual mode.\textsuperscript{15} In addition, Cheskes et al (2011) previously demonstrated that the pre-shock and post-shock pauses in compressions, which are typically longer in the advisory mode, were associated with significant reductions in survival.\textsuperscript{16}

With a SC ambulance, even with the use of manual defibrillation, there may be an increased length of pre- and post-shock pauses in chest compressions. With a DC ambulance in order to minimise the pre-shock pause it is usual practice for one responder to continue compressions while the other charges the defibrillator, pausing compressions only to confirm a shockable rhythm exists and to deliver the defibrillator shock. However, with a SC ambulance this is not possible as the lone responder would need to cease compressions while they charge and use the defibrillator, potentially resulting in prolonged pre- and post-shock pauses in compressions. In order to further limit reductions in chest compression quality it may also be that advanced life support skills, such as intubation and administration of drugs are not performed in patients attended by a SC ambulance as these skills would require prolonged pauses in chest compressions.

This study represents the first comparative analysis of patient outcomes according to attendance by a SC or DC ambulance in response to OHCA in the New Zealand context. The strength of this study is that the registry held equivalent information on patients attended by both SC and DC ambulances that enabled sufficient numbers for statistical analyses. In addition, the responders were all from a single ambulance service utilising the same clinical procedures and guidelines. However, there are several limitations of the study in that the study was unable to investigate relationships between electronic defibrillator data, the characteristics of the receiving hospitals or patient comorbidities, all factors which may also influence survival outcomes following OHCA.

**Conclusion**

This study examined survival differences in patients where the first locating ambulance was single crewed or double crewed in the setting of OHCA in New Zealand. Patients had lower survival to hospital discharge outcomes when the first locating ambulance was single crewed than those where the first locating ambulance was double crewed. Although further investigation into relationships is required, the number of crew in the first locating ambulance impacts OHCA survival rates. This research supports the elimination of single-crewed ambulances in New Zealand.
Competing interests:
All authors are employees of the St John ambulance service.

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URL:

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Bionic balance organs: progress in the development of vestibular prostheses

Paul F Smith

ABSTRACT

The vestibular system is a sensory system that is critically important in humans for gaze and image stability as well as postural control. Patients with complete bilateral vestibular loss are severely disabled and experience a poor quality of life. There are very few effective treatment options for patients with no vestibular function. Over the last 10 years, rapid progress has been made in developing artificial ‘vestibular implants’ or ‘prostheses’, based on cochlear implant technology. As of 2017, 13 patients worldwide have received vestibular implants and the results are encouraging. Vestibular implants are now becoming part of an increasing effort to develop artificial, bionic sensory systems, and this paper provides a review of the progress in this area.

The first cochlear implant was performed in 1961 by William House and John Doyle of Los Angeles, California. This was followed by stimulation tests conducted by Blair Simmons and Robert White at Stanford in 1962. Graeme Clark of Melbourne, Australia, implanted the first multi-electrode cochlear implant in 1978, which became the first successful commercially available multi-electrode cochlear implant. Although the concept was met with considerable scepticism, over the last several decades the procedure has been refined and it is estimated that nearly half a million people had received cochlear implants by 2016. The success of cochlear implant technology has naturally encouraged researchers and clinicians to consider other forms of bionic implants that can substitute for lost sensory function, and considerable progress has now been made in the development of retinal and other cortical implants for humans. Another kind of sensory implant that is developing rapidly is the ‘vestibular implant or prosthesis’, which aims to replace a missing or dysfunctional vestibular system. Groups of patients have been receiving such implants since approximately 2007 and considerable progress has been made in this area, which this paper aims to review.

It is often said that the vestibular system is a sensory system that is not appreciated until something goes wrong with it. More primitive than the visual and auditory systems, it is estimated to have evolved over 500 million years ago, and exists in a rudimentary form in animals such as jellyfish, where it functions to indicate gravitational vertical, i.e., which way is up. In mammals it is more sophisticated and consists of three semi-circular canals and two otolithic organs, in each inner ear. The horizontal, anterior and posterior semi-circular canals sense rotation of the head in three dimensions and the otoliths, the utricle and saccule, sense translation in three dimensions. It is important to appreciate that, strictly speaking, the stimulus for all of these sensory organs is ‘acceleration’ or change in angular or linear velocity, not velocity itself, and therefore one of the stimuli they detect is linear acceleration by gravity, which is critical for survival. Together, these vestibular end organs sense acceleration during head movement as well as gravitational vertical. The vestibular system contributes to the control of posture through the vestibulo-spinal reflexes and even to autonomic function, but in humans one of its most important roles is...
in the generation of rapid compensatory eye movements during unexpected head movement—the ‘vestibulo-ocular reflexes (VORs)’. These reflexes generate equal and opposite eye movements during unexpected head movement and keep the visual image of the world stable on the retina, thereby preventing blurring of the visual image or ‘oscillopsia’ (see Figures 1 and 2). It is natural to think that the vestibular system should not be necessary for this purpose, because the visual system should be able to compensate for this kind of head movement. However, this is not the case. The visual system is too slow to adequately correct for unexpected, high acceleration head movements, because visual feedback is required before the eye movements can be generated. The vestibular system responds to acceleration of the head directly (ie, it is an ‘open-loop system’), generating VORs in approximately 9ms, and does not require any visual feedback, although feedback regarding the success of the VORs does modulate the reflex. Furthermore, the vestibular system is exquisitely sensitive to head acceleration, generating VORs even in response to the small degree of head movement caused by the pulse beat. Although we are not usually aware of it, we are exposed to high accelerations of the head when we walk down a street, and without adequate compensatory eye movements from the VORs, we would see the world as blurred and bouncing around (‘oscillopsia’), as in footage taken from a video camera while walking.

**Figure 1:** The push-pull organisation of the horizontal (yaw) rotational vestibulo-ocular reflex (VOR).

The direct pathway comprises a short tri-synaptic reflex consisting of the vestibular nerve (VIIIth nerve), the vestibular nuclei (VN), motoneurons in the VI (abducens) and III (oculomotor) nuclei, and the lateral rectus (LR) and medial rectus (MR) muscles. When the head rotates to the right (arrows), the right horizontal semi-circular canal afferents increase their firing rates, whereas the left afferents decrease their firing rates (orange versus blue colours, respectively). The excitation/inhibition is transmitted to the contralateral/ipilaternal abducens (VI) nucleus through neurons in the right/left VN, respectively. Internuclear neurons in the abducens nuclei cross the midline and terminate in the contralateral medial rectus motoneurons (III). Thus, motoneurons in the left VI and right III nuclei fire at a higher frequency, whereas those in the right VI and left III nuclei fire at a lower frequency. As a result, the left LR and right MR muscles contract, whereas the left MR and right LR muscles relax and both eyes rotate leftward. Reproduced from Angelaki (2008) with permission.
For these reasons, the consequences of dysfunction of the vestibular system in humans can be severe and extremely debilitating. In the worst case scenario, people without effective vestibular systems become housebound and lead very restricted lives, with high rates of anxiety disorders and depression. Recent evidence also indicates that such people develop cognitive deficits as a result of the effects of the loss of self-motion information generated by the vestibular system, on the brain’s ability to construct mathematical maps of the spatial environment. Vestibular dysfunction of various sorts is now thought to be quite common. Although there are no reliable statistics available in New Zealand, in the US it is estimated that approximately 35% of people aged 40 and over have suffered from some form of vestibular dysfunction (based on a sample of 5,086). The incidence of vestibular deficits increases with age, reaching almost 50% over the age of 60, with a 12-fold increase in the risk of falling. There are, of course, many different types of vestibular disorders and not all of them would be candidates for a vestibular implant. Vestibular disorders can be acute, chronic, paroxysmal, unilateral or bilateral and lesions partial or complete. The most common vestibular disorders are generally agreed to be benign paroxysmal positional vertigo (BPPV), vestibular migraine (a relatively recent diagnostic category) and Meniere's Disease. Less common are conditions such as vestibular neuritis and labyrinthitis, aminoglycoside antibiotic vestibulo-otoxicity (eg, from gentamicin), vestibular schwannomas (a tumour on the vestibular nerve), perilymph fistulas, idiopathic vestibular loss and central vestibular disorders. To date, vestibular implants have been investigated and trialled mostly in cases of complete bilateral vestibular loss. In this case very few therapies have been successful and the quality of life for patients with this condition is generally very poor. Mammalian vestibular hair cells do not readily regenerate, therefore despite substantial attempts to stimulate their re-growth using drugs and gene therapy, this option remains unavailable. Unfortunately, no drug treatment can substitute for the sensory functions of the vestibular system. Non-vestibular sensory substitution has been used with some success, such as electrical stimulation of the tongue or torso during head movement, and vestibular rehabilitation delivered by physiotherapists does help, but ultimately the unique functions of the vestibular system cannot be replaced. Therefore, implanting an

![Figure 2: Computer generation of an acuity chart in original unfiltered format (A) and blurred (B) to take into account the change in spatial response brought about by whole body oscillation for patient P3 (ie, with an absent vestibulo-ocular reflex).](image)

The lines of the acuity chart correspond to 6/9, at the top, followed by 6/6, 6/5, and finally 6/4 at the bottom. Reproduced from Morland et al (1998) with permission.
artificial vestibular system that senses head acceleration electronically, using miniature three-dimensional accelerometers, and translating those signals into patterned electrical stimulation of the vestibular nerve, becomes an enticing possibility.13

