Originality statement

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at ANU or any other educational institution, except where due acknowledgement is made in the thesis. The work was undertaken from February 2016 to November 2018 as part of the degree of Master of Philosophy in Applied Epidemiology at the Australian National University.

Laura Jessica Edwards

8 November 2018
Treatment without prevention is simply unsustainable

—Bill Gates
Acknowledgements

Many people provided support throughout the MAE. At the Department of Health I would like to thank Kate Garvey, Siobhan Harper and Fay Johnston for encouraging me to apply to the program and for providing a workplace-supported position. At Primary Health Tasmania I would like to thank Kelly Shaw for arranging the opportunity for me to work while completing the MAE, Susan Powell and Phil Edmondson for making it possible, and Sarah Ahmed and Valentina Ho who helped to answer my questions on data analysis and interpretation.

I was very fortunate to have Mark Veitch and Stephanie Williams as my supervisors. They both have such a breadth and depth of knowledge and experience in public health and a knack for keeping sight of the big picture while simultaneously paying attention to the tiniest details. This challenged and helped me enormously throughout the MAE and I hope to have picked up some of their skills along the way.

Thanks to the other members of my MAE cohort—Mica, Meru, Jonathan, Aly, Katherine, Siobhan, Rose, Julie, Linda, Katherine, Sam, and Brigitta—for all the fun times at course blocks and at the International TEPHINET conference in Chiang Mai.

To my extended family who supported me throughout this whole process. If you ever read this thank you so much for keeping up with our schedules over the last few years that required all kinds of logistics. I promise you this is really it, no more studying. To my friends and the Saturday@7 crew, thanks for inspiring me to get out onto the mountain every weekend.

Mike, thanks for supporting me in all my pursuits, motivating me when I lose sight of the big picture and reminding me to not take things too seriously. Audrey and Lenore, thanks for living in the moment and enthusiastically taking on every new adventure that comes your way.
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Abstract

This thesis comprises four major projects completed for the Master of Philosophy in Applied Epidemiology (MAE). All four of the projects are in primary health care epidemiology in Tasmania and comply with the key requirements of the MAE program, which are to: 1) analyse a dataset, 2) perform an epidemiological study, 3) investigate an urgent public health problem, 4) evaluate a surveillance system.

In the first chapter, I present the findings of a data analysis of all ambulance dispatches in Tasmania from 2009 to 2015. In this analysis I assessed the completeness of the dataset and analysed the temporal, demographic, clinical and spatial characteristics of ambulance dispatches in the study period. The completeness of the data was very high. The key finding was that there was a statistically significant increase in the age-standardised annual incidence rate of ambulance dispatches over the study period. Adults over 85 years had the highest rate of ambulance dispatches, 17-fold higher than the youngest age group of five to 14 years. There were also variations in the time of day, day of the week, month of the year, dispatch categories, paramedic diagnosis, transfer information and geospatial characteristics of the ambulance dispatches.

The second chapter is an epidemiological study that I performed to investigate the relationship between fine particulate matter generated by landscape fires and emergency ambulance dispatches in Tasmania using a case crossover design. We investigated the exposure to fine particulate matter at lag times of 1-48 hours prior to the event and the 24-hour average for the 24 hours prior to the event and 24-48 hours prior to the event. The main finding was that increased fine particulate matter was positively associated with the emergency ambulance dispatch categories of stroke, breathing problems and diabetic problems and the final paramedic assessment of asthma at different lag times.

The third chapter is a report of a public health investigation into an outbreak of gastroenteritis that occurred following a Mother's Day High Tea in Tasmania in 2016. I used a retrospective cohort design to investigate the outbreak in association with environmental and laboratory investigations. The findings of the investigations supported the initial hypothesis that undercooked chicken
wontons were the most likely cause of the outbreak but that cross-contamination of another food source could not be ruled out.

In the fourth chapter I present the findings of my evaluation of the Tasmanian real-time prescription monitoring system (RTPMS), which is used to monitor controlled drug dispensing events in Tasmania. Tasmania is currently the only state in Australia to have a RTPMS. I performed a mixed methods evaluation using the United States Centre for Disease Control and Prevention Framework for Evaluating Surveillance Systems. Participation rates for use of the system were moderate among pharmacists and low among General Practitioners. Key informants and health practitioners that I interviewed reported that they found the system simple and easy to use and valued the contributions of the staff that operate the system. There were limited data available to assess the surveillance system attributes, such as sensitivity and positive predictive value, and insufficient evidence to determine if its overall aim—to reduce opioid-related harms in Tasmania—had been achieved. In the evaluation I make a number of recommendations to improve participation rates and address the gaps in data collection, collation, analysis and dissemination.
INTRODUCTION
Field Placement Overview

I started the MAE while working as a Public Health Medicine Registrar at the Tasmanian Department of Health (DoH). My first position was at the Communicable Disease Prevention Unit (CDPU) at DoH for six months where I participated in a range of activities such as responding to cases, clusters and outbreaks of notifiable diseases. While working at CDPU I was involved in the investigation of an outbreak of campylobacteriosis at a Mother’s Day High Tea.

In the second half of 2016, I moved to the Menzies Institute for Medical Research where I performed a data analysis of seven years of ambulance dispatches and an epidemiological study to investigate the acute health effects of air pollution.

From Menzies, I moved to the World Health Organisation Western Pacific Regional Office (WPRO) in Manila to complete an eight-week Fellowship in Field Epidemiology. Working in Manila was a highlight of the MAE program. I joined the Emerging Diseases, Surveillance and Response team where I worked with a team of technical officers, medical officers and other field epidemiology trainees from the Western Pacific Region. Several highlights of the fellowship were analysing and preparing updates on the 2015/2016 epidemic of avian influenza A(H7N9), performing a formal risk assessment of mumps in the Marshall Islands and being involved in using the WHO Emergency Response Framework in response to Cyclone Donna in Vanuatu.

After WPRO, I returned to Australia and started a new position at Primary Health Tasmania to work as a Public Health Physician and complete the final 18 months of the MAE while continuing to work part-time at DoH. While working at Primary Health Tasmania I evaluated the Tasmanian real-time prescription monitoring system, the most challenging of all my MAE projects.

Throughout the MAE I continued to work as a general practitioner in rural Tasmania. Working in a rural community and providing clinical advice helped to balance the time working on the MAE and provided me with an opportunity to apply some of the skills I had developed in evidence-based practice to managing clinical problems. I think my patients were occasionally bemused by
my detailed epidemiological explanations of ‘the evidence’ for or against various treatment recommendations!

It is somewhat ironic that I joined the MAE to pursue my passion for outbreak investigations as a disease detective and yet almost all my projects ended up being in non-communicable diseases. That said, it has been rewarding to apply the epidemiological approaches of the MAE to primary health care projects and I hope others choose to take a similar approach in the future.
Master of Philosophy in Applied Epidemiology requirements:

I completed the following requirements for the degree of Master of Philosophy in Applied Epidemiology:

Field Projects:

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<td>Design and conduct an epidemiological study</td>
<td>Case crossover study of fine particulate matter and emergency ambulance dispatches in Tasmania, January to March 2016</td>
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<td>Investigate an acute public health problem</td>
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<td>Evaluate a surveillance system</td>
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Additional requirements:

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**Teaching**

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Abbreviations

ABS: Australian Bureau of Statistics
AIHW: Australian Institute of Health and Welfare
AT: Ambulance Tasmania
CAD: Computer Aided Dispatch
CBRN: Chemical, Biological, Radiological or Nuclear
COPD: Chronic Obstructive Pulmonary Disease
CI: Confidence Interval
EAD: Emergency Ambulance Dispatch
FPA: Final Primary Assessment
GBD: Global Burden of Disease
HAZMAT: Hazardous Materials
ICD-10: International Classification of Diseases 10th Revision
IHD: Ischaemic Heart Disease
LGH: Launceston General Hospital
MPDS: Medical Priority Dispatch System
NWH: North West Regional Hospital
RACF: Residential Aged Care Facilities
RHH: Royal Hobart Hospital
SCUBA: Self Contained Underwater Breathing Apparatus
VACIS: Victorian Ambulance Clinical Information System
WHO: World Health Organization
Prologue

My role

I was offered the opportunity to perform this data analysis at Menzies Institute for Medical Research under the supervision of Fay Johnston who leads the environmental epidemiology unit. As I planned to analyse ambulances in my epidemiological study, Fay suggested I analyse all ambulance dispatches in Tasmania in the ten years prior to the study. She had recently received the data from Ambulance Tasmania and had ethics approval to perform the analysis. I designed and performed all aspects of the analysis with support from my supervisors.

Lessons learnt

In this analysis I had to carefully consider which descriptive analyses were the most relevant and choose the most appropriate methods of presenting the data. I also learnt to use Tableau, which is a mapping tool that I will continue to use in the future. The process of writing the discussion provided an opportunity to think carefully about the public health implications of the data and the impact on health services across Tasmania. I also wrote a two-page summary of the findings to share with Ambulance Tasmania (Appendix 1) and we plan to prepare a manuscript to submit for publication. Another lesson I learnt during this analysis was to finish one project before moving on to the next, especially when working part-time. I started the analysis while at Menzies in 2016 but did not complete it until the end of the MAE, two years later. This meant I had to repeat almost all the analyses and I could have saved a lot of time if I had completed the chapter earlier.

Public health implications

We found that the number of ambulances in Tasmania increased by approximately five per cent each year over the study period, significantly faster than can be attributed to population growth or changes in the population age-distribution. This has important implications for ambulance services and for hospitals and other health services that receive ambulances. Our finding that the highest rates of ambulance usage were in the elderly over 85 years suggests
further research is needed to understand the reasons for, and potential alternatives to, ambulance dispatches in the elderly. The information can then be used to plan health promotion programs that reduce the need for ambulances for certain conditions, such as falls, and to determine whether alternative—and less costly—primary health services could be used instead of ambulances.

**Acknowledgements**

At Menzies I would like to thank Fay Johnston for providing the opportunity to do this analysis and her suggestions throughout the process, and Sharon Campbell for preparing the data request from Ambulance Tasmania. Alice Richardson at ANU gave advice on the statistical analysis. I would also like to thank Chris Benjamin at Ambulance Tasmania for providing information on Ambulance services in Tasmania and answering my questions about how VACIS is used by paramedics and ambulance officers.
Abstract

Background

Ambulance services aim to provide emergency medical care that is accessible, timely, appropriate, high quality and sustainable (1). To monitor the services that ambulances provide, the Australian Government Productivity Commission report annually on key performance indicators including response times, patient satisfaction, pain management, sentinel events, cardiac arrest survival and the ambulance workforce (1). Relatively little detailed analysis of the trends and variations in Tasmania ambulance dispatches has been undertaken. Our aim was to examine the epidemiology of ambulance dispatches in Tasmania from 2009 to 2015.

Methods

We analysed all emergency ambulance dispatches (EAD) recorded in the Clinical Information System used by Ambulance Tasmania from 1 January 2009 to 31 December 2015. We calculated the total number, age-specific and age-standardised rates of EAD using population data from the Australian Bureau of Statistics. We performed descriptive analyses of the temporal and regional variations in the EAD and the demographic and clinical characteristics of individuals who received EAD during the study period. We used the Cochran-Armitage trend test to determine whether there were statistically significant increases in the incidence of all-cause or age-specific EAD across the study period.

Results

There were 398,870 EAD in the study period, of which 52 per cent were for female patients and 48 per cent were for male patients. The median age was 58 years (interquartile range 32 to 76 years). There was a statistically significant five per cent annual increase in the number of EAD across the study period from an average of 134 per day in 2009 to 177 per day in 2015 ($p<0.001$). There was also an increase in the age-standardised annual incidence rate from 88 per 1000 population per year in 2009 to 113 per 1000 population per year in 2015. The
elderly aged 85 years and over had the highest age-specific incidence rate at 606 EAD per 1000 population per year, 18-fold higher than children aged five to 14 years (33 EAD per 1000 population per year). We also observed variations in the time of day, day of the week, month of the year, dispatch categories, paramedic assessment, transfer information and geospatial characteristics of the EAD.

**Conclusions**

Our findings demonstrate that EAD have increased faster than population changes and the ageing population in Tasmania in recent years. If these trends continue, they will have implications beyond ambulance services into other primary and tertiary health services in Tasmania. We recommend allocating resources to develop initiatives that support prevention of the common reasons for ambulance dispatches and to develop alternatives to ambulance transport. These efforts should be focused on the groups with the highest demand for ambulances, such as the elderly, and to areas with the highest usage of ambulances, such as Hobart North West. Investment in research that reviews the need for EAD in high-risk groups, such as falls in the elderly, and to develop strategies for reducing preventable ambulance services could result in substantial cost savings for the Tasmanian Government and ensure ambulances continue to provide timely and effective care across Tasmania.
1. Introduction

Ambulance services are an integral component of the primary health care system in Australia. Ambulances link individuals in the community with health services and are essential for the safe and timely transfer of acutely unwell individuals into emergency departments where they can receive tertiary level care. The timeliness and quality of care provided by paramedics has a direct impact on patient outcomes (2-4) and, for many conditions such as out of hospital cardiac arrest, affects their chance of survival (2, 5).