The first vestibular implants

The idea for vestibular implants arose from the original studies of Cohen, Suzuki and Bender in the 1960’s, who demonstrated that electrical stimulation of individual semicircular canal nerves could elicit VORs in the plane of the corresponding canal.14 The first experimental vestibular implants in animals were performed in 2001 by the Harvard/Mass Eye and Ear (MEE) research group15–18 and then later by the Johns Hopkins research group.19,20 Based on cochlear implant technology, the prototype MEE VI transduced angular head acceleration around one rotational axis using an accelerometer and transmitted this information to the brain by modulating the rate of electrical impulses delivered to the corresponding semicircular canal nerve.15–18 All of these studies focused on the semicircular canals rather than the otoliths, due to the more complex nature of the latter. Whereas the direction of excitation during angular acceleration—the ‘polarization vector’—is the same for each hair cell in the cupula inside the ampulla of each individual semicircular canal (but different for different semicircular canals), in the utricle and saccule the pattern of polarization vectors reverses halfway across the sensory epithelium.3 This division, known as the ‘striola’, means that each otolithic structure is capable of responding with depolarization for either direction of translational acceleration in each plane.3

The actual transduction of head acceleration could be performed by modified accelerometers. Accelerometers have been used in engineering for a long time but they have been miniaturised to the point where they can occupy very little space. However, in this case the accelerometers needed to mimic the biophysical properties of real semicircular canals.21,22 There was a clear anatomical and physiological framework for the conception of the vestibular implant.23 The cochlear implant-style processor and its electrode design provided the means of delivering the patterned electrical stimulation (see Figure 3).24–27 In many cases, patients with vestibular implants also received cochlear implants.12 So the remaining question for the vestibular system was: what should be the nature of this electrical stimulation?28 Decades of neurophysiological research in animals had provided detailed information on the nature of the electrical activity in the primary afferent neurons of the vestibular nerve, which takes information from the vestibular hair cells and transmits it to the brainstem vestibular nucleus complex (VNC) and the cerebellum (see Figure 1).29 It was well established that there were two main kinds of vestibular afferents, regular and irregular, and that their basic pattern of activity was a high baseline firing rate (approximately 90 spikes/sec on average) that was modulated up or down during stimulation of the semicircular canals.3,28 During head acceleration, the dynamic range of these neurons extended to over 300 spikes/sec.29 It was also well known that these afferents synapsed on ‘position-vestibular-pause (PVP) neurons’ in the VNC—so-called because they carry both vestibular and eye movement signals—and ‘flocular target neurons (FTNs)’, which project to motor neurons innervating the eye muscles and driving the VORs (see Figure 3).3,4 Therefore, theoretically, if an electrode positioned on a semicircular canal ampullary nerve delivered a baseline firing rate of approximately 250 pulses/sec and this was modulated by an accelerometer during rotational head acceleration, it would be possible to modulate the afferent firing rate up to approximately 450 pulses/sec during angular rotation that would normally excite that canal, and down to approximately 100 pulses/sec during angular rotation that would normally inhibit it. The pulses were biphasic and in the amplitude range of 160–300µA.30 The electrodes could be positioned accurately in one of the ampullary nerves by extending the mastoidectomy normally used for a cochlear implant procedure.30 Studies were initially carried out in guinea pigs and then in monkeys.15,16,31,32 The results showed that electrodes implanted in any of the three semicircular canal nerves could elicit quasi-normal VORs in the appropriate plane.15,16,32
Neurons in the vestibular nuclei that receive direct input from the vestibular afferents can be categorised into two main categories: (i) neurons that control and modulate the vestibulo-ocular reflex to ensure gaze stability during everyday life (ie, PVPs and FTNs), and (ii) neurons that control posture and balance, and also project to higher order structures involved in the estimation of self-motion (ie, VO neurons). Reproduced from Cullen (2012) with permission.

Human trials
The first trials of the vestibular implant were carried out in humans in Geneva in 2007. To date, all of these trials have been conducted at the University Hospital of Geneva, Geneva, Switzerland, and University of Maastricht Medical Centre, Maastricht, the Netherlands, and the University of Washington, Seattle. Thirteen patients have received implants to date, mostly for complete bilateral vestibular loss, and they were also deaf in the implanted ear. Most patients have received a single implant in one of the semi-circular canal nerves. Some have also received implants in all of them (but not the otoliths). It is conceivable that the VOR could be partially restored without any perceptual benefit; however, perceptual studies of visual acuity, including during ambulation, indicate that vestibular implants do actually improve visual function.

Studies in humans have shown that vestibular implants can elicit reasonable approximations of the normal VOR (see Figures 4 and 5). However, the response is generally better, with high frequencies of sinusoidal rotational head movement (eg, higher than 0.25Hz) and there is often some misalignment of the axis of eye rotation relative to the plane of the canal that the ampullary nerve would normally innervate.

Figure 4: Example of a cochlear implant (SONATA; MED-EL, Innsbruck, Austria), which was modified to provide electrodes for electrical stimulation of the vestibular system (from Perez Fornos et al).
A key issue to be resolved is whether pulse amplitude modulation or pulse rate modulation of the vestibular nerve is more effective. The original vestibular implants in animals employed pulse rate modulation (PRM), in which the electrical stimulation of a canal nerve is modulated only by varying the rate of pulses. An alternative, which is used in cochlear implants, is pulse amplitude modulation (PAM), in which the frequency of pulses remains the same but the amplitude varies. Theoretically, PAM should recruit activity in more neurons than PRM, whereas PRM should recruit the same number of neurons but with a higher firing rate than PAM. So far it appears that PAM evokes higher peak eye velocities in the VORs than PRM; however, the eye movement responses are better aligned with the canal axes using PRM. Nguyen et al have suggested that the larger peak eye velocities obtained with PAM are more advantageous.

Figure 5: VOR responses of three implanted patients to 30°/s peak-velocity sinusoidal rotations around the vertical axis in complete darkness at frequencies of 0.1, 0.25, 0.5, 1 and 2Hz (columns).

For each patient, the panels on the upper row show data gathered in the system OFF condition. The panels on the lower row show data gathered in the system ON condition. Solid lines represent the average cycle plots (±standard deviation, SD shown in dotted lines) of the horizontal angular velocity of the eye (red lines) and the head (blue lines). Note that at the lower frequencies eye movement recordings were polluted by random artifacts mainly due to the long duration of cycles at these frequencies (eg, 10s for 0.1Hz rotations) (from Perez Fornos et al).
One critical issue is what will be the effect of stimulating the canal nerves to generate VORs in the absence of otolithic signals that indicate gravito-interial force (GIF). The otoliths normally integrate linear acceleration by gravity with linear acceleration due to translation, so that they calculate a vector sum of linear acceleration signals. These are important to indicate to the brain whether the head is tilted relative to gravity. If the head is rotated off the vertical axis, otolithic signals would normally provide the brain with information about the degree of head tilt, so that it can integrate this with information from the canals about rotational acceleration.\textsuperscript{17,18} Without this additional information, it is possible that the brain will be confused about the plane of rotation of the head relative to space. At present it is unclear what the long-term effects of this may be.

Although most patients to have received vestibular implants to date have had bilateral hearing loss from disease,\textsuperscript{12,30} there is evidence from case reports that auditory function can be maintained despite the surgery on the vestibular system.\textsuperscript{43}

It is clear that, as with cochlear implants,\textsuperscript{44} the brain adapts to the artificial stimulation provided by vestibular implants over time. When the initial baseline stimulation is turned on, the brain adapts to that high rate of stimulation, over several days.\textsuperscript{45–50} One concern is that many of the stimulated afferents are likely to be entrained at the same firing rate, while normal afferent firing rates vary between fibres.\textsuperscript{17,18} It has been suggested that the phase or timing of the VORs does not adapt because the noise in the afferent fibres is coherent rather than random.\textsuperscript{17,18} It is evident that brain plasticity in response to stimulation by the vestibular implant can actually enhance its efficacy, so that the brain attempts to compensate for the shortcomings of the artificial stimulation.\textsuperscript{51}

Although there is relatively little information available on the chronic effects of vestibular implants on neuronal activity itself, some very recent studies have recorded from both the vestibular nerve and the VNC in monkeys with implants. Mitchell et al\textsuperscript{52} reported that while the primary afferent firing rate does not adapt with repeated stimulation, the PVP neurons in the VNC which receive input from them and which drive the VORs do undergo some habituation. Nonetheless, the artificial VOR responses are relatively preserved.\textsuperscript{52} Neural network simulation studies are also underway to predict the effects of vestibular implants on the central vestibular system.\textsuperscript{53}

**Conclusions**

Artificial vestibular implants have been developed and several groups of patients around the world have received them. Although the technology is in its infancy, it is developing rapidly.\textsuperscript{12,17,18} To date, adverse side effects appear to be minimal,\textsuperscript{12,17,18} although it might be predicted that as more patients with intact hearing receive implants, complications related to the spread of current to the cochlea will arise, just as with cochlear implants in relation to the vestibular end organs.\textsuperscript{54} However, there is too little information available at present to speculate on the impact of vestibular implants on auditory function.\textsuperscript{43} The long-term effects of vestibular implants on the brain, especially on higher cognitive and emotional functions, remain to be determined, but the first studies have been conducted analysing the effects of chronic electrical stimulation on primary afferent and VNC neurons that are part of the VOR pathways. Whether vestibular implants may evolve as a treatment possibility for patients with other kinds of vestibular disorders, not involving complete vestibular loss, remains to be seen; however, they have been considered for the treatment of Meniere's Disease.\textsuperscript{12} As the vestibular implant moves closer to becoming a clinical reality, the bioethical issues surrounding this kind of intervention are increasingly being discussed.\textsuperscript{18,55,56}
Competing interests:
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The apprenticeship model of clinical medical education: time for structural change

Kate Rassie

ABSTRACT
The apprenticeship model, which forms the backbone of the current medical education system, has a strong historical precedent (and indeed multiple strengths). It is, however, important to acknowledge that its application to modern medicine is far from perfect, particularly with the breadth and complexity of current hospital systems. Demands on clinician resources, the sheer volume of knowledge our trainees must amass, short attachments and rigorous assessment schedules are all major challenges to a relatively simplistic educational system. Identifying and addressing these vulnerabilities is essential to enhancing the educational experiences of both undergraduate medical students and junior doctors.