Ensuring ambulance services are available in a timely manner across populations including to rural and remote locations, socially disadvantaged areas and across age groups is essential to enable equitable access to health services. Funding models for ambulance services vary across Australia with 72 per cent of funding nationally provided by state and territory government grants and indirect government funding. In Tasmania, the state government provided $53.5 million of $64.2 million (83%) in funding for ambulance services in 2016-17 (1).

Ambulance Tasmania has a network of 55 ambulance stations across Tasmania comprising 14 stations in and around Tasmania’s major cities staffed by salaried officers, 16 stations in larger regional towns staffed by a combination of salaried officers and volunteers, 20 stations staffed by volunteers only and five Community Emergency Response Team (CERT) units staffed by volunteers who respond by car prior to the arrival of a crewed ambulance (Figure 1)(6).

The Headquarters of Ambulance Tasmania and the State Communications Centre, based in Hobart, receive all emergency medical calls and coordinate ambulance dispatches. For all other operations, the state is divided into three regions: South, North and Northwest. Ambulance Tasmania employ 375 salaried paramedics and works with approximately 600 volunteer ambulance officers (6).
The performance of ambulances is measured across Australia and reported annually by the Australian Government Productivity Commission. National key performance indicators are in the categories of response times, patient satisfaction, patient-reported pain management, sentinel events, cardiac arrest survival, ambulance workforce and ambulance services expenditure.

Response times for acute time-critical situations are one of the most important ambulance performance measures. These data, which are collected digitally,
reflect the time between an emergency call being received and an ambulance arriving at the case. In 2016-17, Tasmania had the longest state-wide response time in Australia with 90 per cent of code 1 (time-critical) emergency service calls responded to within 31 minutes, above the Australian Capital Territory (14 minutes), Western Australia (15 minutes), Queensland (17 minutes), South Australia (19 minutes), Victoria (21 minutes), New South Wales (23 minutes) and the Northern Territory (25 minutes) (1). There has been an eight-minute increase in the ambulance response times in Tasmania since 2009-10 when 90 per cent of code 1 incidents were responded to within 23 minutes (1).

Reasons for the increase in response times are not well understood but an audit by the Tasmanian Auditor General’s Office found the discrepancy between Tasmania and other jurisdictions can be attributed to Tasmania’s greater number of emergency responses per person and lower levels of urbanisation. They also found that the increase in response times in the last five years was largely due to an increase in the total number of ambulance dispatches in Tasmania (7).

The increasing demand for ambulance services has corresponded with an increase in costs, with the annual expenditure in Tasmania rising from $49 million ($96 per person) in 2009-10 to $70 million ($136 per person) in 2015-16 (1). Very little analysis has been performed to examine the epidemiology of the ambulances that are being used across Tasmania, which may provide some information on what is driving the rising costs. Few studies have investigated the trends, variations, age-specific incidence rates and clinical reasons for ambulances in Tasmania. Following the introduction of a digital clinical information system used by paramedics in 2008, data are now available to perform these analyses. Our aim was to analyse the epidemiology of ambulance dispatches in Tasmania from 2009 to 2015.

2. Aims and objectives

The aim of this study was to examine the epidemiology of emergency ambulance dispatches (EAD) in Tasmania from 1 January 2009 to 31 December 2015.

The objectives were to analyse:

- the completeness of the data
- trends in the number and rate of emergency ambulance dispatches in Tasmania from 2009 to 2015

- the demographic and clinical characteristics of individuals who received emergency ambulance dispatches in Tasmania from 2009 to 2015


3. Methods

3.1. Study setting and population

The study setting was Tasmania, Australia, which has an area of 68 000 km² and an estimated resident population of 517 000 in 2015 (8). The majority of Tasmanians live in the three main urban centres of Hobart (estimated resident population 208 000), Launceston (estimated resident population 87 000) and Devonport (estimated resident population 30 500), with the remainder residing in outer regional and remote locations.

3.2. Case definition

We defined EAD as an ambulance dispatched within Tasmania from 1 January 2009 to 31 December 2015 with information recorded electronically in the Clinical Information System used by Ambulance Tasmania. We included all emergency, urgent and non-acute land-based and aeromedical ambulance services.

3.3. Data collection

We received de-identified data from the Victorian Ambulance Clinical Information System (VACIS) from 1 January 2008 to 31 May 2016. VACIS is the Clinical Information System that has been used by all paramedics (but not volunteer ambulance officers) in Tasmania since its introduction in 2008. Data are collected by paramedics using a portable digital device. These data include the demographic and clinical characteristics of the individuals who required the ambulance and information on whether the case was transferred to a hospital or
health service (Table 2). It also contains information on the ambulance dispatch time, category and priority.

Dispatch information is collected by trained personnel at Ambulance Tasmania at the time of the emergency medical call and prior to ambulance dispatch. These data include the time of the emergency response call, the priority of the EAD, the location of the ambulance team responding to the case and the ambulance dispatch category, known as the Medical Priority Dispatch System (MPDS). There are 33 MPDS categories, which were developed by the International Academies of Ambulance Dispatch, that are used throughout Australia and in comparable countries such as the United Kingdom and the United States (9, 10). MPDS categories are allocated to ambulances based on responses by callers to key questions about the case. A full list of MPDS categories is in Table 4.

In addition to the MPDS category, ambulances are assigned to a priority level of one to three. Priority one is for situations that are potentially life-threatening and time-critical. Priority one ambulances are dispatched from the nearest available ambulance resource with lights and sirens. Priority two is for urgent ambulances that are not considered time-critical. They are dispatched from the most appropriate ambulance resource without lights and sirens. Priority three is for non-acute ambulances, such as for transport of patients who require clinical monitoring or assistance but do not need a time-critical emergency ambulance.

The final primary assessment (FPA) is the final diagnosis decided by the paramedic following assessment and management of the patient. For the FPA, the paramedic can select the diagnosis from a list of 205 categories and they can add free text, or they can choose to skip the categories and just use free text.

The demographic details we received were age and sex. We also received details on the location of the case (suburb and postcode) and transfer details including the referral destination for those that were transferred to a hospital.

3.4. Inclusion and exclusion criteria

The dataset we received included all EAD recorded in VACIS from January 2008 to May 31 2016. We did not receive data on EAD from the 20 volunteer-only stations and the five Community Emergency Response Team units unless
the case had been recorded in VACIS by a salaried paramedic from another station. Data received from Ambulance Tasmania did not include identifying information on the cases or a unique case ID therefore we were unable to identify duplicates.

We excluded EAD from 2008 and 2016 because they were incomplete (2008 was the year VACIS was introduced in Tasmania and 2016 data were available until May only). In our subgroup analyses we excluded cases with missing variables. In our analysis of the FPA we only analysed the top 20 most common FPA categories and we excluded the cases that contained any free text.

3.5. Data analysis

We assessed the completeness of the data by calculating the number and proportion of missing fields for each variable in the dataset. We then performed descriptive analysis of the temporal, spatial, demographic and clinical characteristics of the EAD. We used medians with interquartile range for continuous variables and counts and percentages for categorical variables.

We used population data from the Australian Bureau of Statistics (ABS) from the relevant years to calculate annual incidence rates and from June 2015 to calculate clinical, demographic and regional rates of ambulance usage. We used the Australian Standard Population 2011 from the ABS to calculate age-standardised rates using direct age-standardisation.

For our geospatial analysis, we converted suburb into Statistical Areas Level 3 (SA3), ABS classification. SA3 are geographical areas that have a population of 30 000 to 130 000 and are designed to provide a regional breakdown of Australian states and territories (11). We calculated the total number and crude incidence rates of EAD for each of the 15 SA3 regions in Tasmania.

To assess whether there was a statistically significant increase in the incidence rates of EAD across the study period we used the Cochran-Armitage test for trend. Statistical analyses were performed using Stata version 14.2 (Statacorp, College Station, Texas). We used Microsoft Excel (Microsoft Office) to create figures and Tableau (Tableau 2018.2, Seattle, WA) to create maps.
3.6. Ethics

This data analysis was approved by the Tasmanian Health and Medical Human Research Ethics Committee (Reference number H0012974) and the Australian National University Human Research Ethics Committee (Protocol 2016/603).

4. Results

4.1. Participants and numbers

There were 398,870 EAD recorded in VACIS in the study period. Cases had a median age of 58 years (interquartile range [IQR] 32 to 76 years). The proportion of females (52%) was higher than males (48%). The average age-standardised incidence rate of EAD across the study period was 101 per 1000 population per year.

4.2. Data completeness

Overall the completeness of the data was high (Table 2). The case date, time and dispatch priority had 100 per cent completeness. Most cases (98.3%) had a recorded MPDS dispatch category. Among the 6772 cases that did not have an MPDS category, 808 cases were recorded as standby (e.g. where an ambulance was on standby at a fire) and 4703 cases had an alternative reason recorded for the dispatch (e.g. red cross alarm). Age and sex were complete in 99.4 per cent and 99.7 per cent of cases respectively. The FPA was recorded in all cases but used a combination of categories and/or free text. All cases had a destination listed or ‘null’ recorded, which was interpreted as the patient not being transported to a health service or hospital. Of the 89,822 cases that had the destination recorded as ‘null’, 1472 (16%) did not have a reason listed for not transporting the patient.
Table 2: Type and completeness of the data available in the VACIS dataset

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<td>Case demographics</td>
<td>Age</td>
<td>Number (years)</td>
<td>3965</td>
<td>99.4</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
<td>Female, Male</td>
<td>1043</td>
<td>99.7</td>
</tr>
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<td>Case clinical information</td>
<td>Final primary assessment</td>
<td>205 categories or free text</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Destination</td>
<td>Hospital, health care service or free text</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Not transported reason</td>
<td>28 categories</td>
<td>1472</td>
<td>84.0</td>
</tr>
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</table>

4.3. Temporal analysis

4.3.1. Number and incidence rate of EAD

The number of EAD per day across the study period ranged from 61 to 242 with a median of 156 (IQR 141-172)(Figure 2). There was a statistically significant five per cent annual increase in the number of EAD from an average of 134 per day in 2009 to an average of 177 per day in 2015 (Cochran-Armitage test $p<0.001$)(Table 3). There was also a statistically significant increase in the age-standardised incidence rate of EAD across the study period from an annual incidence rate of 88 per 1000 population in 2009 to 113 per 1000 population in 2015 ($p<0.001$)(Table 3).
Figure 2: Total number of EAD recorded in VACIS in Tasmania by day and year
Table 3: Average daily number and annual crude, age-standardised and age-specific incidence rates of EAD, 2009-2015 in Tasmania

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>p-value*</th>
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<td>508847</td>
<td>511483</td>
<td>512106</td>
<td>513100</td>
<td>514762</td>
<td>516586</td>
<td>—</td>
</tr>
<tr>
<td>Average number per day</td>
<td>134</td>
<td>144</td>
<td>147</td>
<td>158</td>
<td>164</td>
<td>170</td>
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<td>—</td>
</tr>
<tr>
<td>Crude rate*</td>
<td>96</td>
<td>103</td>
<td>105</td>
<td>112</td>
<td>116</td>
<td>121</td>
<td>125</td>
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</tr>
<tr>
<td>Age-standardised rate*</td>
<td>88</td>
<td>93</td>
<td>95</td>
<td>102</td>
<td>105</td>
<td>109</td>
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<td>Age-specific rate*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>65</td>
<td>68</td>
<td>69</td>
<td>81</td>
<td>82</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>5-14</td>
<td>28</td>
<td>29</td>
<td>29</td>
<td>33</td>
<td>34</td>
<td>36</td>
<td>39</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>15-24</td>
<td>83</td>
<td>88</td>
<td>88</td>
<td>93</td>
<td>96</td>
<td>96</td>
<td>99</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>25-34</td>
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<td>80</td>
<td>84</td>
<td>90</td>
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<tr>
<td>35-44</td>
<td>68</td>
<td>71</td>
<td>71</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>85</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>45-54</td>
<td>66</td>
<td>73</td>
<td>73</td>
<td>84</td>
<td>86</td>
<td>89</td>
<td>92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>55-64</td>
<td>84</td>
<td>89</td>
<td>91</td>
<td>98</td>
<td>100</td>
<td>102</td>
<td>108</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>65-74</td>
<td>149</td>
<td>161</td>
<td>164</td>
<td>163</td>
<td>168</td>
<td>172</td>
<td>177</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>75-84</td>
<td>321</td>
<td>336</td>
<td>339</td>
<td>350</td>
<td>359</td>
<td>371</td>
<td>374</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>85+</td>
<td>543</td>
<td>591</td>
<td>590</td>
<td>616</td>
<td>613</td>
<td>636</td>
<td>659</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Annual incidence rate per 1000 population
#Cochran-Armitage test for trend
4.3.2. Monthly variations

Across the study period the average number of EAD each month was 4748. This fluctuated slightly with the lowest number of EAD in March at 4334 on average and the highest number in January with 5067 on average (Figure 3).