Clincial medical education in New Zealand is based, essentially, on an apprenticeship framework. This model (which is applied to our undergraduate medical courses, the prevocational intern programme and vocational training schemes) undoubtedly has strengths: with the medical workforce as the ultimate destination, early immersion in the clinical environment enables the acquisition of practical and applied knowledge. The apprenticeship model sees the trainee become familiar early on with common medical problems and presentations; and facilitates their progress from observation through to participation, supervised execution and then independence. Progressive responsibility is conferred, but ongoing close clinical supervision safeguards patient safety and aims to further refine and develop the skill of the apprentice.1

The apprenticeship model also allows the student to become familiar with the culture, processes and expectations of the medical workforce. It enables them to become comfortable interacting with patients, and to model their own clinical behaviour on that of respected seniors. Professor Tim Wilkinson, in his 2013 reflections on medical education systems, deftly summarises the intent of modern, clinically-based, apprentice systems: “the major challenge of medical education is to integrate formal knowledge with clinical experience and to develop habits of inquiry and innovation. The gold standard of good medical education is where students learn the underlying theory and science of a problem at the same time as they encounter that problem in real life”.2

For undergraduate medical students, patient contact is relatively structured and goals are often assessment-driven. The education provider is the responsible university, and there is no expectation of service delivery. After graduation, resident medical officers (RMOs) actively care for patients as part of a wider clinical team. Employed by district health boards (DHBs), they have professional, moral and social responsibilities to patient care. They learn through clinical practice, receiving feedback from the wider professional body. Both educational phases, however, involve gradual acquisition of knowledge and skill, graded delegation of responsibility; and comprehensive oversight, supervision and feedback.

Despite being standard—and seemingly unquestioned—within medical education, some elements of our current apprenticeship-based education system are less than ideal. In my recent years (as an undergraduate medical student, then
as a house officer, and now as a registrar and physician trainee) the flaws of our prevailing model have become increasingly apparent. While it is both desirable and realistic to assume that the apprenticeship model is here to stay, several areas of the current system are in need of modification and improvement. In my recent position as a clinical medical education fellow at the University of Auckland, current undergraduate medical students frequently expressed similar sentiments.

Watling et al demonstrate the drawbacks of the apprenticeship model in their 2013 and 2014 pieces, drawing interesting comparisons between medical educational culture and other educational cultures, namely those of performance music and competitive sport. Their group used a constructivist grounded theory approach with formal interviews and focus groups, interviewing students and educators within all fields. When contrasted in this way, several features of the medical apprentice system emerged as significant potential vulnerabilities.

Teaching education to clinicians

One of the most striking drawbacks of the current apprenticeship model is that very few clinicians have any specific education in teaching itself. Virtually all doctors find themselves within teaching roles at some stage, and all of us aim to fulfil the obligations sworn in the Hippocratic Oath: “to impart precept, oral instruction, and all other instruction … to indentured pupils who have taken the physician’s oath”. However, very few clinicians have actually had formal instruction in the theory and execution of effective teaching.

As Watling et al point out, within medicine, a teacher’s credibility is seen to depend more on their personal clinical skills than their teaching ability. This is a stark contrast to music, where teachers’ instructional skills are perceived as paramount, and their own performance proficiency is seen as a more secondary concern. Despite this perception, however, both medical and musical students acknowledged that teaching ability was of profound importance; and—as such—the ideal situation was to have a teacher who was both an apt clinician and an effective teacher.

McCann et al conducted a large survey of senior medical officers (SMOs) within the Auckland region, focusing on the role of ‘doctor as teacher’. His group acknowledged the lack of preparedness of senior clinicians in New Zealand for their teaching and supervisor roles: “the role of SMOs as teachers and supervisors is vitally important to the continued practice of medicine and to the training of the future medical workforce … In all of the categories surveyed (ie, teaching, supervision and feedback) there was a statistically significant difference between the SMOs’ self-rated competence and the perceived competence required to perform the job (p<0.0001). In other words, SMOs feel inadequately prepared to fulfil their role as teachers”. His group suggested this was a potential source of significant job dissatisfaction for senior clinicians, notwithstanding its impact on the quality of the educational experience provided to students and junior doctors.

While there are professional development opportunities for senior clinicians which focus specifically on the skills of supervision and teaching, these sessions are often brief and relatively infrequent. Tertiary institutions have increasingly recognised the need to bolster health education teaching—the Centre for Medical and Health Sciences Education at the University of Auckland, for example, focuses specifically on the area. The centre offers both formal postgraduate qualifications in medical education and more practical “teach the teacher support” for those in primarily-clinical roles. Many specialist vocational colleges also require supervisor attendance at professional development workshops. McCann et al, however, note that educational fixtures of this type are often most attended by clinicians who have formal university affiliation, which is actually a minority of those providing day-to-day supervision.

Lack of continuity

Another unique aspect of the medical apprenticeship model is its inherent lack of continuity. It is, of course, vital that students and junior doctors gain exposure to (and proficiency across) a number of subspecialties, but this inevitably results in a string of short clinical attachments under different supervisors. There is very little long-term
continuity of supervision, which makes it difficult to establish trusting teacher-learner relationships.

Interestingly, many of the musical students surveyed by Watling’s group felt that the continuity of their relationship with their teachers was central to meaningful and effective feedback: “the longitudinal relationship with the music teacher facilitated the perception of feedback as not only accurate and well-informed, but also firmly well-intentioned. Within such trusting relationships, feedback could be more direct, more critical and at times harsher, while remaining influential”. Medical students, whose supervisor relationships were necessarily much shorter-term, described receiving feedback that was more superficial and felt easier to discard. This feedback was “less likely to be perceived as credible and thus less likely to be accepted and acted upon.”

This issue has been acknowledged among medical educationalists: the University of Auckland, for example, has moved in recent years to a ‘cohorting’ system, which attempts to retain undergraduate medical students within the same institution for an entire year of the medical programme. This, it is hoped, helps to mitigate the detrimental impact of constant transitioning and may allow students to develop longer-lasting and more meaningful relationships with key senior clinicians. However, the system is more effective in small institutions than in larger ones, where continuity is often still minimal. Expanding medical student numbers also present an ongoing logistical challenge.

For junior doctors, educational continuity remains an issue after graduation. Recent industrial action, for example, was a major threat to educational quality and stability. The changes to working conditions mandated in the new Multi Employer Collective Agreement (MECA) settlement present a further challenge to the apprenticeship model, and are likely to further fragment educational exposures. International comparisons are apt here: after work time restrictions laid down in the European Working Time Directive were rolled out in the UK, limiting rostered hours, multiple workplace surveys assessed the impact on junior doctor education. A literature review for the General Medical Council in Britain in August 2012 concluded that “doctors’ perceptions of the educational impact of restrictions are largely negative.” The negative sentiment was shared by junior doctors and consultants, with issues including missed clinical and surgical experience, reduced exposure to managing emergencies, missed teaching sessions, less ability to follow a patient from admission to discharge, and more general cultural issues such as an absence of teamwork and feelings of less support. The majority of those surveyed felt the more fragmented hours had adversely impacted on the delivery of training.

Dual roles: supervisor and assessor

The dual role of many clinical supervisors as both tutor and assessor is another uniquely medical idiosyncrasy. In most medical student attachments, and in the supervised intern years post-qualification, the senior clinician providing daily tutelage and feedback to the trainee is the precise same individual who will ultimately decide on their definitive assessment grade. This arrangement may dissuade students from openness and curiosity, creating a sense of ‘distance’ and ‘formality’. The assessment grade becomes the focus, unintentionally detracting from the quality of the educational experience.

Mentorship

Many of the issues discussed here (a lack of supervisor continuity and the supervisor/assessor dichotomy) may be difficult to change at a structural level. As such, many have suggested that the succession of clinical supervisors should ideally be supplemented by a longitudinal, more objective relationship with a separate medical ‘mentor’. Fraser provides interesting perspective on the subject, with reference to the historical evolution of medical education and emphasis on the concept of mentorship. His 2004 piece points out that the original medical apprenticeship model was a simple dyad, with a supervisor and his apprentice working together over years. In this context, the supervisor could comfortably assume a mentorship role too. Over time, however, medical training “has moved further away from the traditional apprentice model by focusing very intensely on the acquisition...
of knowledge ... the satisfaction of the training requirements is largely time-based, although a succession of supervisors affirm that the trainee has performed to an at least adequate standard".9

The dynamic of an effective modern mentoring relationship, then, should be very different to the serial supervisor relationships: it should be parallel to, and uncoupled from, performance expectations or fear of assessment. “Mentorship ... is characterised by an intense and global nature, extending over a long time. It covers both professional and personal issues and is aimed at the mentored person’s development, with the mentor having the best interests of the mentored person at heart”.9

In some fields, this sort of relationship is culturally sanctioned (or indeed mandatory). For example, most clinical psychologists and psychiatrists are encouraged to work under lifelong ‘supervision’ (a relationship that, despite its name, is actually much more akin to mentorship). A relationship of this description is accepted as essential—for the professional development and clinical competency of the clinician, but also for their personal and pastoral health: “supervision is proposed as a core competency area in psychology for which a number of elements reflecting specific knowledge, skills and values must be addressed to ensure adequate training and professional development of the trainee ... professional development is a lifelong, cumulative process requiring attention to diversity in all its forms, as well as legal and ethical issues, personal and professional factors, and self- and peer-assessment”.10

In most areas of medicine, however, there is no such expectation, nor any set mentoring framework. As such, mentors are often acquired relatively ‘organically’: “informal mentoring relationships ... develop during training, as the trainee identifies a senior whose practice he/she wishes to emulate”.9 Because of this relatively opportunistic route, then; not every trainee is lucky enough to develop such a connection.

Service load
A final key limitation to the apprenticeship model (and again, one fairly unique to medicine) is the ongoing and inevitable tension between service provision and education. When time is in short supply, service delivery and patient care necessarily take absolute priority over teaching. This conflict can be difficult to navigate even when resources are plentiful, but the reality of clinical medicine in New Zealand’s public hospitals is very different, and clinicians often work (and attempt to teach) in environments which may be thinly-staffed and time-pressured. Recent increases to medical student and RMO numbers have attempted to fill workforce gaps, but have not been matched by proportional increases in SMO positions, further eroding the viability of an effective apprenticeship model.

Jaye et al11 conducted a 2009 observational study of the teaching environment for medical students on surgical ward rounds in Dunedin. They combined direct observation of rounds with medical student interviews, and noted that “high patient volume and throughput can result in decreased learning activities ... If students feel they are in the way or a nuisance, opportunities to practice clinical skills and professionalism will not be taken up”. McCann et al6 show that these concerns are shared at SMO level: “results showed that a number of SMOs reported a ‘lack of time’ or ‘clinical workload’ as the greatest impediment or barrier to teaching RMOs in the workplace”.

Central to this tension, of course, is the fact that New Zealand’s DHBs routinely issue mandates that focus exclusively on service delivery. Their key performance indicators weigh patient experience against financial bottom lines and do not overtly place priority on clinician education; an approach which seems overwhelmingly near-sighted. McCann and colleagues suggest that “possible strategies to overcome these impediments would be appropriate job sizing for consultants, protected teaching time built into contracts, protected time to attend training courses and seminars, as well as specific in-house courses to assist with management and supervision of RMOs. These strategies would be in keeping with trends in international institutions.”6 His group also points out that many SMOs surveyed felt their role as teachers and supervisors was often overlooked, and that a more general cultural shift towards increased interest and recognition of the importance of teaching is required.
Potential solutions

While it is the universally accepted model for the education of medical students and junior doctors, an apprenticeship-style training programme has several key vulnerabilities when applied to medicine. Many doctor-teachers have minimal or no formal educational training, and are often valued primarily on the basis of clinical acumen and experience (which is not always positively correlated with teaching ability). In addition, consistent attachment transitions result in a lack of supervisor continuity, and the dual role of many supervisors as both teacher and assessor can be detrimental to educational experience. Finally, the constant tension between service delivery and time to teach is a major issue, and is perceived as problematic by both teachers and learners.

Solutions for these issues are not straightforward. However, strong clinical mentorship and a culture which emphasises and values mentor relationships (as relationships distinct from instruction and assessment) is vital. Strong objective mentors help to ‘unload’ the clinical attachment supervisor, who—in many cases—is expected to be instructor, assessor, supervisor and pastoral carer all in one. Mentoring helps to circumvent the issues with discontinuity of supervision, and allows feedback to be given within a more trusting framework. While some junior doctors ‘naturally’ find such an individual, this is not guaranteed, and structured networking and mentorship programmes may be invaluable in the establishment of such connections. We may even begin to create a cultural ‘expectation’ of such a relationship, following precedents set by the fields of clinical colleagues in psychology and psychiatry.

As medical student numbers expand, an increased focus on alternatives to apprenticeship is also important. Simulation-based medical education (SBME), for example, is gaining increased credibility as a learning tool; and many medical educational institutions now integrate intensive clinical simulation sessions into the curriculum alongside more traditional ward-based apprentice training and didactic teaching. These are run in high-fidelity environments, and may incorporate interactive mannequins or trained medical actors. They can be multi-disciplinary (the WardSim programme at the University of Auckland, for example, trains medical students alongside colleagues from the nursing and pharmacy). Such initiatives are a valuable adjunct to traditional, apprenticeship-style teaching: “Simulation-based medical education is one of many educational approaches that is used most powerfully and effectively to achieve learning objectives in concert with other educational methods. It complements clinical education but cannot substitute for training grounded in patient care in real clinical settings.”

In addition, a cultural shift toward increased recognition of the doctor-as-teacher role is well overdue. A systems solution is required, and would need buy-in from the service delivery sector as well as traditional educational and academic institutions. Doctors at all stages of training should be given at least basic training in the art of teaching, supervision and feedback delivery. For the most established and senior members of our medical communities, more comprehensive formal training in teaching and supervision should be mandatory. This may require express changes to guidelines and requirements for clinical educational supervisors within university teaching networks, the prevocational supervision programme and vocational colleges.

Workshops and training days are one aspect of this, but additional measures could include incentivising teaching, providing appropriate leave entitlements and remuneration, and creating clearly ring-fenced teaching roles within hospital environments. (‘Non-clinical hours’ within DHB contracts for senior medical officers are currently nebulously defined, and may be used for administration, research or private sector work well ahead of teaching. More explicit, and appropriately remunerated, protected teaching time is required.)

Educational opportunities should not be offered exclusively to SMOs, but to junior doctors too: fostering strong future teachers is also critical to the future of medical education, and medical students often learn best from junior members of the medical
workforce, whom they may find it easier to relate to.

More structured opportunities for supervision are also important. The New Zealand Curriculum Framework for prevocational medical training has recently moved to a new ePortfolio system, which provides a defined list of clinical competencies and requires maintenance of a sustained supervisory relationship. Importantly, this curriculum accommodates community-based attachments, allowing RMOs to be directly supervised in general practice settings and extending the apprenticeship model beyond hospital-based medicine.

Conclusion

Medical apprenticeship follows a time-honoured tradition, dating back to the Hippocratic Oath era. However, its application to modern medicine is imperfect: thinly-resourced health systems create conflicts between service delivery and dedicated teaching time, short clinical attachments threaten quality longitudinal relationships between teacher and learner, and the value of mentorship is often overlooked. There is a need for structural change, which places increased emphasis on ‘teaching the teacher’, which formally recognises the importance of dedicated teaching and incentivises it accordingly, and which provides structured opportunities for clinical mentor relationships. Addressing key vulnerabilities in the prevailing apprentice model, and adjusting this model to keep pace with the changing face of healthcare delivery, is essential for the future of medical education.

Competing interests:
Nil.

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Unusual cause of dilated cardiomyopathy in an adolescent girl
Shilanjan Roy, Biswajit Majumder, Sankar Paulchowdhury

Dilated cardiomyopathy (DCM) is one of the cardiomyopathies where left ventricular (LV) or right ventricular systolic pump function of the heart is impaired with progressive cardiac enlargement and hypertrophy. About one-third of cases of congestive heart failure (CHF) is due to DCM.

Takayasu's arteritis (also known as 'aortic arch syndrome' and the 'pulseless disease') is a form of granulomatous vasculitis involving mainly the aorta and its branches, which causes extensive intimal fibrosis and narrowing of arteries. Females are 8–9 times more affected than males. Due to obstruction of the main branches of the aorta, Takayasu's arteritis can present as pulseless upper extremities. Renal arteries are also involved.

In India, Takayasu's arteritis as cause of renovascular hypertension is reported in 28–75% cases. DCM per se, however, is reported in only 5–6% of cases of Takayasu's arteritis.

Case report
A 13-year-old female child presented with complaints of severe shortness of breath, weakness, pedal swelling and low-grade fever since last seven days. The complaints were of six months duration with a recent increase in severity of symptoms.

On examination she was thin built, febrile with temperature 100°F, dyspnoea grade 4 (New York Heart association grading), and pulse 110/min in left radial artery, regular in rate and rhythm, BP 110/64mmHg in left arm in supine position.

Right upper limb pulsations were absent. There was no radiofemoral delay. Pulsations were feeble in bilateral femoral, popliteal, and dorsalis pedis arteries. Jugular venous pressure was raised.

Heart sounds were normal with LV S3. A systolic murmur at the left sternal edge, with inspiratory accentuation was audible.

On respiratory system examination, bilateral crepitations extending up to lung apex (killip class 4) were present.

Right carotid pulsation was feeble in comparison to left carotid pulsations while abdominal aortic pulsations could not be felt. Bruit was audible over abdomen.

Abdomen—tender hepatomegaly (Liver span 16cm) CNS and other system examinations were normal. Fundus was normal.