![Figure 3: Average number of EAD by month, Tasmania, 2009 to 2015](image)

4.3.3. Day of the week

There was a slight variation in the daily number of EAD according to the day of the week. The highest number of EAD occurred on Saturdays and Sundays with an average 159 per day and the lowest number was on Tuesdays with an average of 153 per day (Figure 4).
4.3.4. Time of the day

On average there were seven EAD per hour. The number of EAD per hour was relatively constant from a small peak between 10am and midday (9 per hour) through to 9pm (7 per hour) with a slight drop between 5pm and 6pm (Figure 5).

Figure 5: Average number of EAD at each hour of the day, Tasmania, 2009 to 2015
4.4. Demographic characteristics

4.4.1. Age-specific incidence rates

Adults over 85 years of age had the highest incidence rate of ambulance usage with an average of 606 EAD per 1000 population per year across the study period, 18-fold higher than the lowest incidence rate, which was among children aged five to 14 years who had 33 EAD per 1000 population per year across the study period. The age groups between 15 to 24 years and 55 to 64 years had similar rates of 80 to 90 EAD per 1000 population per year across the study period and the rate increased steeply above the 65 years. The age-specific rate of EAD increased among all age groups between 2009 and 2015 (Table 3). The largest increase in the study period occurred in the 75 to 84 years age group, from 321 per 1000 population per year in 2009 to 374 per 1000 population per year in 2015 (Table 3).

4.4.2. Age and sex

Overall, more ambulances were dispatched to women (52%) than men (48%) and the overall EAD incidence rate was slightly higher among women than men (112 versus 106 EAD per 1000 per year) but the age-specific rates between men and women were similar (Figure 6).
4.5. Clinical characteristics

4.5.1. Priority

Most ambulances were dispatched as priority one (time critical; 61%) followed by priority two (acute non-time critical; 32%) and priority three (non-acute; 8%). There were equal proportions of males and females in the priority one and priority three ambulances whereas there were more females than males who received priority two ambulances (55%).

For all age groups, 54 to 67 per cent of EAD were priority one. The lowest proportion of priority one was in the 85 years and older age category (54%) and the highest was in the zero to four years age group (67%). Priority two accounted for 32 per cent of EAD overall, ranging from 25 to 36 per cent across the age groups. Adults over 85 years had the highest proportion of priority two ambulances at 36 per cent and children zero to four years had the lowest proportion at 25 per cent. Priority three ambulances accounted for seven per
cent of EAD overall, ranging from five per cent in 15 to 24 year-olds and nine per cent in 65 to 74 years and 85 years and older.

4.5.2. Ambulance dispatch category

The most common MPDS categories were chest pain (12%), sick person (11%) and breathing problems (11%) (Table 4). Among the EAD without an MPDS category, there were 808 EAD listed as standby (at fire or other incident) and 4703 dispatched for an alternative reason (e.g. palliative care, red cross alarm or a specific cause). MPDS category 22 (inaccessible incident/entrapment) was not used in the study period in Tasmania.
Table 4: Number and proportion of EAD in each Medical Priority Dispatch System category, 2009-2015, Tasmania

<table>
<thead>
<tr>
<th>Description</th>
<th>MPDS category</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Pain (non-traumatic)</td>
<td>10</td>
<td>47549</td>
<td>12</td>
</tr>
<tr>
<td>Sick person</td>
<td>26</td>
<td>44179</td>
<td>11</td>
</tr>
<tr>
<td>Breathing Problems</td>
<td>6</td>
<td>42751</td>
<td>11</td>
</tr>
<tr>
<td>Falls</td>
<td>17</td>
<td>40577</td>
<td>10</td>
</tr>
<tr>
<td>Evaluation—interfacility</td>
<td>37</td>
<td>35617</td>
<td>9</td>
</tr>
<tr>
<td>Abdominal pain/problems</td>
<td>1</td>
<td>25243</td>
<td>6</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>31</td>
<td>24055</td>
<td>6</td>
</tr>
<tr>
<td>Traffic/transportation accidents</td>
<td>29</td>
<td>15976</td>
<td>4</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>30</td>
<td>12517</td>
<td>3</td>
</tr>
<tr>
<td>Convulsions/seizures</td>
<td>12</td>
<td>11590</td>
<td>3</td>
</tr>
<tr>
<td>Haemorrhage/lacerations</td>
<td>21</td>
<td>11494</td>
<td>3</td>
</tr>
<tr>
<td>Back Pain</td>
<td>5</td>
<td>9971</td>
<td>3</td>
</tr>
<tr>
<td>Stroke</td>
<td>28</td>
<td>9783</td>
<td>3</td>
</tr>
<tr>
<td>Cardiac problems (non-chest pain)</td>
<td>19</td>
<td>9074</td>
<td>2</td>
</tr>
<tr>
<td>Overdose/poisoning</td>
<td>23</td>
<td>8431</td>
<td>2</td>
</tr>
<tr>
<td>Psychiatric/abnormal behaviour/suicide attempt</td>
<td>25</td>
<td>7370</td>
<td>2</td>
</tr>
<tr>
<td>Assault/sexual assault</td>
<td>4</td>
<td>5654</td>
<td>1</td>
</tr>
<tr>
<td>Headache</td>
<td>18</td>
<td>5318</td>
<td>1</td>
</tr>
<tr>
<td>Unknown problem</td>
<td>32</td>
<td>4776</td>
<td>1</td>
</tr>
<tr>
<td>Allergy/envenomation</td>
<td>2</td>
<td>4555</td>
<td>1</td>
</tr>
<tr>
<td>Diabetic problems</td>
<td>13</td>
<td>4348</td>
<td>1</td>
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<tr>
<td>Cardiac or respiratory arrest/death</td>
<td>9</td>
<td>3891</td>
<td>1</td>
</tr>
<tr>
<td>Pregnancy/childbirth/miscarriage</td>
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<td>2860</td>
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</tr>
<tr>
<td>Burn/explosion</td>
<td>7</td>
<td>1277</td>
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</tr>
<tr>
<td>Choking</td>
<td>11</td>
<td>1030</td>
<td>0</td>
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<tr>
<td>Stab/gunshot/penetrating trauma</td>
<td>27</td>
<td>532</td>
<td>0</td>
</tr>
<tr>
<td>Eye problems/injury</td>
<td>16</td>
<td>464</td>
<td>0</td>
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<tr>
<td>Animal bite/attack</td>
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<td>451</td>
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<tr>
<td>Electrocution/lightning</td>
<td>15</td>
<td>284</td>
<td>0</td>
</tr>
<tr>
<td>Carbon Monoxide/inhalation/HAZMAT</td>
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<td>174</td>
<td>0</td>
</tr>
<tr>
<td>Drowning /Diving/SCUBA Accident</td>
<td>14</td>
<td>163</td>
<td>0</td>
</tr>
<tr>
<td>Heat/cold exposure</td>
<td>20</td>
<td>144</td>
<td>0</td>
</tr>
<tr>
<td>Inaccessible incident/entrapment</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>—</td>
<td>392098</td>
<td>100</td>
</tr>
</tbody>
</table>
Among the top ten most frequent MPDS categories with the sex recorded, females had a higher number of EAD for the dispatch categories of sick person (54%), breathing problems (51%), falls (58%), abdominal pain (59%) and unconscious /fainting (53%) while males had a higher number of EAD for chest pain (49%), evaluation—interfacility (53%), traffic/transportation accidents (55%), traumatic injury (66%) and convulsions or seizures (56%)(Figure 7).

Figure 7: Total number of EAD for males and females for the top 10 most frequent MPDS categories, Tasmania, 2009-2015

Age-specific rates

The age-specific incidences rate of EAD followed a non-linear age distribution with the lowest rates among children aged five to 14 years and adults aged 35 to 44 years. EAD for chest pain steadily increased from ten per 1000 population per year at 35 to 44 years to 57 per 1000 population per year in the 85 years and over age group. There was a steep increase in the rates of EAD for most of the MPDS categories from 65 to 74 years but not for traumatic injuries or traffic/transport accidents (Figure 8).
Among the top four most common MPDS categories, adults over 65 years accounted for around half of the EAD for chest pain (48%), sick person (53%) and breathing problems (50%) and around 60 per cent of the EAD for falls (59%)(Table 5). The highest incidence rate of EAD was in the 85 years and older age group who had an average incidence rate of 117 EAD per 1000 population per year for falls across the study period (Table 5).
Figure 8: Average annual age-specific incidence rate per 1000 population by age group for the top nine MPDS categories, 2009-2015, Tasmania
<table>
<thead>
<tr>
<th>Age category (years)</th>
<th>Breathing problems</th>
<th>Chest pain</th>
<th>Sick person</th>
<th>Falls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>%</td>
<td>Rate*</td>
<td>Number</td>
</tr>
<tr>
<td>0-4</td>
<td>4439</td>
<td>10</td>
<td>21</td>
<td>71</td>
</tr>
<tr>
<td>5-14</td>
<td>1806</td>
<td>4</td>
<td>4</td>
<td>320</td>
</tr>
<tr>
<td>15-24</td>
<td>2803</td>
<td>7</td>
<td>6</td>
<td>2356</td>
</tr>
<tr>
<td>25-34</td>
<td>1940</td>
<td>5</td>
<td>5</td>
<td>2843</td>
</tr>
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<td>35-44</td>
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<td>7057</td>
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<td>55-64</td>
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<td>11</td>
<td>10</td>
<td>7847</td>
</tr>
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<td>65-74</td>
<td>7367</td>
<td>17</td>
<td>19</td>
<td>9076</td>
</tr>
<tr>
<td>75-84</td>
<td>8640</td>
<td>20</td>
<td>43</td>
<td>8768</td>
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<tr>
<td>85+</td>
<td>5223</td>
<td>12</td>
<td>65</td>
<td>4651</td>
</tr>
</tbody>
</table>

*annual incidence rate per 1000

Legend

Proportion
Rate per 1000 per year
4.5.3. Final primary assessment

Of the 398 870 EAD in the dataset, 144 581 (36%) had an FPA that we could analyse i.e. did not contain free text. The most common FPA categories were: no problem identified (12%), abdominal pain (8%) and angina or chest pain (7%)(Table 6). A further 19 per cent were recorded as “null” by the paramedic suggesting the proportion with no cause identified was 31 per cent.

Table 6: Number and proportion of the top 20 FPA categories and cases recorded as null, 2009-2015, Tasmania

<table>
<thead>
<tr>
<th>FPA category</th>
<th>Number</th>
<th>Percent*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No problem identified</td>
<td>16782</td>
<td>12</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>10902</td>
<td>8</td>
</tr>
<tr>
<td>Angina or chest pain</td>
<td>9470</td>
<td>7</td>
</tr>
<tr>
<td>Chest infection</td>
<td>8470</td>
<td>6</td>
</tr>
<tr>
<td>Unknown problem</td>
<td>7676</td>
<td>5</td>
</tr>
<tr>
<td>Gastrointestinal problem</td>
<td>6996</td>
<td>5</td>
</tr>
<tr>
<td>Back pain</td>
<td>6785</td>
<td>5</td>
</tr>
<tr>
<td>Laceration</td>
<td>6337</td>
<td>4</td>
</tr>
<tr>
<td>Acute coronary syndrome</td>
<td>6176</td>
<td>4</td>
</tr>
<tr>
<td>Muscular or soft tissue pain</td>
<td>6106</td>
<td>4</td>
</tr>
<tr>
<td>Anxiety</td>
<td>5841</td>
<td>4</td>
</tr>
<tr>
<td>Seizure or post-ictal</td>
<td>5594</td>
<td>4</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>4776</td>
<td>3</td>
</tr>
<tr>
<td>Headache</td>
<td>3085</td>
<td>2</td>
</tr>
<tr>
<td>Psychiatric episode</td>
<td>2656</td>
<td>2</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>2393</td>
<td>2</td>
</tr>
<tr>
<td>Altered conscious state</td>
<td>2047</td>
<td>1</td>
</tr>
<tr>
<td>Depression</td>
<td>1796</td>
<td>1</td>
</tr>
<tr>
<td>Deceased</td>
<td>1764</td>
<td>1</td>
</tr>
<tr>
<td>Croup</td>
<td>1237</td>
<td>1</td>
</tr>
<tr>
<td>Null</td>
<td>27273</td>
<td>19</td>
</tr>
<tr>
<td><strong>Total</strong>*</td>
<td>144581</td>
<td>100</td>
</tr>
</tbody>
</table>

*Includes top 20 FPA categories only

Among the top ten FPA categories, females were more likely to have the FPA of no problem identified (53%), abdominal pain (62%), gastrointestinal problems (60%), back pain (55%) and muscular or soft tissue pain (55%) while males were
more likely to have angina or chest pain (55%), lacerations (62%) and acute coronary syndrome (59%) (Figure 9).