A clinical diagnosis of DCMP with biventricular failure due to aortoarteritis was made.

Investigations
Blood sugar fasting-80mg/dl, Creatinine-0.6mg/dl, Haemoglobin-10.5g/dl, ESR-90mm first hour, TLC-7900, N55L34, Mantoux test was negative, ASO titre-123(<200), CK-MB-16, Total bili 1.7, albumin-3.3, SGPT-39, SGOT-47, CRP-16.6 (high), RA factor-5.4(<15).

ANA, anti-ds DNA, p ANCA and c ANCA were negative.

PA chest radiograph—enlarged cardiac shadow, with diffuse alveolar shadows consistent with pulmonary edema (Figure 1).
ECG showed sinus tachycardia with left ventricular hypertrophy, Left axis deviation, left atrial enlargement and prominent p-waves.

Ultrasonography whole abdomen—mild hepatomegaly with normal size kidneys, mild ascitis.

2D Echocardiography (M mode) showed dilated cardiography, with severe left ventricular systolic dysfunction, LVIDD -56, LVIDS-52, ejection fraction–16%, moderate mitral regurgitation and severe tricuspid regurgitation (Figure 2).

Color arterial Doppler of right upper extremity showed monophasic flow noted in subclavian artery with narrowing of right subclavian artery. Monophasic flow noted distally in axillary, brachial, radial and ulnar artery.

The peak flow velocities are reduced. Findings are suggestive of obstruction in the aortic arch region.

MDCT scan of Aortic arch and thoracic and abdominal aorta shows NO significant stenosis or dilatation seen in aortic arch or ascending thoracic aorta. Descending thoracic aorta and abdominal aorta shows long segmental areas of diffuse luminal narrowing and associated concentric wall thickening. Left subclavian artery and left axillary artery shows diffuse luminal narrowing with non-visualisation (cut off) of luminogram in distal two-thirds of right subclavian and right axillary artery.

Segmental concentric wall thickening with associated luminal narrowing seen in both renal arteries with mild post-stenotic dilatation further s/o aortoarteritis (Figure 3).

Incidentally, all four chambers were dilated, ie, DCMP with dilated MPA (main pulmonary artery) (Figure 4).
Figure 2: Echo Doppler study showing dilated all four chambers of heart with poor contractile function.
Figure 3: MDCT angio of thoracic and abdominal aorta shows diffuse luminal narrowing involving renal arteries.

Figure 4: MDCT scan showing dilatation of all four chambers (DCM) including main pulmonary artery.

Discussion

Exact pathogenesis of the Indian origin aortoarteritis is still unclear, tuberculosis, streptococcal infections, rheumatoid arthritis and other collagen vascular diseases have been attributed as its etiology in the past. Recently, more emphasis has been given on an immunopathological cause.3,4

The primary presentation of Takayasu’s arteritis as DCM with biventricular failure is rarely reported and may be due to inflammatory process directly involving the myocardium, coronary arteries or severe hypertension secondary to renovascular involvement.5,6

Therapeutic modalities include steroids and immunosuppressive agents. Cyclophosphamide and methotrexate are often needed to control intense inflammatory response. In addition, balloon dilatation or stenting is often necessary. Drug therapy can slow down progression of cardiomyopathy and in some cases even improve the heart condition.

Conclusion

With this case report, we want to emphasise that the young female patient with heart failure, dilated cardiomyopathy and/or hypertension, renal failure should be screened for systemic vasculitis, as it is potentially correctible with timely immunosuppressive treatment.
Competing interests:
Nil.

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Sweet rebellion: a campaign for a sugar-sweetened beverage tax in New Zealand

Tiffany Parmenter, Charlotte Jordan, Ishika Jayasinghe

In June this year, as part of our undergraduate medical training, we were asked to devise a public health programme to improve the obesogenic environment in New Zealand. Our team interviewed several stakeholders, and reviewed the scientific evidence relating to potential programmes. Through the week, we developed a strategy to garner political and public support for a sugary drinks tax. We were inspired by the project and decided to seek philanthropic funding to make this project a reality. This letter outlines our reasons for choosing this programme and the resources we seek to get it off the ground.

In recent decades, increasing obesity prevalence has become a major public health issue.1 In New Zealand, 10.7% of 2–14 year-olds are considered obese.2 Moreover, there are significant ethnic and socioeconomic disparities in obesity rates, with 14.7% of Māori and 29.8% of Pacific children aged 2–14 years classified as obese.2 The singular focus of the Government’s Child Obesity Plan (ChOP) is on lifestyle behavioural change at the individual level.3 For this reason, we believe it is unlikely to work. Sustainable change is more likely to succeed when a broader synergistic package of population-level, settings-based and individual-level interventions is adopted.4

According to the World Health Organization’s Commission on Ending Childhood Obesity,1 this should include the regulation and taxation of obesogenic beverages. Acknowledging this, we propose to lobby for a sugary drinks tax. A number of our community and non-government organisations we spoke to supported this idea, but were unable to do so publicly due to financial dependence on government or private companies with conflicting financial interests.

Sugary drink intake is now widely recognised as an important cause of childhood obesity. Sugar drinks are a uniquely harmful product because of their contribution to increased energy intake, their limited nutritional value and because they bypass food intake regulatory systems.4 The high sucrose and fructose content of such drinks is also linked with a range of important health and metabolic disorders, such as diabetes, raised blood pressure, gout, dental caries as well as weight gain.5

Sugary drinks taxes implemented in other parts of the world have led to reduced purchasing and intake of the targeted products. In 2014, Mexico imposed a 10% tax on sugary drinks as part of a wide-ranging strategy to combat obesity. The first evaluation of its effects reported a higher than expected drop in intake of sugary drinks, while intake of untaxed drinks, mainly bottled water, rose.6 The changes were greatest in poorer households and accelerated over time. Similar results followed policy change in several other countries, including France, Denmark, Hungary and Ireland. In New Zealand, an important consideration is whether or not the public support such a policy. A recent New Zealand Herald poll reported 83% support for a sugary beverage tax from 11,700 respondents,7 suggesting that such a strategy has potential for success.

Social media campaigning was cost effective in similar campaigns overseas.8 In New Zealand, 88% of people aged 10 years or older use the internet at least weekly, and 88% access social media.9 However, a social media campaign alone is unlikely to be sufficient.8 Thus, our strategy will also directly lobby for policy change and will involve collaborating with health organisations.
We propose a focused short-term campaign that will take place in the lead up to the New Zealand election. This is a particularly sensitive time for political activity, given the potential for government change. The campaign will operate with input from the established Fighting Sugar in Softdrinks (FIZZ) group and consists of two approaches: one aimed at convincing policy makers and organisations, and another aimed at raising awareness with the general public.

**Policy makers and health organisations**

This will involve lobbying:

1. Politicians and policy makers to get a sugary drinks tax on the agenda in the run up to the New Zealand election.
2. Health organisations and professionals to build collaborative effort and support in this area. Recent work has suggested an important role for health professionals in reducing SSB consumption and childhood obesity.10

**General public**

This will primarily involve a social media-based marketing campaign. We intend to:

1. Drive social media campaigns aiming to:
   a. Raise awareness and gain support among key target population segments through social media marketing/competitions.
   b. Gain signatures for a citizens-initiated referendum to force the issue into the political forum.
2. Develop relationships with public personalities who endorse the campaign. As an example, Dame Tariana Turia and Nigel Latta have already expressed support.
3. Generate visibility of our campaign through a variety of print and internet media sources.

Two individuals could conduct this work, each working full time, for the equivalent of one full-time equivalent salary (approximately NZ$60,000 for the next three months, including the weeks leading up to and following the September election).

We believe that a sugary drinks tax is among the most effective interventions to address the burden of obesity in this country. Many other countries and regions have decided to adopt such a strategy, and the timing of this election raises the impetus for focused action to elevate the issue in the minds of politicians and the voting public.

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**Competing interests:**

Nil.

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Response to—Orbital fractures treated in Auckland from 2010–2015: review of patient outcomes

Prue Baxter

I compliment Lanit Anand and Christopher Sealey on their most interesting paper and agree with their conclusion that titanium is a very well-tolerated material for orbital reconstruction. I note that commercially available plates or cut-to-fit mesh were used in their study. I first used custom-made titanium plates in 2003–3 and they are now used for the vast majority of patients having orbital reconstruction in the regional oral and maxillofacial unit in Swansea, Wales. Bespoke titanium plates decrease theatre time and facilitate accurate reconstruction. Now that the technology to make 3D models from CT scans is more widely available, I was wondering if the authors are considering moving on to use custom-made plates in the future?

Competing interests:
Nil.

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REFERENCES:
Response to—Better organ donation education

James Judson, Stephen Streat

We were dismayed to read the letter Better organ donation education by sociologist Rhonda Shaw in the 7 July 2017 issue of New Zealand Medical Journal. It is muddled, ill-informed and perpetuates misunderstanding about organ donation in New Zealand.

Firstly, it muddles deceased organ donation with live organ donation. These are entirely different donation scenarios with different frameworks for informed consent. In the case of deceased donation, the New Zealand Human Tissue Act specifically requires informed consent by family before organs can be removed for the purpose of transplantation, and specifically states that a yes or a no on the driver licence is neither informed consent nor informed objection. The driver licence therefore has no legal status at all in New Zealand.

At the time of seeking a licence, New Zealanders are required to answer yes or no to the question “Would you be willing to donate organs in the event of your death?” and the NZTA website explains that “Ticking the ‘Yes’ box on your driver licence form only means that you have indicated your wish to be identified as an organ and tissue donor...it does not automatically mean that your organs or tissues will be donated in the event of your death...in practice, your family will always be asked for their agreement to organ and tissue donation.”

The website cannot allow for discussion, clarification, asking specific questions or having them answered by someone who truly knows the answers. It only refers to a hypothetical situation. Fewer than 1% of New Zealanders die in circumstances where organ donation is a realistic possibility. The provision of further educational material about a hypothetical situation which will usually never occur cannot lead to informed decision-making in the real situation.

When people do end up in a real situation where donation after brain death or donation after circulatory death are realistic options, it will be in an ICU and the issues will be discussed with their family at that time by ICU staff with the necessary knowledge, skill and experience. Staff in all 24 New Zealand ICUs are well aware of organ donation processes, and ODNZ senior nursing and medical staff are available 24 hours a day to support them according to their needs at the time of every potential donation.

The Ministry of Health may well have recently stated expansion of donation after circulatory death as a strategic priority, but it does not itself have the knowledge, staff or expertise to do this. ODNZ already has that responsibility through its contract with the Ministry of Health. It is already promoting donation after circulatory death in the ICUs, along with other quality improvement initiatives, and is currently seeing an increase in organ donation in New Zealand for the fourth consecutive year as a result of those initiatives. It will continue to do so unless and until the Ministry changes the contract.

The current contract requires ODNZ to provide accurate information about organ donation to the New Zealand public. With that in mind, we need to point out that:

1. DCD is the abbreviation for donation after circulatory (not cardiac) death.
2. DBD is an abbreviation for donation after brain (not brain stem) death.
3. DCD has not been reintroduced; it was introduced in New Zealand by ODNZ in 2008.
4. DBD and DCD are not ‘menu’ options for people to choose from; they apply in different types of situations.
5. Shaw’s second reference applies to donation after euthanasia, which is not practised in New Zealand.
6. The Ministry of Health Review was released in 2017 not 2016.
Competing interests: Nil.

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URL:
Bowel cancer screening

Lindsay Robertson, Garath Roberts, Trisha Cooney, Peter Krijger, Rachel Holdaway, Sue Crengle, Sarah Derrett

Bowel cancer continues to be a leading cause of mortality and morbidity in New Zealand. Around 3,000 new cases of bowel cancer are diagnosed in New Zealand each year. Bowel cancer has the second highest cancer mortality rate in New Zealand, and is the cause of over 1,200 deaths annually; 1,252 deaths in 2013.

The stage of bowel cancer at diagnosis is the most important determinant of prognosis. Screening programmes are a crucial part of any programme aimed at reducing the impact of bowel cancer. They help detect cancers at an earlier and more treatable stage, and can also prevent cancers entirely through polypectomy. After years of advocating for a national bowel screening programme, Bowel Cancer New Zealand welcomed the Government’s announcement earlier in 2016 to implement a national screening programme. As details of the proposed programme emerge, Gandhi and colleagues have appropriately pointed out that the question has shifted to how and who we should screen.

The Waitemata DHB Bowel Screening Pilot Programme included people aged 50–74 years, screened with faecal immunochemical tests (FIT) at two-yearly intervals. However, the national programme will only be available to people aged 60–74 years as it rolls out. This is a concern for various reasons.

Firstly, New Zealand has a higher proportion of patients diagnosed with metastatic (stage IV) colon cancer (24%) and rectal cancer (19%) than both Australia (19% and 17% respectively) and the UK (17% for both cancers). Secondly, provisional cancer registration data indicates that of 9,513 new diagnoses of bowel cancer in 2013–2015, 39% occurred in individuals aged 60–74; and 12% occurred in people aged 50–59 years. In 2014 alone, there were 120 deaths from bowel cancer in the 50–59 year age group. In view of these statistics, and the fact that screening has the potential to shift the stage at diagnosis, we urge planning for New Zealand’s national bowel cancer screening programme to include people aged 50–59 years.

A further justification for extending the eligible screening age is the Government’s commitment to reducing inequities in outcomes between Māori or Pacific people and non-Māori/non-Pacific people. While 12% of all bowel cancer occurs in people aged 50–59 years, among Māori diagnosed with bowel cancer the proportion in the 50–59 year age group is 22%, and among Pacific people the proportion is also high. Māori and Pacific New Zealanders are younger at time of bowel cancer diagnosis, yet they are also more likely to be diagnosed with stage III or stage IV cancer. Restricting the screening programme to people aged 60–74 years is inconsistent with the Government’s aim of reducing inequity in bowel cancer outcomes between different ethnic groups.

A recent study summarising international bowel cancer screening programmes indicates that the many organised, population-based, colorectal screening programmes across the globe begin screening from age 50. We are told by representatives of the Ministry of Health’s Bowel Cancer Working Group that ‘hard calls’ are required in New Zealand’s screening programme as our DHBs do not have the colonoscopy workforce to cope with the projected volume of colonoscopies required after positive FIT screening test results. Initiatives to address this workforce shortfall have repeatedly stalled, and too little has been done to address the problem.

Given that New Zealand has among the highest incidence of bowel cancer worldwide and poorer survival outcomes compared to Australia, we believe plans to properly resource New Zealand’s DHBs and to extend the national programme to those aged 50–59 years are required urgently. To address known inequities, Māori and Pacific people in the 50–59 year age range should be eligible for inclusion in the screening programme now.
Competing interests:
Nil.

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REFERENCES:
Bioresorbable scaffolds versus metallic stents in the treatment of coronary artery disease?

Drug-eluting stents are the standard of care in percutaneous coronary intervention (PCI). Stent thrombosis can occur when the stent has a rigid metallic scaffold. The question evaluated in this study is whether stents with a bioresorbable scaffold would be better.

In this study in the Netherlands, 1,845 patients were randomly assigned to be treated with a bioresorbable stent or a metallic stent.

At follow-up the researchers report that there was no significant difference in the rate of target-vessel failure between the patients who received a bioresorbable scaffold and the patients who received a metallic stent. The bioresorbable scaffold was associated with a higher incidence of device thrombosis than the metallic stent through two years of follow-up.


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Target blood pressure in patients at high cardiovascular risk

Guidelines recommend a blood pressure target of less than 140/90mmHg to reduce cardiovascular events but the degree to which blood pressure should be lowered to achieve the lowest risk of cardiovascular disease events is unknown.

In this report the authors throw some light on this issue. They review data from two trials involving high-risk patients aged 55 years or older with a history of cardiovascular disease, 70% of whom had hypertension. Approximately 40,000 patients from 733 centres in 40 countries were included and followed up for a median of 56 months.

The authors report that their study suggests that reduction of systolic blood pressure to less than 120mmHg or diastolic blood pressure to less than 70mmHg is associated with an increase in cardiovascular death and all-cause death events, and with no reduction in myocardial infarction or stroke. In high-risk patients, a target blood pressure of 120–130mmHg systolic and 70–80mmHg diastolic is associated with lowest rates of cardiovascular disease events.

*Lancet* 2017; 389:2226–37

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Trial of minocycline in a clinically isolated syndrome of multiple sclerosis

After a first focal clinical demyelinating event (also called a clinically isolated syndrome), the risk of conversion to multiple sclerosis is high.

Minocycline has immune-modulating properties. Its use may lower the risk of such a conversion. In this trial, 142 eligible patients were randomised to receive either minocycline or placebo as treatment.

The risk of conversion from a clinically isolated syndrome to multiple sclerosis was significantly lower with minocycline than with placebo over six months but not over 24 months. There were significantly more adverse effects in the minocycline cohort.

*N Engl J Med* 2017; 376:2122–33

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**URL:**

In severe cases of Dupuytren's contraction, certainly when the affected digits are rigidly bent into the palm, the operations in vogue are disappointing. Whether the surgeon divides or excises the palmar fascia he cannot straighten the contracted finger by manual force, still less can he trust to splint-pressure, however prolonged. The reason generally assigned is consecutive contraction of the flexor tendons. These have often been divided in the vain hope of overcoming the resistance. But it is easy to prove that the fault does not lie in the tendons, for full flexion of the wrist or metacarpo-phalangeal joints makes no difference.

Intra-articular adhesions in the metacarpo-phalangeal and interphalangeal joints of the contracted fingers might be invoked as the cause of the resistance, especially by those who see a close relation between this condition and gout or rheumatism. The idea of the existence of these adhesions is also favoured by the grave danger of stiffening of the fingers during the splint-treatment ordinarily pursued after operation. But the X-rays show a perfectly smooth articular surface in the joints. The cause of the resistance is as follows:—Owing to the second phalanx being extremely flexed so that its base is pressed against the neck of the first phalanx, and owing to this position being kept up during many months or years, the glenoid ligament in front of this joint, as well as the lateral ligaments, become shortened and incapable of extension.

The only way to overcome this obstacle is to excise the head of the first phalanx. This is done as follows:—

1. Through a palmar incision the bands of contracted and thickened fascia are dissected out, including their prolongations in front of the first phalanx. The palmar wound or wounds are closed with the finest black silk-worm-gut. The finger still remains flexed at the first interphalangeal joint.

2. The hand is turned over so that the dorsal surface is uppermost, a semilunar incision is made over the first interphalangeal joint, the extensor tendon divided, the head of the first phalanx cleared to its neck, the latter cut across and the head dissected out.