Figure 9: Number of ambulance dispatches to males and females for the top 10 most frequent FPA categories, Tasmania, 2009-2015

4.5.4. Age-specific incidence rate

The lowest incidence rates of EAD for the top 10 FPA categories were in children aged 5 to 14 years and adults aged 25 to 34 years. There was an increase in all of the top ten FPA categories in the age categories from 65 to 74 years and older with the steepest increase in the EAD with no problem identified, which increased from an average of five per 1000 per year in the 65 to 74 year age group up to 27 per 1000 population per year in the 85 years and older age group (Figure 10 and Table 7).
Figure 10: Average annual age-specific incidence rate per 1000 population for the top nine FPA categories, 2009-2015, Tasmania
Table 7: Number, proportion and annual incidence rate of the four most common FPA categories by age group, 2009-2015, Tasmania

<table>
<thead>
<tr>
<th>Age category (years)</th>
<th>No problem identified</th>
<th>Abdominal pain</th>
<th>Angina/chest pain</th>
<th>Chest infection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Rate*</td>
<td>Number</td>
</tr>
<tr>
<td>0-4</td>
<td>1908</td>
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<td>9</td>
<td>45</td>
</tr>
<tr>
<td>5-14</td>
<td>792</td>
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<td>2</td>
<td>348</td>
</tr>
<tr>
<td>15-24</td>
<td>2043</td>
<td>12</td>
<td>5</td>
<td>1883</td>
</tr>
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<td>25-34</td>
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<td>35-44</td>
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<td>1304</td>
</tr>
<tr>
<td>45-54</td>
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<td>8</td>
<td>3</td>
<td>1379</td>
</tr>
<tr>
<td>55-64</td>
<td>1488</td>
<td>9</td>
<td>3</td>
<td>1246</td>
</tr>
<tr>
<td>65-74</td>
<td>1816</td>
<td>11</td>
<td>5</td>
<td>1315</td>
</tr>
<tr>
<td>75-84</td>
<td>2487</td>
<td>15</td>
<td>12</td>
<td>1204</td>
</tr>
<tr>
<td>85+</td>
<td>2146</td>
<td>13</td>
<td>27</td>
<td>601</td>
</tr>
</tbody>
</table>

*Annual incidence rate per 1000

Legend

<table>
<thead>
<tr>
<th>Proportion</th>
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<tr>
<td>5-10</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>≥10</td>
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</table>
4.5.5. Transport destination

Overall, 77 per cent of EAD were transported to a health facility or hospital and the proportion remained stable across the study duration. Among the cases transferred, the most common destination was the Royal Hobart Hospital (RHH) followed by Launceston General Hospital (LGH) and the North West Regional (NWH) Hospital. Private hospitals accounted for around six per cent of transfers and other destinations, such as rural hospitals, nursing homes and other health services, accounted for 19 per cent of transfers. The biggest increase from 2009 to 2015 was observed at the RHH where there was a seven per cent annual increase in the number of EAD transferred from 13,930 in 2009 to 20,664 in 2015. There was also an increase in the proportion of EAD transferred to the RHH from 29% to 32% (Table 8).

The LGH and NWH received an increase in the total number of EAD transferred but a reduction in the proportion of cases transferred over the study period (Table 8). In contrast, private hospitals received fewer cases at the end of the study period than at the start with 3500 cases transferred to private hospitals in 2009 (7%) and 2734 in 2015 (4%) (Table 8).

Among the 89,822 (23%) EAD that did not transport the patient to a health service or hospital, the most common reasons listed were: treatment not required (55%), treatment refused (18%) and transport by private vehicle (7%) (Table 9).
<table>
<thead>
<tr>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Number transferred</td>
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<td>4428</td>
<td>41873</td>
<td>44464</td>
<td>46276</td>
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<tr>
<td>%</td>
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<td>NWH</td>
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</tr>
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<td>%</td>
<td>30</td>
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<td>6</td>
<td>20</td>
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<td>3447</td>
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<td></td>
</tr>
<tr>
<td>%</td>
<td>31</td>
<td>19</td>
<td>9</td>
<td>6</td>
<td>19</td>
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<td>Number</td>
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<td>11877</td>
<td>5753</td>
<td>2734</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>%</td>
<td>32</td>
<td>18</td>
<td>9</td>
<td>4</td>
<td></td>
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</table>

RHH: Royal Hobart Hospital; LGH: Launceston General Hospital; NWH: North West Regional Hospital
Table 9: Total number and proportion of cases not transported to a health service or hospital by recorded reason, Tasmania, 2009-2015

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment not required</td>
<td>49802</td>
<td>55</td>
</tr>
<tr>
<td>Treatment refused</td>
<td>15871</td>
<td>18</td>
</tr>
<tr>
<td>Transport by private vehicle</td>
<td>5917</td>
<td>7</td>
</tr>
<tr>
<td>Dead on arrival</td>
<td>2701</td>
<td>3</td>
</tr>
<tr>
<td>Treated by ambulance team</td>
<td>2160</td>
<td>2</td>
</tr>
<tr>
<td>Ambulance cancelled</td>
<td>1475</td>
<td>2</td>
</tr>
<tr>
<td>Referred to local medical officer</td>
<td>1289</td>
<td>1</td>
</tr>
<tr>
<td>Died at scene</td>
<td>1279</td>
<td>1</td>
</tr>
<tr>
<td>Standby ambulance only</td>
<td>419</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>8909</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>89822</td>
<td>100</td>
</tr>
</tbody>
</table>

4.6. Geospatial distribution

4.6.1. Statistical area level 3

Across the 15 statistical areas in Tasmania, the highest number of EAD was in the Launceston SA3 with 8739 EAD on average per year and the lowest number was in the Central Highlands with 698 EAD on average per year (Figure 11). The incidence rate was highest in Hobart North West SA3, where there was an average of 133 EAD per 1000 population per year across the study period, more than double the SA3 with the lowest rate, the Central Highlands where there were 61 per 1000 population per year (Figure 12).
Figure 11: Average number of EAD per year in each SA3 region, 2009-2015, Tasmania
Figure 12: Crude annual incidence rate of EAD per 1000 population for each SA3 region in Tasmania, 2009-2015.
5. Discussion

5.1. Key findings

In this study, we found there was a statistically significant five per cent annual increase in the number of EAD in Tasmania from 2009 to 2015. Adults over 85 years had the highest rate of ambulance usage and adults aged 65 to 74 years received the highest total number of ambulance dispatches. The annual incidence rate of EAD increased in all age-groups across the study period. For all the top four MPDS dispatch categories (chest pain, sick person, breathing problems and falls) and two of the top four FPA categories (no problem identified, abdominal pain, angina/chest pain and chest infection/pneumonia) adults over 65 years accounted for more than half of all the EAD. Almost four in five (77%) of the cases in our study were transported to hospital with the Royal Hobart Hospital and Launceston General Hospital the most common destinations, receiving 30 per cent and 19 per cent of ambulance transfers respectively.

There were variations in the total number and crude rates of ambulances across the 15 SA3 region in Tasmania. The Central Highlands in central Tasmania had the lowest number and crude incidence rate of ambulance dispatches at 61 per 1000 population per year, less than half the incidence rate of the SA3 region with the highest rate of ambulance dispatches, Hobart North West, where there were 133 EAD per 1000 population per year. The reasons for such wide variation by SA3 region are unclear. It is unlikely that age contributed significantly because the median age in the Central Highlands in 2015 was 40 to 44 years, similar to the Tasmanian median age of 42 years (12). It is possible that residents of the Central Highlands are less likely to call an ambulance because of its relatively remote location and greater proportion of volunteer-only ambulance stations in the region. This may result in residents using private vehicles instead of ambulances to access health services. Checking the response times and analysing the severity of emergency medical calls in the Central Highlands may be useful to determine why the number and incidence rate of ambulance usage is lower than other areas.
We found the number of ambulance dispatches across Tasmania fluctuated widely, ranging from 61 to 242 per day, with an interquartile range of 141-172, which is consistent with previous findings that demand for ambulances fluctuates widely (13, 14). Occasionally extreme events result in a rapid increase in ambulance demand. The 2016 thunderstorm asthma event in Victoria is a recent Australian example, which resulted in a 2.5-fold increase in calls to the emergency medical service, a 42 per cent increase in the overall caseload for the emergency medical service and a 432 per cent increase in emergency medical attendances for acute respiratory distress symptoms (15). We were not able to investigate the reasons for fluctuations in this study, such as bushfire events, which may warrant further research. However, the extent of the fluctuations can be used by Ambulance Tasmania in planning staff and other resource allocation to ensure they have the capacity to scale up their response when there is increased demand for ambulances.

Females had a higher number of ambulance dispatches in this study than males but the age-specific rates by sex were similar. The higher proportion of females overall is likely due to the greater proportion of females in older age groups. Other studies have found that males have higher rates of ambulance usage than females (16-19). It has been proposed that the gender differences may be due to differences in health-seeking behaviour, differences in treatment of men and women by health professionals, or a lower threshold to seeking emergency care for women (16) but our study findings of near-identical incidence rates by females and males do not support these differences.

The finding that the number of ambulance dispatches has increased in recent years has also been shown in several other Australian and international studies (19-24). Factors identified that may have contributed to the increase include an ageing population, greater prevalence of chronic diseases and multimorbidity, increased community awareness of ambulances, improved access to ambulances and changes in the threshold for calling an ambulance (21).

Our finding that the elderly had high rates of ambulance usage is consistent with other studies (20, 25) and has important public health implications. The ageing population is a major issue faced by the primary health care system, particularly in Tasmania which has the highest median age of all states and
In our study, the highest incidence rate of all dispatch categories was for falls in adults 85 years and over at 116 per 1000 population per year. This equates to more than one ambulance dispatch to a fall for every ten adults 85 years and over per year in Tasmania. A similar study in Victoria found that falls among people aged over 65 years accounted for 9.7 per cent of ambulance attendances and the median age of patients was 83 years (27). Although the dispatch category for falls has not been validated to correlate with a real fall, a study in Victoria found that the 87 per cent of paramedic-assessed falls cases were correctly identified at the point of dispatch (28) and another study by the same author found that the dispatch category for falls may underestimate the true incidence of falls by up to 13 per cent (28).

If falls prevention interventions were implemented more widely across Tasmania a reduction in the demand for ambulances among the elderly—in addition to the health benefits attributed to falls reduction and decreased hospital costs—may occur. Several initiatives have been shown to reduce the risk of falls (29, 30). One initiative in Western Australia, which involved emergency department nurses providing primary health care services in residential aged care facilities (RACF), resulted in a statistically significant 17 per cent reduction in the number of transfers to an emergency department, of which most would have been provided by an ambulance (30).

Few studies have examined the reason paramedics choose to take patients to public or private emergency departments. One study that looked at the reasons for paramedics choosing private emergency departments found that the patient’s wishes or those of the patient’s family or GP were the greatest influencer of the decision to transfer to a private ED but the paramedics view of the hospital logistics and system were also influential (31).

Balancing the information to the public about appropriate and inappropriate use of ambulances needs to be carefully considered. Several initiatives have
been developed to encourage community members to call an ambulance, such as the F.A.S.T (Face, Arms, Speech, Time) campaign by the Stroke Foundation of Australia, which encourages people to call an ambulance in the setting of suspected stroke, whereby early access to treatment has been shown to reduce mortality (32, 33). Another initiative by the National Heart Foundation of Australia successfully raised awareness of possible acute coronary syndrome and was associated with an increase in the use of ambulance attendances for chest pain and suspected acute coronary syndromes (34).

In contrast, other initiatives have been developed to educate the public about distinguishing emergency situations from non-life-threatening situations and raise awareness about alternatives to ambulances, such as visiting a pharmacy, general practitioner or calling the HealthDirect phone service (35). There are several reasons for this. Firstly, using ambulances in non-life-threatening situations can reduce the response times to life-threatening situations, particularly in rural or remote locations; and secondly, ambulances incur substantial costs to the health system, and avoiding unnecessary expenditure is a priority for state and territory governments.