3. The extensor tendon is slightly shortened and its two ends united, preferably with fine kangaroo tendon or Japanese silk, and the small dorsal incision is then sewn up. The finger should now become perfectly straight (or nearly so) without any tension whatever.

4. No splint is required in the after-treatment, the gauze dressing is a sufficient support; gentle active and passive movements should be resorted to within the first few days. No digit should be allowed to stiffen. The prolonged and irksome splinting usually resorted to has been responsible for many stiff fingers and hands following the orthodox operations. It is to some extent also responsible for the tendency after them to recurrence of the contraction.—J. Hutchinson, "Lancet," Feb., 1917.
The proceedings of the 238th meeting of the OMSRS

10 May 2017

Investigating early genetic regulators of sex change in labrid fish

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Sexual fate is highly labile, arising from an ongoing battle for dominance between antagonistic feminising and masculinising gene networks. Numerous human disorders of sexual development (DSDs) result from imbalances in these systems, affecting one in 5,500 live births. However, few useful models of DSDs exist. Fishes that exploit the developmental lability of sexual plasticity in other sex-changing species, their expression patterns are currently being measured in New Zealand spotty (Notolabrus celidotus) and Japanese kyusen wrasse (Paralabrus poecilepterus). Understanding the molecular mechanisms underlying sexual plasticity in fish, specifically the early regulators of sex change, is a means to understanding the function, and dysfunction (ie, human DSDs) of vertebrate sexual development.

Supported by an Otago School of Medical Sciences Summer Studentship.

A new peripheral blood test for HPV to predict perinatal disease

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Human papillomavirus (HPV) is intimately involved in the pathogenesis of cervical cancer. More recently, HPV has been found in a significant proportion of placenta associated with pregnancy complications, such as pre-eclampsia. Previous studies have only been able to detect HPV after birth, thus developing a non-invasive, antenatal diagnostic test to detect HPV during pregnancy is required. The goal of this research was to develop a quantitative PCR (qPCR) based method to detect HPV in blood samples.

Seventeen placentas and the corresponding placental maternal space (predicted to be concentrated for HPV DNA) and peripheral (target sample type) blood samples were collected over eight weeks from pregnant women with complicated preganacies who delivered in the southern DHB area. Immunohistochemistry (IHC) was used to detect HPV in placental tissues. DNA was extracted from blood using the Qiagen DNA Mini kit using a modified protocol to increase viral yield. A published qPCR method using SYBR Green was used to detect HPV. PCR products were separated onto agarose gels to ensure the correct sized products were present and sent for Sanger sequencing to confirm the presence of HPV DNA.

Eighty-eight percent of placental samples were positive for HPV by IHC (N=15/17). All blood samples from HPV-positive placenta showed amplified DNA using qPCR. Agarose gel electrophoresis confirmed the correct sized product was present in three samples. Non-specific PCR products were present in all samples. Sequencing confirmed the presence of HPV DNA in three samples and showed that the other PCR products were from human DNA. In conclusion, HPV could be detected in blood samples from pregnant women with preeclampsia.
Further assay development is required to avoid non-specific PCR products and determine whether HPV DNA can be identified earlier in pregnancy.

Supported by an Otago Medical School summer studentship.

Cytotoxicity of second-generation curcumin analogues in human lung adenocarcinoma cell lines

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Lung cancer accounts for the highest incidence in cancer mortality worldwide. Non-small cell lung carcinomas make up around 85% of all cases and of this around 40% are adenocarcinomas, which is the most common type found in non-smokers. Adenocarcinomas usually occur through mutations such as the anaplastic lymphoma kinase (ALK) mutation, which is found in around 8% of cases. Crizotinib is currently the leading drug treatment for ALK-positive patients, however, resistance usually occurs after one year of treatment. Therefore, novel cytotoxic drugs are needed to overcome this resistance and enhance survival rates. This study investigated whether orally available curcumin derivatives (RL66 and RL118) elicit cytotoxicity in ALK negative (A549) and ALK-positive (H3122) lung cancer cell lines.

Cell viability was examined using the sulforhodamine B assay, in which A549 and H3122 cells were exposed to increasing concentrations of curcumin (0–40µM), RL66 (0–10µM) and RL118 (0–10µM) for 72 hours. Cells were then fixed, stained with sulforhodamine B and absorbance (510nm) read on a spectrophotometer. The absorbance was converted to cell number using a standard curve for each cell line. Data was normalised and analysed by non-linear regression to calculate the concentration, at which there was 50% cell viability (EC50).

In the ALK-negative A549 cells the EC50 values were 6.1, 2.5 and 1.1µM for curcumin, RL66 and RL118 respectively. The ALK-positive H3122 cells were more sensitive to the compounds compared to the A549 cells with EC50 values of 5.3, 0.55 and 0.44µM for curcumin, RL66 and RL118 respectively. To determine if the drugs induced apoptosis, Western blots were performed examining cleaved caspase-3, however, the results were inconclusive.

These results show that curcumin decreases cell viability in lung cancer cell lines. The cells are more sensitive to the novel orally available curcumin derivatives RL66 and RL118. These analogues are also more strongly cytotoxic towards the more difficult to treat ALK-positive cell line H3122, suggesting that curcumin derivatives may be a promising line of enquiry for treatment-resistant ALK-positive lung cancers.

Supported by a Summer Studentship from the Department of Pharmacology and Toxicology, the Prestigious Fred Fastier Scholarship.

Determining sexually dimorphic changes in CRH neural network activity Induced by Stress Hormones

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Stress is involved in maintaining homeostasis, and thus survival of an organism. Although stress is necessary for survival, chronic stress can become pathological and is involved in the onset of numerous neuropsychiatric disorders. Corticotropin-releasing hormone (CRH) neurons are the central controllers of the stress response, therefore, this study investigated how chronically elevated corticosterone (CORT), a model of chronic stress, would affect CRH neuronal activity in male and female mice.

Mice (Crh-ires-cre;Ai95Dm+) expressing the genetically-encoded calcium indicator, GCaMP6f, specifically in CRH neurons were given CORT (25mg/mL) or vehicle (0.25% ethanol) in the drinking water for 14 days. Mice were then euthanised and calcium imaging performed on live brain slices. To stimulate electrical activity, noradrenaline (10µM) was applied in the bath. Activity of CRH neurons was analysed and compared between the CORT-treated and vehicle-treated males and females.

It was found that mean (± SEM) active cells per slice from CORT-treated mice (1.111±0.279; N=18 slices, six animals) was significantly lower (p<0.0001, unpaired t-test) than from vehicle-treated mice (4.538±0.462; N=13 slices, five animals). Average number of bursts per recording, average burst amplitude and average burst half-width were not significantly different between CORT-treated mice and vehicle-treated mice (P>0.05, unpaired t-test). Mean (±SEM) active cells per slice from CORT-treated female mice (2.200±0.374; N=5 slices, two animals) was significantly greater (p<0.05, unpaired t-test) than from CORT-treated male mice (0.692±0.286; N=13 slices, four animals).

The findings of this study suggest that chronic exposure to elevated CORT decreases excitability of CRH neurons. Furthermore, there appears to be sex differences in the response to CORT. CRH neurons from male CORT-treated mice showed greater reductions in excitability than female CORT-treated mice.

Supported by a summer studentship from the Department of Physiology, University of Otago, Dunedin.
Development of a new in vitro skin infection model to assess topical antivirals against Molluscum contagiosum virus

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Molluscum contagiosum virus (MCV) causes a contagious skin disease in humans, primarily in children, sufferers of atopic eczema and the immunocompromised. MCV is extremely difficult to grow in vitro and this has contributed to a lack of specific antivirals to treat infection. This project aimed to develop an in vitro model for MCV infection using a three-dimensional raft culture that closely resembles human skin.

Initially, conditions for culturing human keratinocytes (HaCaTs) on commercial scaffold were optimised. Matrix coatings, a human dermal fibroblast (hDF) layer and culture time (two weeks and three weeks) were trialled. Impact on raft thickness and epidermal differentiation was assessed using histological analyses. Infection trials were conducted on intact and breached rafts using purified orf virus, a virus known to infect rafts, and lysates from MCV-infected lesions. Viability of the rafts after seven days was assessed using neutral red staining and live microscopy.

The culturing conditions that produced the rafts most closely resembling human skin were 600µl collagen coating grown for two weeks at the air liquid interface. The rafts showed no difference when grown with or without a fibroblast layer. As was observed with orf virus, infection with MCV reduced the viability of skin rafts consisting of differentiated HaCaTs with or without hDFs in a dose-dependant manner (three dilutions of each, N=1). Breached HaCaT-only rafts showed a larger decrease in cell viability following MCV infection (50.43%) than non-breached rafts infected with MCV (78.9%). MCV-infected breached and non-breached rafts consisting of HaCaTs and hDFs equivalently, with no difference in viability (approximately 80%).

These findings suggest that MCV can reduce viability of the human skin raft culture, but further analysis is needed to show if productive infection occurs. If successful, this model could be used to test antivirals to treat MCV infection.

Supported by an Undergraduate Summer Research Scholarship from the Webster Centre for Infectious Diseases.