5.2. Strengths

This study, which covers a seven-year period, was the first major analysis of data collected by the VACIS clinical information system since its introduction in Tasmania in 2008. VACIS, which is also used in Victoria, provides detailed information on the dispatch, demographic, clinical and transfer information of cases. A strength of the analysis of VACIS was the completeness of the data. This is supported by the design of the VACIS platform used by paramedics whereby most of the fields have be completed before moving onto the next or before closing the case.

Another advantage to using VACIS data is that we were able to minimise duplicate entries in the setting of volunteer ambulance officers and paramedics attending a case as VACIS is not used by volunteer-only stations and the five CERT units. It also ensures that the paramedics that use VACIS have adequate training in completing the case information and in recording a working diagnosis—the FPA—rather than using information from volunteers who do not have the same amount of training.
5.3. Limitations

Our data only included ambulance dispatches where a VACIS record was created therefore we did not have data on the cases responded to by volunteers only, which is reported by Ambulance Tasmania to be five per cent of ambulance dispatches (6). For incidents attended by paramedics and volunteer ambulance officers—reported to be nine per cent of all incidents—the case created by the paramedic would be included (6). This means we have underestimated the total number and rate of ambulances across the study period and that our results are applicable to incidents requiring salaried ambulance crew only.

In our analysis of incidence rates, we did not account for duplicates, either for individual events, where multiple ambulances may have been dispatched, or for individuals who required multiple ambulances over the study period. Therefore, we were unable to determine the characteristics of individuals with the highest frequency of ambulance usage. However, for planning purposes the incidence rates provide a good estimate of the overall demand for ambulance services in Tasmania. These limitations applied systematically across all calculations therefore the trend estimates should not be affected. We did not account for visitors and tourists to Tasmania who required an EAD during the study period, which may partially explain annual variations, such as an influx of tourists during summer months in Tasmania. We also were unable to assess the accuracy of some of the data, such as age, which may have been estimated by the paramedic (e.g. for unconscious patients), therefore it is possible some our age-specific rates are inaccurate.

A limitation of our analysis of the FPA was that it only included around one third of the original cases because we excluded the cases where the FPA contained free text. This is also connected to one of the main limitations of ambulance data, which is the lack of evidence to validate the diagnostic accuracy of the MPDS dispatch category or the FPA paramedic diagnosis. Researchers have used a range of methods to analyse the FPA which have resulted in a lack of consistency in ambulance research into the diagnosis by paramedics (9, 14). One study purports to have developed a system of aligning the International Classification of Disease 10th Revision (ICD-10) coding system with the FPA category by paramedics, but this is not used routinely (36). Linkage of
ambulance case data to emergency department or hospital diagnoses using an internationally standardised coding system such as ICD-10 would help to overcome these data limitations.

Finally, we were unable to ascertain the living arrangements of the cases which would have been useful to determine whether the high incidence rates among adults 85 years and over were predominantly from residential aged care facilities or independent living arrangements.

5.4. Public health implications

The increasing number of ambulance dispatches is an important public health issue that impacts on staff and other resources at Ambulance Tasmania and has flow-on effects to state Emergency Departments and other health services. We found that 77 per cent of patients were transported to a hospital or health service and 30 per cent of all cases were transported to the Royal Hobart Hospital. If this proportion remains steady and ambulance dispatches continue to increase there will be a significant increased burden on emergency departments. An intervention that has been successfully used in Victoria to divert patients away from ambulance transport involved a secondary telephone triage system for low acuity emergency services calls. A similar intervention could potentially be introduced in Tasmania (37). Extended care paramedics (ECP)—paramedics trained with a greater scope of practice than other paramedics—were introduced in Tasmania in 2017 aiming to treat a greater number of patients in the community and therefore reduce the number of patients transferred to hospitals. Evaluation of whether the ECP have achieved their aims, which may include repeating this analysis with 2016 to 2020 data, will help determine whether further investment by the Tasmanian Government is warranted.

The Tasmanian population is projected to increase in age therefore it is likely that demand for ambulances will continue to increase. Strategies that focus on reducing the requirements for ambulances among the elderly, particularly among the most frequent ambulance dispatch and FPA categories, such as falls reduction strategies, are likely to yield the greatest benefit. Training and education of carers and health professionals who care for elderly members of the community in the appropriate use of ambulances or alternative care
pathways, such as telephone health information services and general practitioners, may reduce some of the demand in that age group.

There were regional variations in ambulance dispatches in this study that warrant further investigation. The identification of geospatial hotspots, such as within the Hobart North West SA3, and more detailed analysis of the reasons for the geospatial variations could provide information on which to develop health promotion campaigns. This could result in increased appropriateness of emergency medical service calls and may also assist in the allocation of Ambulance Tasmania resources. Likewise, further assessment of the regions with the lowest rates of ambulance usage, such as the Central Highlands, may be useful to ensure there is equity in access to ambulance services across Tasmania. An intervention using geospatial data to assist in resource allocation was associated with significantly reduced response times for out of hospital cardiac arrest in Singapore (13).

To improve VACIS data quality for future research, we recommend developing a more systematic field for the FPA. One way of doing this would be to separate the categorical FPA and the free text that paramedics enter into separate fields. This way, free text can still be provided and used for clinical research purposes but the FPA could be more systematically analysed. We also recommend a standardised technique for aligning the FPA with ICD-10 codes, therefore ensuring a consistent approach by researchers across Australia, which has previously been described (36).

Another recommendation is to investigate the individuals who received multiple EAD. As we were unable to identify duplicates in our study, we couldn’t analyse frequent users of ambulance services. Further research to identify factors associated with high ambulance usage, such as elderly age or lack of social supports, could be helpful to develop strategies to prevent the need for ambulances in these groups, which may in turn reduce overall EAD and lead to faster response times.

6. Conclusion

Our study provides an overview of the number, rate and types of ambulance services provided from 2009 to 2015 and highlights important trends and
variations in ambulance usage across Tasmania in that period. There was a statistically significant increase in the number of ambulance dispatches in Tasmania between 2009 and 2015 from an average of 134 per day in 2009 to an average of 177 per day in 2015. The age-specific incidence rate increased in all age groups during the study period.

Overall, adults over the age of 85 years had the highest annual incidence rate of ambulance usage with an average of 606 EAD per 1000 population per year across the study period, 18-fold higher than the lowest rate, which was among children aged five to 14 years who had 33 EAD per 1000 per year across the study period.

One of the most common ambulance dispatch categories was falls, which accounted for ten per cent of all ambulance dispatches. Falls also had the highest age-specific incidence rate of 116 per 1000 population per year in adults 85 years and over, which corresponds with more than one ambulance dispatch to a fall for every ten adults 85 years and over per year in Tasmania per year. This may also be an underestimate as other studies have shown the dispatch category of falls underestimates the true number of falls attended by ambulances.

We found that most of the information in the VACIS data was complete and, despite the implementation of VACIS in Tasmania for use as a clinical information system and not a research tool, it provides useful data for research. One key improvement in the data that could assist with future analyses would be to introduce a method for the systematic recording of FPA categories by separating out categorical and free text fields. This would provide more accurate information on the paramedic diagnosis. In addition, developing a strategy to consistently align ICD-10 diagnoses with the paramedic diagnosis would enable better comparisons with hospital data.

Our findings demonstrate that EAD have increased faster than population changes and the ageing population in Tasmania in recent years. If these trends continue, they will have implications beyond ambulance services into other primary and tertiary health services in Tasmania. We recommend allocating resources to develop initiatives that reduce the need for ambulance dispatches in groups with the highest demand, such as the elderly, and areas with the highest usage of ambulances, such as Hobart North West. Investment in
research to assess the need for EAD in high-risk groups, such as falls in the elderly, and to develop strategies for avoiding unnecessary ambulances could result in substantial cost savings for the Tasmanian Government and ensure ambulances continue to provide timely and effective care across Tasmania.
References


Appendix 1: Plain language summary prepared for Ambulance Tasmania

Analysis of ambulance dispatches in Tasmania from 2009 to 2015

Key Findings

We analysed all land-based and aeromedical ambulance dispatches recorded in the Victorian Ambulance Clinical Information System (VACIS) in Tasmania from 2009 to 2015. Here’s what we found:

There was a five per cent increase each year in the number of ambulance dispatches in Tasmania

Between 1 January 2009 and 31 December 2015, there were almost 400 000 ambulance dispatches in Tasmania, which is about 57 000 per year. This is around one ambulance dispatch for every nine Tasmanians each year. Over the same period, the average daily ambulance dispatches increased from 134 ambulances per day in 2009 to 177 per day in 2015.

Ambulance use increases steadily in those aged 65 and over

Adults over the age of 65 years accounted for 42 per cent of all ambulance dispatches, with the highest rate of ambulance dispatches for adults over 85 years. In 2015, there were 659 ambulances for every 1000 adults aged 85 years and over—nearly seven ambulance dispatches for every ten adults 85 years and over per year.

Each year, adults 85 years and over had the following:

- One in nine received an ambulance for the MPDS category of falls
- One in 13 received an ambulance for the MPDS category of sick person
- One in 15 received an ambulance for the MPDS category of breathing problems

The number of ambulance dispatches for every 1000 people increased in all age groups from 2009 to 2015 showing that factors other than population growth and an increase in the older population have contributed to the increase.

There is steady daily demand for ambulance dispatches between 10am-9pm, but weekends are busier than weekdays.
Between 2009 and 2015, the demand for ambulances was steady from 10am to 9pm, with a small peak between 10am and midday and a small drop between 5 and 6pm. Saturdays and Sundays had slightly greater demand with 159 per day compared to Tuesdays with 153 per day on average.

About four in five ambulances are transferred to a health facility or hospital

Four in five ambulance dispatches resulted in the case being transferred to a health facility or hospital. From 2009 to 2015:

- The total number of cases transferred to all the public hospitals increased every year
- The Royal Hobart Hospital had the largest increase in the number of ambulance transfers from 14 000 in 2009 to 21 000 in 2015 (around 7% increase each year)
- The proportion of transfers to the Launceston General Hospital (LGH) and North West Regional Hospital (NWH) went down slightly—from 20% to 18% at LGH and from 11% to 9% at NWR.
- The number and proportion of patients taken to private hospitals went down from 3500 (7%) in 2009 to 2700 (4%) in 2015.

Hobart North West had the highest rate of ambulance dispatches between 2009 and 2015

Hobart North West statistical area level 3 (extending from West Moonah to New Norfolk) had the highest rate of ambulances with one for every eight residents per year, more than double the rate of the Central Highlands (including the Central Highlands and the Southern Midlands region), of one for every 18 residents per year.

What was not included in the analysis?

Ambulances where the paramedic or ambulance officer did not complete a VACIS record (e.g. volunteer-only ambulances) were not included in this analysis. We also couldn’t identify individuals who used multiple ambulances in this study because we didn’t have a unique identifier. Visitors and non-residents were not included in our calculations of the population rates.

For the full report or further information please contact Laura Edwards, Specialist Medical Advisor, Department of Health laura.edwards@health.tas.gov.au
This work was supported by the Tasmanian Department of Health and Menzies Institute for Medical Research. It was completed as part of a Master of Philosophy in Applied Epidemiology at the Australian National University.
CASE CROSSOVER STUDY OF FINE PARTICULATE MATTER AND EMERGENCY AMBULANCE DISPATCHES IN TASMANIA, JANUARY TO MARCH 2016
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Abbreviations

BLANkET: Base Line Air Network of EPA Tasmania

CAD: Computer Aided Dispatch

COPD: Chronic Obstructive Pulmonary Disease

CI: Confidence Interval

EAD: Emergency Ambulance Dispatches

FPA: Final Paramedic Assessment

GBD: Global Burden of Disease

IHD: Ischaemic Heart Disease

MPDS: Medical Priority Dispatch System

NEPC: National Environment Protection Council

NEPM: National Environment Protection Measure

OR: Odds ratio

PM: Particulate matter

PM$_{2.5}$: Fine particulate matter less than 2.5 micrometers diameter

PM$_{10}$: Fine particulate matter less than 10 micrometers diameter

RH: Relative humidity

TEPHINET: Training Programs in Epidemiology and Public Health Interventions Network

VACIS: Victorian Ambulance Clinical Information System

WHO: World Health Organization
Prologue

My role

The opportunity to conduct this study arose after a summer during which multiple bushfires caused several periods of smoke haze across Tasmania. Following the bushfires, there were discussions within the Public Health Services branch of the Department of Health about how to determine whether there had been any health impacts of the fires. My supervisor for this study, Dr Fay Johnston, leads the environmental epidemiology branch at Menzies Institute for Medical Research and works as a Specialist Medical Advisor at the Department of Health. She suggested the topic would be appropriate as a MAE epidemiological study and arranged for my transfer to Menzies Institute for Medical Research for the duration of the project.

Lessons learnt

This project enabled me to learn about environmental epidemiology and its relevance to population health. It took some time grasp the case crossover methodology, but I now appreciate what a useful study design it is for investigating the acute effects of changes in environmental conditions. Performing this study provided me with an opportunity to use many of the statistical methods that I had learnt during course blocks at ANU including multivariable analysis.

I presented the findings at a NCEPH lunchtime seminar and the international TEPHINET conference (Appendix 3), for which I learnt to explain the study design clearly and concisely to others. In preparing a manuscript for peer-reviewed I had to summarise the study, which was challenging but helped me to determine the key findings.

Public health implications

Our study adds to the emerging literature on the acute health effects of exposure to fire smoke. The finding that there are selected health conditions that are increased during or following landscape fires is an important public health implication of this study. However, public health authorities and Ambulance
Tasmania can be reassured that there wasn’t an overall increase in demand for ambulances as a result of the bushfires.

The results were shared with a range of stakeholders, including the Environmental Protection Authority (EPA), Tasmania, the Tasmanian Department of Health and Ambulance Tasmania. The findings were also published in a special issue of Fire, Extreme Fire Events, Ecosystem Resilience and Human Wellbeing. *Fire* is an open access multidisciplinary journal about vegetation fires and how they interact with communities and the environment. A copy of the article is in Appendix 2.

**Acknowledgements**

In addition to the supervision provided by Fay Johnston, I am grateful for the assistance from Grant Williamson, a spatial scientist at the University of Tasmania School of Health Science and Farhad Salimi, a postdoctoral scholar at the University of Tasmania. Grant showed me how to do basic mapping using QGIS and provided information on air pollution data and interpolation. Farhad assisted me to match the two ambulance datasets and categorise the VACIS paramedic assessment diagnoses. Petr Otahal at the University of Tasmania and Alice Richardson at the Australian National University provided advice on the statistical methods and how to check whether I could use a linear model or an adjusted model, such as with cubic splines. I would also like to thank John Innis at the EPA Tasmania for providing feedback on the study findings and contextual information on the concentrations of PM$_{2.5}$ during the study period. Finally, thanks to Ambulance Tasmania for providing the data for the study.
Bushfire smoke and a firefighting helicopter over Lorinna in northwestern Tasmania, January 2016 (photo courtesy of Arana Flora)
Abstract

Background

During an unusually hot and dry summer in early 2016, over 70 landscape fires in Tasmania, Australia, caused several severe episodes of fire smoke across the island state. 24-hour concentrations of fine particulate matter—microscopic particles less than 2.5 micrometers diameter suspended in the air (PM$_{2.5}$)—of up to 497 µg/m$^3$ were recorded, well above the concentration at which acute health effects have been shown to occur. Our aim was to investigate if there was an increase in emergency ambulance dispatches (EAD) associated with increased concentrations of PM$_{2.5}$ generated from the landscape fires in Tasmania.

Methods

We performed a case crossover analysis that measured the association between increased concentrations of PM$_{2.5}$ and EAD from 1 January to 31 March 2016. We assessed EAD that were related to respiratory conditions, cardiovascular conditions, diabetes and syncopal episodes. For our primary analysis we assessed the EAD dispatch category and for our second analysis we assessed the paramedic diagnosis (final primary assessment [FPA]) by the ambulance officer.

Control days were matched to case days by latitude and longitude, day of the week and calendar month. We obtained exposure data from air quality monitoring stations at lag times of 1-48 hours preceding the event and the 24-hour mean on the same day (0-24 hours) and 1-day lag (24-48 hours) preceding the event.

Results

There was no association between a 10 µg/m$^3$ rise in PM$_{2.5}$ and all-cause EAD (same day odds ratio [OR] 1.00, 95% confidence interval [CI] 0.99-1.01; 1-day lag OR 1.00, 95% CI 0.99-1.02). In the primary analysis, we observed positive associations between a 10 µg/m$^3$ increase in PM$_{2.5}$ and the EAD dispatch categories of breathing problems, stroke and diabetic problems at a range of lag times between 12 and 46 hours. This association was significant for stroke on the same day (OR 1.10, 95% CI 1.02-1.19) and at 1-day lag (OR 1.10, 95% CI
There were also non-significant increases in the dispatch categories of breathing problems (OR 1.04, 95% CI 1.00-1.08) and diabetic problems (OR 1.11, 95% CI 0.99-1.22) at 1-day lag.

In our second analysis, we observed a positive association between a 10 µg/m³ increase in PM$_{2.5}$ and EAD with the FPA of asthma at a range of lag times from 0 to 40 hours prior to the EAD. This association was significant on the same day (OR 1.21, 95% CI 1.04-1.41) and at 1-day lag (OR 1.27, 95% CI 1.06-1.52).

**Conclusion**

We did not observe an increase in all-cause EAD. Our findings suggest that increased concentrations of PM$_{2.5}$ are associated with an increase in selected ambulance dispatch and paramedic diagnosis categories. Although the absolute increase in EAD for each category was small this may have an impact on ambulance services if the rise in PM$_{2.5}$ concentration is very large, sustained for several days and within or adjacent to a large population, such as in a capital city in mainland Australia.

These findings add to the emerging evidence for acute respiratory and cardiovascular events associated with exposure to landscape fire smoke. Our findings have important public health implications for the emergency sector and public health professionals and support the development of early warning systems, public health alerts and communication plans to prepare for, and respond to, future smoke events.
1. Introduction

1.1. Background

During an unusually hot and dry summer in early 2016, over 70 landscape fires within a 60-day period in Tasmania caused several multi-day episodes of fire smoke across the island state. 24-hour concentrations of fine particulate matter—microscopic particles less than 2.5 micrometers in diameter suspended in the air (PM$_{2.5}$)—of up 497 µg/m$^3$ were recorded, well above the concentration at which acute health events have been shown to occur. In response to the size and extent of the landscape fires, and in recognition of the emerging evidence for acute health effects of smoke exposure (1), we sought to investigate if smoke generated during these landscape fires caused an increase in acute health conditions requiring emergency ambulance dispatches (EAD).

1.2. Health effects of particulate matter

Exposure to ambient air pollution is the leading environmental cause of death globally resulting in an estimated 4.2 million deaths each year (7.6% of all deaths)(2). The health effects of air pollution occur predominately due to PM$_{2.5}$ exposure. Anthropogenic sources of PM$_{2.5}$ are the most common and originate predominantly from the combustion of fossil fuels, domestic wood heating and industrial processes, but natural processes, such as dust storms, volcano explosions and smoke from landscape fires also contribute (3).

Morbidity and mortality due to air pollution include acute health effects, such as asthma exacerbations, myocardial infarction and stroke; and chronic health effects, such as chronic obstructive pulmonary disease (COPD) and lung cancer (4). The Global Burden of Diseases (GBD) Study 2016 estimated that ambient air pollution caused 27 per cent of deaths due to COPD, 24 per cent of deaths from lower respiratory infections, 17 per cent of deaths from ischemic heart disease, 17 per cent of deaths from lung cancer, and 14 per cent of deaths due to cerebrovascular disease (stroke; 14.2%)(2).

Few epidemiological studies have assessed the burden of disease from of air pollution in Australia. One study in Sydney attributed 2.1% of all deaths to PM$_{2.5}$
and ozone exposure (5). The GBD Study 2016 estimate that ambient air pollution causes 12.7 deaths per 100 000 population per year in Australia, resulting in 5.8 per cent of deaths due to COPD, 5.6 per cent of deaths from ischemic heart disease, 4.4 per cent of lower respiratory infection deaths, 3.8 per cent of stroke deaths, and 2.5 per cent of lung cancer deaths (6).

1.3. Health effects of landscape fire smoke

Landscape fires—wild and planned forest fires, peat fires, agricultural burning and grass fires—are estimated to cause eight per cent (340 000) of all air pollution deaths globally each year (7). Previous studies into the health effects of exposure to landscape fire smoke have shown an increase in acute respiratory conditions (8, 9), cardiovascular conditions (1, 10), non-traumatic emergency department attendances (11) and all-cause mortality (1, 12, 13). The most vulnerable groups to health effects from landscape fires are the elderly and people with pre-existing health conditions (9).

1.4. Air pollution legislation in Australia

Australian states and territories are required by the National Environment Protection Council Act 1994 to monitor particles as PM$_{10}$ (microscopic particles less than ten micrometers in diameter suspended in the air) and PM$_{2.5}$. Current standards for monitoring are outlined in the National Environment Protection Measures (NEPM). The standards, which are based on evidence of health effects occurring at increasing concentrations of PM, require an average PM$_{2.5}$ concentration of less than 25 µg/m$^3$ per day and less than eight µg/m$^3$ per year. However, there is no known safe threshold for PM exposure.

1.5. Rationale for the study

Research into acute health conditions often use data from emergency department or hospital settings. These data are limited in that they provide the location at which the case was treated, but not the location of the cases when the health event occurred. EAD offer an advantage over these traditional settings by providing geospatial information on cases at the time of the health event. This is especially useful in studies of environmental exposures. Several studies examining the impact of fire smoke exposure on EAD have been performed,
which have shown an increase in cardiovascular events including out of hospital cardiac arrest (10, 14-16) and chest pain (17); respiratory problems (18); diabetic symptoms (19); syncope or fainting (19) and non-traumatic causes (20, 21).

Most studies have examined the exposures of cases to PM$_{2.5}$ measured as the average exposure over a 24-hour period in the days leading up the health event. Few studies have analysed the exposures at hourly lag-times prior to the health event occurring. In Tasmania, air pollution concentrations are measured as PM$_{10}$ and PM$_{2.5}$ and recorded at multiple locations across the state in real-time and recorded every hour. These data provided an opportunity to investigate the health effects of exposure to PM$_{2.5}$ generated during landscape fires at hourly lag times and compare these findings with the 24-hour average PM$_{2.5}$ in the days leading up to the health events.

1.6. Objectives

Our aim was to investigate if there was an increase in EAD associated with increased concentrations of PM$_{2.5}$ generated from the landscape fires overall or for conditions that have previously been associated with fire smoke including respiratory conditions, cardiovascular conditions, diabetes and syncope or fainting during the study period of 1 January to 31 March 2016. In our primary analysis, we assessed all cause and selected dispatch categories of EAD and for our second analysis we assessed selected final diagnoses by paramedics.

2. Methods

2.1. Setting

Tasmania is an island state with a land mass of 68 000 km$^2$ and an estimated resident population of 518 000 (22). Tasmania has low concentrations of air pollution during summer with occasional peaks during bushfires (23). The NEPM standards are exceeded periodically during winter months in towns situated in plateaus or valleys due to domestic woodfire emissions. Very little air pollution is generated from industrial sources or traffic (23).
2.2. Study design

We used a time-stratified case crossover design to measure the association between exposure to PM$_{2.5}$ and EAD. The case crossover design is used in environmental epidemiology to measure the effect of short term environmental exposures on acute health conditions (24). In this methodology, cases act as their own control. Cases included all individuals who required an EAD during the study period of 1 January to 31 March 2016. We matched the environmental conditions (PM$_{2.5}$, relative humidity and temperature) at the time of the case EAD with control environmental conditions by location (latitude and longitude) and day of the week within the same calendar month, resulting in three or four controls per case.

2.3. Exposure data

We obtained data on air pollution from the Base Line Air Network of EPA Tasmania (BLANkET), a network of 29 stations established to measure PM$_{2.5}$ and other meteorological variables in the major cities and towns of Tasmania (Figure 13). BLANkET data provides a good estimate of the population exposure to PM$_{2.5}$ with 95% of the Tasmanian population residing within 20 kilometers of a station (25). We extracted exposure data on PM$_{2.5}$, air temperature and relative humidity for the cases and controls using hourly inverse distance weighted interpolation of the BLANkET network data at lag times of 0 to 48 hours prior to the EAD and the 24-hour average on the same day (0-24 hours) and at 1-day lag (24-48 hours) prior to the EAD.
2.4. Outcome data

The primary endpoint of interest was EAD. An EAD was defined as an emergency ambulance dispatched within Tasmania during the study period with a recorded dispatch category. We received two separate datasets from the Tasmanian Ambulance Service, the first from the Computer Aided Dispatch (CAD) system, and the second from the Victorian Ambulance Clinical Information System (VACIS). CAD contains information from the time the ambulance is dispatched. Trained operators answer emergency calls and categorise ambulances into one of 37 Medical Priority Dispatch System (MPDS) categories. MPDS categories, developed by the International Academies of Ambulance Dispatch, are used throughout Australia and in comparable countries such as the United Kingdom and the United States (17, 26). Data in
the CAD database included the time of the call, location of the incident, age and sex of the case and the MPDS category. MPDS categories provide broad information on the ambulance dispatch category but do not provide clinical information on the cases as they are based on the emergency medical service operator’s assessment of the need for the ambulance.