Identifying cancer-associated mutations within the New Zealand population using high-resolution melting

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Accurate detection of cancer-associated gene mutations is a crucial part of cancer prevention, diagnosis and treatment. While a variety of mutation screening techniques are implemented in cancer research, a compromise exists between a highly sensitive technique and one that is low in cost. This study aimed to investigate whether a modified version of the genotyping technique high-resolution melting (HRM) could fulfill both these criteria when detecting cancer-associated mutations in BRCA1 and PIK3CA genes.

DNA samples from three breast cancer patients with different BRCA1 mutations were individually screened for these specific mutations using HRM, with DNA from a non-cancer patient acting as a wild-type (WT) control. The three samples were then screened using modified HRM, which used an endonuclease enzyme to increase fluorescence difference between WT and mutant samples. DNA was also extracted from MCF7 breast cancer cells, which contain a mutation in the PIK3CA gene. This DNA was screened using modified HRM and Sanger sequencing at varying mutant-in-WT dilutions to assess the sensitivity of these techniques.

Compared to standard HRM, modified HRM showed 1.2-fold, 2.3-fold and 7.6-fold differences in the change in average fluorescence between WT and mutant DNA for the three BRCA1 samples respectively.

The modified HRM was also able to distinguish between the PIK3CA mutant sample and WT control even when the mutant DNA represented only 5% of the DNA sample. In contrast, Sanger sequencing failed to detect the mutant PIK3CA DNA at this same dilution.

This study showed that modified HRM was able to detect BRCA1 mutants more clearly than traditional HRM. Modified HRM also showed a greater sensitivity in detecting PIK3CA mutations compared to the more expensive and time-consuming Sanger sequencing. These results demonstrate the potential for modified HRM to be used as a highly sensitive, low-cost genotyping technique in a research or clinical setting.

Supported by the Crowe Horwath Summer Studentship from the Otago Medical Research Foundation.

H3K9me3 distribution in the arcuate nucleus is altered in offspring exposed to maternal obesity

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Maternal obesity during pregnancy increases the risk of offspring developing obesity. A network of neurons in the arcuate nucleus of the hypothalamus is central to regulating energy expenditure and feeding behaviours appropriate to the body's needs. When gestation occurs in an obese mother, neural projections in this network are reduced. While
Neurotransmitter changes in the auditory and non-auditory brain regions of rats following tinnitus-inducing acoustic trauma

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Tinnitus has been suggested to arise from neuronal hyperactivity in the auditory and non-auditory brain regions. Thus, excitatory and inhibitory neurotransmission imbalance in these regions may be the pathophysiological mechanism underlying tinnitus. However, the neurochemical basis of tinnitus remains poorly understood. This study investigated changes in amino acid levels in the auditory and non-auditory brain regions of rats at one week following tinnitus-inducing acoustic trauma.

Male Wistar rats were randomly divided into acoustic trauma (16kHz, 115dB pure tone presented unilaterally for 1h) and sham groups (n=8 per group). Auditory brainstem-evoked responses (ABR) were used to examine the hearing levels of rats before and immediately after acoustic trauma or sham treatment. One week later, each hemisphere was dissected into 12 distinct anatomical regions. Neurochemical analyses were performed using high-performance liquid chromatography coupled with an electrochemical detector. Results were analysed using a linear mixed model analysis.

The ABR thresholds were elevated in the noise-exposed animals. A significant exposure effect on glutamine levels was detected (F1,1114 = 15.07, P<0.05), which was due to a marked elevation of glutamine levels across all regions examined. The exposure × region × side interaction for the glycine levels was significant (F3,1,57,58 = 2.03, P<0.05), and this was attributed to a 25% increase in glycine levels in the cochlear nucleus contralateral to the noise-exposed ear of exposed animals. No statistically significant difference between the sham and exposed groups was found for glutamate, serine, threonine, taurine, alanine and GABA levels.

The widespread increases in glutamine, the major precursor for the synthesis of the excitatory neurotransmitter, glutamate, may be responsible for the neuronal hyperactivity related to tinnitus development. The increase in glycine levels could be an initial compensatory inhibitory response to counteract the neuronal excitation brought about by acoustic trauma.

Supported by a Eunice Isobel Beswick Summer Studentship.

Pretreatment with a novel carbon monoxide-releasing molecule produces cardioprotection during acute ischaemia-reperfusion injury

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Controlled delivery of carbon monoxide (CO) is indicated to induce cardioprotection through established ischaemic preconditioning signaling pathways. By eliciting a mild stress signal within the heart, the myocardium can be made resilient to subsequent ischaemic insults. This study looks at the pharmacological benefits of a novel CO releasing molecule, oCOM-21, in hearts subjected to acute ischaemia-reperfusion injury.

Hearts isolated from male Sprague-Dawley rats (270–300g) were perfused with Krebs-Henseleit buffer in the Langendorff mode and

these structural changes have been characterised, the mechanisms underpinning them are poorly understood. One hypothesis is that the epigenetic regulation of developmental gene expression is altered. To begin to understand epigenetic changes induced by obesity during pregnancy, the distribution of a histone modification associated with repressed transcription, Histone 3 Lysine 9 trimethylation (H3K9me3), was studied in the arcuate nucleus of foetuses of obese and control mouse dams.

Tissue sections were taken from the brains of gestational day-17 foetuses of three maternally obese and three control offspring (1,965±76.94 pixel density/µm² control n=3, vs 2,388±104.3 pixel density/µm² obese n=3, P<0.05, two-tailed unpaired t-test, results given as mean ± SEM).

H3K9me3 immunostaining was significantly increased in the arcuate nucleus of offspring of obese dams compared to control offspring (1,965±76.94 pixel density/µm² control n=3, vs 2,388±104.3 pixel density/µm² obese n=3, P<0.05, two-tailed unpaired t-test, results given as mean ± SEM).

The preliminary finding that H3K9me3 expression is increased in the arcuate nucleus of pups undergoing gestation in obese dams raises a number of questions about the underlying biology. While the result requires validation, it supports the idea that epigenetic alterations may underpin the disruption of arcuate circuitry development. However, further work is needed to characterise the cell types affected and understand the functional relevance of the H3K9me3 increase.

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haemodynamic parameters measured at an end-diastolic pressure of 10mmHg. Hearts were then infused with either oCom-21 (1µM, N=5) or non-CO releasing DB-21 (1µM, N=4) for 10 minutes immediately prior to warm global ischaemia (30 minutes) and reperfusion (60 minutes). Data are expressed as mean ± SEM.

Pretreatment with oCom-21, but not DB-21, significantly attenuated ischaemia-reperfusion induced loss of left ventricular developed pressure and other indices of function compared to untreated controls (N=4) at 15 minutes reperfusion (78.95±11.16 vs 19.31±5.91mmHg, respectively, P<0.0001, two-way ANOVA). These findings indicate that CO release is critical to oCom-21 cardioprotection. Apoptotic cell numbers were also reduced in ischaemia-reperfusion injured ventricular myocardium following oCom-21 treatment, suggesting a CO-mediated anti-apoptotic effect. Concomitant treatment with oCom-21 and chelerythrine (1µM, N=2), a potent inhibitor of protein kinase C (PKC), inhibited recovery of haemodynamic function following ischaemia-reperfusion injury. Western blot analysis of tissue homogenates revealed a chelerythrine-sensitive reduction in PKCe levels in oCom-21 treated tissues compared to untreated controls within the cytosolic compartment (0.76±0.06 vs 1.098±0.03 PKCe/β-tubulin, respectively, P<0.05, one-way ANOVA). These results suggest that cardioprotection by oCom-21 is mediated by PKCe translocation to subcellular organelles.

This study provides evidence that prophylactic treatment with oCom-21 improves both functional and structural outcomes and may have therapeutic benefit in preventing acute cardiac ischaemia-reperfusion injury.

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Co-prescribing of contraindicated or use-with-caution drugs in a national cohort of new users of simvastatin: are guidelines being followed?

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Simvastatin is a lipid-lowering agent that is widely used in the primary and secondary prevention of cardiovascular events in New Zealand. Although simvastatin is generally well-tolerated, some drug interactions can increase its risk of adverse drug reactions, including muscle injury and rhabdomyolysis. We undertook a descriptive study based on a national cohort of users of simvastatin, using national health and dispensing data, to describe the prevalence of co-prescription of contraindicated and use-with-caution drugs in patients who are taking simvastatin in New Zealand.

The study cohort (N=349,371) included all patients who were first dispensed simvastatin in New Zealand between 1 January 2006 and 31 December 2013. The co-prescription of simvastatin and its contraindicated and use-with-caution drugs was examined in the pharmaceutical collection, which includes dispensing records of prescription drugs which are publicly funded. The drugs contraindicated and use-with-caution drugs investigated in this study were identified using the New Zealand Drug Formulary and Medsafe.

Simvastatin users (9.9%) were co-prescribed contraindicated drugs, most whom received erythromycin ethyl succinate (72.7%). Simvastatin users (22.6%) were co-prescribed use-with-caution drugs, approximately one-third (37.5%) of these patients were co-prescribed when the simvastatin dose exceeded guidelines for co-prescription of use-with-caution drugs. The incidence rate for co-prescription of contraindicated and use-with-caution drugs was 35 and 93 per 1,000 person-years respectively. Rates of co-prescription were higher in females, Māori, older individuals, higher deprivation and patients with a Charlson Co-morbidity Score greater than zero.

The co-prescription of simvastatin and its contraindicated or use-with-caution drugs is common in New Zealand. This suggests limited adherence to national drug co-prescription guidelines and further research is needed to assess the clinical impact of this co-prescription.

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