The Victorian Ambulance Clinical Information System (VACIS) is used by ambulance officers in Tasmania to record information following their initial assessment and management of a patient. In VACIS, ambulance officers select a working diagnosis, known as the final primary assessment (FPA). The FPA, defined as the final assessment of the patient after a full history and examination, has 205 FPA categories or free text (27). We matched cases in the CAD and VACIS datasets by gender, hour of dispatch, suburb and MPDS category over the study period in order to have a full complement of data for each EAD.

We did not receive data on inter-facility transfers or motor vehicle crash notifications and we excluded cases that were categorized as “Standby” or that did not have an MPDS category. Data received from Ambulance Tasmania did not include identifying information therefore we were unable to identify duplicates within each dataset.

2.5. Outcomes of interest

In our primary analysis of the CAD dataset, we analysed all-cause EAD, all non-traumatic causes and the dispatch categories that have previously been associated with acute health effects following exposure to PM$_{2.5}$ including respiratory conditions, cardiovascular conditions, diabetes and syncope or fainting (17, 21, 28). The actual MPDS categories were: chest pain; heart problems (non-chest pain), stroke; cardiac or respiratory arrest or death; breathing problems; diabetic problems and unconscious or fainting.

In the second analysis of the matched VACIS dataset, we analysed the following FPA categories: acute coronary syndrome; angina or chest pain; asthma; COPD; cardiac arrest; dizziness or syncope; diabetes-related problems; shortness of breath; and stroke.
2.6. Statistical analysis

We used population data from the Australian Bureau of Statistics June 2016 to calculate age-specific and regional rates of ambulance usage. Statistical analyses were performed using Stata version 14.2 (Statacorp, TX).

We performed conditional multivariable logistic regression to calculate the adjusted odds ratios for the association between a 10 µg/m³ rise in PM2.5 and EAD for the selected dispatch categories (primary analysis) and selected FPA diagnoses (second analysis) at the time of the EAD and at 1-hour lag periods from one to 47 hours prior to the EAD. Covariates in the logistic regression were chosen based on previous studies of health effects of PM2.5 and included the preceding 24-hour mean temperature and the 24-hour mean relative humidity.

To supplement the analysis of one-hour intervals and to align our methods with other similar studies, we repeated our analysis using the mean PM2.5 concentration for the 24-hour period prior to the EAD (same day) and the mean PM2.5 concentration 24-48 hours prior to the EAD (1-day lag). Odds ratios were considered to be significant if the 95% confidence interval did not cross 1 and p-values were considered significant at less than five per cent (0.05).

Other studies using case crossover methodology have applied natural cubic splines to temperature. This is because of the non-linear relationship between temperature and health events, which increase disproportionately at very low and very high temperatures (29, 30). To test the nature of the relationship between 24-hour temperature and EAD overall, we performed logistic regressions on the deciles of temperature and assessed the regression coefficient for each decile, which was linear, suggesting that temperature could be included as a linear covariate. We confirmed this by performing a likelihood ratio test and the Akaike information criterion test. Quadratic and linear models were compared with the likelihood ratio test demonstrating that the linear model was satisfactory.

We also performed sensitivity testing on school holiday periods to determine if they affected the results. As there was no difference with the addition of school holiday periods, we did not include them in the final model. Influenza
seasonality was not included as the study period was outside the influenza season.

2.7. Ethics

The study was approved by the Tasmanian Health and Medical Human Research Ethics Committee (Reference number H0012974) and the Australian National University Human Research Ethics Committee (Protocol 2016/603).

3. Results

3.1. Summary of data

Data were received on 14,512 cases in the CAD dataset from the Tasmanian Ambulance Service of which 36 were excluded (categorised as “Standby” or did not have an MPDS category) resulting in 14,476 cases. Matching of cases to controls according to the methods described above resulted in 48,984 controls. We successfully matched 76 per cent (11,029/14,476) of cases from the CAD dataset with the VACIS dataset.

3.2. Descriptive analysis

3.2.1. EAD

There were similar numbers of EAD for males and females (7216 v’s 7174) in the study period. Most cases (52%) were in Southern Tasmania, which corresponds to a similar proportion of the Tasmanian population (51%) (Table 10). The average daily frequency of EAD across the study period was 160. Saturdays and Sundays were the busiest days with an average of 166-169 EAD per day compared to the Tuesdays and Wednesdays with the lowest average number of EAD per day at 157.

The highest total number of EAD was among those aged 75 to 84 years, with 2251 in total, whereas the highest age-specific rate of EAD was among the 85 and older age group with an average of 144 EAD per 100,000 population per day during the 91-day study period. This was 16-fold higher than the lowest age
group of 5-14 years, which had an average of nine EAD per 100 000 per day over the study period. (Figure 2).

**Table 10: Demographic features and location of the cases and comparison with the Tasmanian population CAD dataset, January 1 2016 to March 31 2016,**

<table>
<thead>
<tr>
<th></th>
<th>EAD Number (%)</th>
<th>Tasmania Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>14476</td>
<td>519128</td>
</tr>
<tr>
<td>Median age (years)</td>
<td>57</td>
<td>42</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7216 (49.8)</td>
<td>255 728 (49.4)</td>
</tr>
<tr>
<td>Male</td>
<td>7174 (49.6)</td>
<td>261 860 (50.6)</td>
</tr>
<tr>
<td>Unspecified</td>
<td>86 (0.6)</td>
<td>—</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>3747 (26.0)</td>
<td>143 537 (27.7)</td>
</tr>
<tr>
<td>Northwest</td>
<td>3145 (21.8)</td>
<td>111 566 (22.0)</td>
</tr>
<tr>
<td>South</td>
<td>7513 (52.1)</td>
<td>262 485 (50.7)</td>
</tr>
</tbody>
</table>

**Figure 14: Rate of EAD per 100 000 population by age group, 1 Jan to 31 March 2016**

3.2.2. EAD Dispatch categories

The most common MPDS categories were sick person (13.3%), non-traumatic chest pain (12.4%) and falls (11.0%)(Table 2). The most common FPA categories were abdominal pain (4.1%), no problem identified (3.8%) and angina or chest pain (3.6%)(Table 3).
<table>
<thead>
<tr>
<th>MPDS category*</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sick person</td>
<td>1925 (13.3)</td>
</tr>
<tr>
<td>Chest pain (non-traumatic)</td>
<td>1788 (12.4)</td>
</tr>
<tr>
<td>Falls</td>
<td>1585 (10.9)</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>1292 (8.9)</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>961 (6.6)</td>
</tr>
<tr>
<td>Abdominal pain/problems</td>
<td>913 (6.3)</td>
</tr>
<tr>
<td>Evaluation – interfacity</td>
<td>743 (5.1)</td>
</tr>
<tr>
<td>Traffic/transportation accidents</td>
<td>579 (4.0)</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>485 (3.4)</td>
</tr>
<tr>
<td>Convulsions/fitting</td>
<td>446 (3.1)</td>
</tr>
<tr>
<td>Haemorrhage/lacerations</td>
<td>421 (2.9)</td>
</tr>
<tr>
<td>Overdose/poisoning</td>
<td>406 (2.8)</td>
</tr>
<tr>
<td>Stroke</td>
<td>365 (2.5)</td>
</tr>
<tr>
<td>Psychiatric/abnormal behaviour or suicidal</td>
<td>350 (2.4)</td>
</tr>
<tr>
<td>Back pain</td>
<td>333 (2.3)</td>
</tr>
<tr>
<td>Heart problems (non-chest pain)</td>
<td>325 (2.2)</td>
</tr>
<tr>
<td>Allergies/envenomation</td>
<td>323 (2.2)</td>
</tr>
<tr>
<td>Headache</td>
<td>236 (1.6)</td>
</tr>
<tr>
<td>Unknown problem</td>
<td>194 (1.3)</td>
</tr>
<tr>
<td>Assault / sexual attack</td>
<td>187 (1.3)</td>
</tr>
<tr>
<td>Diabetic problems</td>
<td>157 (1.1)</td>
</tr>
<tr>
<td>Cardiac or respiratory arrest/death</td>
<td>128 (0.9)</td>
</tr>
<tr>
<td>Pregnancy/childbirth/miscarriage</td>
<td>127 (0.9)</td>
</tr>
<tr>
<td>Othera</td>
<td>207 (1.5)</td>
</tr>
<tr>
<td>All non-trauma causes combined</td>
<td>9219 (63.7)</td>
</tr>
<tr>
<td>All causes</td>
<td>14,476</td>
</tr>
</tbody>
</table>

*categories in the multivariable analysis are shown in bold

*aChoking; burns/explosion; eye problems/injury; bite/attack; stab/gunshot/penetrating trauma; electrocution/lightning; heat/cold exposure; carbon monoxide/inhalation/hazmat; drowning/diving/scuba accident; inaccessible incident/entrapment
### Table 12: Number and proportion of case final primary assessment categories, VACIS dataset, January 1 2016 to March 31 2016

<table>
<thead>
<tr>
<th>FPA category*</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal pain</td>
<td>454 (4.1)</td>
</tr>
<tr>
<td>No problem identified</td>
<td>424 (3.8)</td>
</tr>
<tr>
<td><strong>Angina or chest pain</strong></td>
<td>397 (3.6)</td>
</tr>
<tr>
<td>Gastrointestinal problem</td>
<td>311 (2.8)</td>
</tr>
<tr>
<td><strong>Acute coronary syndrome</strong></td>
<td>304 (2.8)</td>
</tr>
<tr>
<td>Seizure or post-ictal</td>
<td>296 (2.7)</td>
</tr>
<tr>
<td>Unknown problem</td>
<td>290 (2.6)</td>
</tr>
<tr>
<td><strong>Chest infection</strong></td>
<td>257 (2.3)</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>233 (2.1)</td>
</tr>
<tr>
<td><strong>Dizziness or syncope</strong></td>
<td>226 (2.0)</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>221 (2.0)</td>
</tr>
<tr>
<td>Back pain</td>
<td>220 (2.0)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>186 (1.7)</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>138 (1.3)</td>
</tr>
<tr>
<td>Stroke</td>
<td>114 (1.0)</td>
</tr>
<tr>
<td><strong>COPD</strong></td>
<td>105 (1.0)</td>
</tr>
<tr>
<td>Heart failure or acute pulmonary oedema</td>
<td>86 (0.8)</td>
</tr>
<tr>
<td><strong>Asthma</strong></td>
<td>72 (0.7)</td>
</tr>
<tr>
<td>Altered conscious state</td>
<td>64 (0.6)</td>
</tr>
<tr>
<td><strong>Cardiac arrest</strong></td>
<td>41 (0.4)</td>
</tr>
<tr>
<td>Other</td>
<td>6695 (60.7)</td>
</tr>
<tr>
<td><strong>All causes</strong></td>
<td>11 029</td>
</tr>
</tbody>
</table>

*categories in the multivariable analysis are shown in bold

### 3.2.3. Exposure of cases to PM$_{2.5}$

During the study period, the baseline PM$_{2.5}$ concentrations in Tasmania were low as would normally be expected. There were two distinct peaks of PM$_{2.5}$ in late January and mid-February recorded by the BLANkET stations in northern Tasmania. These corresponded with the landscape fires, most of which were in northern and northwestern Tasmania. Across the three major urban centres in Tasmania, the NEPM Standard was exceeded on two days in Hobart (southern
Tasmania), six days in Launceston (northern Tasmania) and seven days in Devonport (northwestern Tasmania)(Figure 3).

The average 24-hour PM$_{2.5}$ concentrations interpolated to the case locations at the time of the EAD ranged from zero to 487 µg/m$^3$. Most EAD (13788/14476; 95%) occurred during a 24-hour period with normal PM$_{2.5}$ concentrations but five per cent (688/14476) occurred during a 24-hour period that exceeded the NEPM standard at the case location.

![Graph](image)

Figure 15: Mean 24-h PM$_{2.5}$ concentration at Devonport (northwest Tasmania), Launceston (northern Tasmania), Hobart (southern Tasmania) and the NEPM 24-h standard in the study period of 1 January to 31 March 2016

3.3. Case crossover analysis

3.3.1. CAD analysis

In the primary multivariable analysis, there was no association between a 10 µg/m$^3$ rise in PM$_{2.5}$ and all-cause EAD (same day OR 1.00, 95% CI 0.99-1.01, p=0.88; 1-day lag OR 1.00, 95% CI 0.99-1.02, p=0.59). In the analysis of
selected MPDS dispatch categories, breathing problems were increased at lag times of 40 and 42 hours (Figure 4) and there was a non-significant association at 1-day lag (OR 1.04, 95% CI 1.00-1.08, p=0.06)(Table 13 and Figure 17). Diabetic problems were increased at lag times of 26, 36, 38-40, 45 and 46 hours (Figure 16) and there was a non-significant association at 1-day lag (OR 1.11, 95% CI 0.99-1.22, p=0.08)(Table 13 and Figure 17). EAD for stroke were increased at lag times of 12-16, 19-22, 26-31 and 35 hours (Figure 16) with significant positive associations on the same day (OR 1.10, 95% CI 1.02-1.19, p=0.01) and at 1-day lag times (OR 1.10, 95% CI 1.02-1.18, p=0.02) (Table 13 and Figure 17).

There were no associations between a 10 µg/m³ rise in PM$_{2.5}$ and EAD for the MPDS categories of cardiac or respiratory arrest, unconscious/fainting, heart problems (non-chest pain) or all non-trauma causes combined (Table 13).
Figure 16: Adjusted odds ratios and 95% confidence intervals for EAD for the dispatch categories of breathing problems, stroke and diabetic problems at 0-46 hour lag periods, CAD database
Table 13: Adjusted odds ratio, 95% confidence interval and \( p \)-value for a 10 \( \mu g/m^3 \) rise in \( PM_{2.5} \) for all causes and selected EAD dispatch categories at same day and 1-day lag, CAD database*

<table>
<thead>
<tr>
<th>Dispatch category</th>
<th>Number of cases</th>
<th>Same day (lag 0-24 hours)</th>
<th>1-day lag (24-48 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>All causes</td>
<td>14476</td>
<td>1.00</td>
<td>0.99–1.01</td>
</tr>
<tr>
<td>All non-trauma causes</td>
<td>9219</td>
<td>0.99</td>
<td>0.98–1.01</td>
</tr>
<tr>
<td>Chest pain (non-traumatic)</td>
<td>1788</td>
<td>0.98</td>
<td>0.95–1.02</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>1292</td>
<td>1.02</td>
<td>0.98–1.05</td>
</tr>
<tr>
<td>Unconscious / fainting</td>
<td>961</td>
<td>0.99</td>
<td>0.95–1.03</td>
</tr>
<tr>
<td>Stroke</td>
<td>364</td>
<td>1.10</td>
<td>1.02–1.19</td>
</tr>
<tr>
<td>Heart problems (non-chest pain)</td>
<td>325</td>
<td>0.99</td>
<td>0.91–1.08</td>
</tr>
<tr>
<td>Diabetic problems</td>
<td>157</td>
<td>1.07</td>
<td>0.96–1.18</td>
</tr>
<tr>
<td>Cardiac or respiratory arrest/death</td>
<td>128</td>
<td>0.98</td>
<td>0.83–1.14</td>
</tr>
</tbody>
</table>

OR: Odds ratio; CI: confidence interval
Figure 17: Adjusted odds ratios and 95% confidence intervals for a 10 µg/m³ rise in PM$_{2.5}$ and EAD at same day (0-24 hour) and 1-day (24-48 hour) lag, selected MPDS categories and overall, CAD database
3.3.2. VACIS analysis

In the second analysis of the VACIS dataset, a 10 μg/m$^3$ was positively associated with the FPA of asthma at lag times of 0-4, 15, 28, 29, 31-33 and 37-40 hours (Figure 18). This association remained significant on the same day (OR 1.21, 95% CI 1.04-1.41, $p=0.02$) and at 1-day lag periods (OR 1.27, 95% CI 1.06-1.52, $p=0.01$)(Table 14 and Figure 19).

No associations were observed between a 10 μg/m$^3$ rise in PM$_{2.5}$ and EAD with the FPA of acute coronary syndrome, angina/chest pain, cardiac arrest, dizziness/syncope, diabetic problems, shortness of breath, COPD or stroke (Table 14).

![Graph](image)

Figure 18: Adjusted odds ratios and 95% confidence intervals for EAD for asthma per 10μg/m$^3$ increase in PM$_{2.5}$, 0-46 hour lag periods
Table 14: Adjusted odds ratio, 95% confidence interval and p-value for a 10 μg/m³ rise in PM$_{2.5}$ for selected EAD final primary assessment categories at same day and 1-day lag, VACIS database.

<table>
<thead>
<tr>
<th>Final primary assessment</th>
<th>Number of cases</th>
<th>Same day lag (0-24 hours)</th>
<th>1-day lag (24-48 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Angina or chest pain</td>
<td>397</td>
<td>0.96</td>
<td>0.88–1.04</td>
</tr>
<tr>
<td>Acute coronary syndrome</td>
<td>304</td>
<td>0.99</td>
<td>0.91–1.07</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>233</td>
<td>1.05</td>
<td>0.96–1.14</td>
</tr>
<tr>
<td>Dizziness or syncope</td>
<td>226</td>
<td>1.01</td>
<td>0.95–1.08</td>
</tr>
<tr>
<td>Diabetes</td>
<td>138</td>
<td>0.98</td>
<td>0.87–1.11</td>
</tr>
<tr>
<td>Stroke</td>
<td>114</td>
<td>1.08</td>
<td>0.98–1.19</td>
</tr>
<tr>
<td>COPD</td>
<td>105</td>
<td>0.90</td>
<td>0.75–1.08</td>
</tr>
<tr>
<td><strong>Asthma</strong></td>
<td><strong>72</strong></td>
<td><strong>1.21</strong></td>
<td><strong>1.04–1.41</strong></td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>41</td>
<td>1.00</td>
<td>0.70–1.42</td>
</tr>
</tbody>
</table>

OR: Odds ratio; CI: Confidence interval
Figure 19: Adjusted odds ratio and 95% confidence intervals for EAD by final primary assessment per 10 µg/m$^3$ rise in PM$_{2.5}$ at same day (0-24 hour) and 1-day (24-48 hour) lag, VACIS database.
4. Discussion

4.1. Main findings

The primary objective of our study was to assess whether a 10 µg/m³ rise in PM$_{2.5}$ was associated with an increase in all-cause, respiratory or cardiovascular EAD dispatch categories. We found that all-cause EAD were not increased but there were statistically significant increases in EAD for the dispatch categories of breathing problems, diabetic problems and stroke at hourly lag times ranging from 12 to 46 hours. The dispatch category of stroke remained significantly increased on the same day and at 1-day lag. There were positive association between a 10 µg/m³ rise in PM$_{2.5}$ and the dispatch categories of diabetic problems and breathing problems at 1-day lag which did not reach statistical significance.

Our secondary objective was to determine if a 10 µg/m³ rise in PM$_{2.5}$ was associated with an increase in selected categories of FPA. Among the FPA categories analysed, we found a positive association with asthma, for which a 10 µg/m³ increase in PM$_{2.5}$ was associated with significant increases at a range of lag-times between zero and 40 hours. This association was also significant for the same day and at 1-day lag. No associations were observed between a 10 µg/m³ increase in PM$_{2.5}$ and the other FPA categories of acute coronary syndrome; angina or chest pain; cardiac arrest; dizziness/syncope; diabetic problems, shortness of breath; COPD or stroke.

It was unexpected that the results of our primary and second analyses were not consistent in that different conditions were associated with elevations in PM$_{2.5}$ concentrations. These differences may have occurred because of the way EAD dispatch categories and the FPA are selected or because the numbers within each category were small. The dispatch category of breathing problems would be expected to include the FPA of asthma, which may explain the positive associations across these two categories. However, the other FPA category that would be expected to be included within the dispatch category of breathing problems—COPD—was not increased. As there were only 105 cases with an FPA of COPD it is possible that there were too few cases in this category to accurately assess this relationship. Notwithstanding, there were only 72 cases with the FPA
of asthma, and a positive association was observed. Alternatively, it may be that COPD cases were not affected by PM generated from the landscape fires or that the FPA for COPD is not representative of COPD exacerbations. Verification of the FPA of COPD with other health service settings, such as in general practice or emergency departments, would be useful to further assess this relationship.

There were 364 cases with a dispatch category of stroke and 114 cases with an FPA of stroke during the study period. While the odds ratio was positive across the two analyses, ranging from 1.04 to 1.10 among the same day and 1-day lag periods, the confidence intervals were broad indicating uncertainty in the results. It is possible that the results would have been significant if there were more cases with an FPA of stroke. A similar study of EAD in Australia by Salimi et al., which assessed the relationship between PM$_{2.5}$ and the MPDS category of stroke, did not find an increase associated with landscape fires despite the study being carried out over a longer time period and across a larger population (17).

In contrast, other studies including a systematic review have found a relationship between exposure to PM$_{2.5}$ and stroke (31-33) and the GBD Study 2016 estimate that ambient air pollution causes 14 per cent of deaths due to stroke globally (2). However, many of the studies have looked at stroke following chronic exposure to air pollution, which might partially explain the discrepancy.

Our finding that the dispatch category of diabetic problems was increased at lag times of 26, 36, 38-40, 45 and 46 hours and that there was a non-significant positive association at one day lag is interesting and warrants further investigation. It is consistent with the findings from a study investigating the relationship between PM$_{2.5}$ and emergency medical services calls in the United States that found a statistically significant positive association between PM$_{2.5}$ and diabetes on the same day as emergency medical services calls (19). Several studies have found interactions between exposure to PM and glucose homeostasis (34, 35) and a number of studies have found an association between long-term exposure to PM and prevalence of type 2 diabetes (36-38).

The nature of the diabetic problem that prompted a request for the EAD in our study—such as hypoglycaemia or hyperglycaemia—is not known, and the finding was not confirmed in our FPA analysis, therefore our results need to be interpreted with caution.
The finding of increased concentrations of PM$_{2.5}$ not being associated with the dispatch category of chest pain is consistent with some, but not all, other studies (17, 19). This may be because the dispatch category of chest pain is not specific and has been shown to have a wide range of causes, including cardiovascular, gastrointestinal and psychological problems (17). Only a proportion of these are likely to be affected by PM$_{2.5}$ exposure. Our finding that a rise in PM$_{2.5}$ was not associated with EAD for the dispatch category of cardiac or respiratory arrest or death contrasts with several other studies (14-16, 39, 40). However, the confidence intervals for this category were also wide therefore the results should be interpreted with caution.

Our finding that EAD for the FPA of asthma increased following a rise in concentration of PM$_{2.5}$ was expected. It has been well established that exposure to air pollution increases asthma prevalence and exacerbations (41-46) through direct irritant effects of air pollution and airway hyperresponsiveness that occurs among asthmatics (45).

The lag time between the exposure of cases to increased concentrations of PM$_{2.5}$ and the acute health events of between 12 and 47 hours across all our results is consistent with findings in other studies that the health effects of landscape fire smoke are often delayed by hours up to several days (13, 15, 47). The physiological mechanism for the lag time is not completely understood but has been shown to occur as a consequence of the direct irritant and pro-inflammatory effects of PM, which trigger metabolic processes involving cytokine release, oxidative stress, thrombosis and coagulation, and take time to have actual health consequences (40, 45).

### 4.2. Strengths

A major strength of this study was that PM$_{2.5}$ concentrations were matched geospatially with the EAD. Geospatial information, which provides more precise estimates of the exposure of cases to PM$_{2.5}$, is not available in other settings, such as emergency departments of hospitals. Another strength of this study was the time-stratified case crossover design where cases act as their own controls, thus removing confounding factors, such as age, sex and comorbidities.
4.3. Limitations

Our study of a dispersed population was relatively small in its size and time frame compared with other environmental epidemiological studies. Analyses within individual MPDS and FPA categories were underpowered to detect small associations that may have existed. Matching the ambulance datasets resulted in a loss of approximately 20% of the cases which further limited our analysis.

We did not distinguish between the sources of PM$_{2.5}$ or other air pollutants but it is unlikely that sources other than fire smoke significantly contributed to exposures because of the low population density and limited number of industrial and traffic sources of air pollution in Tasmania. Although fire smoke is a mixture of hundreds of different aerosols and gases, PM is recognised as the primary driver of adverse health impacts from fire smoke (1, 12). The Tasmanian Environmental Protection Agency (EPA) monitor the concentrations of several industrial and vehicle generated pollutants in Tasmania (ozone, nitrogen dioxide, carbon monoxide and sulfur dioxide) through the BLANkET network, and concentrations are consistently found to be well below national standards (23).

The MPDS dispatch categories are designed to facilitate rapid ambulance dispatch and have not been validated against a final diagnosis either by an ambulance officer or a medical practitioner therefore we cannot conclude that an increase in the dispatch category of stroke, diabetic problems or breathing problems and an increase in the FPA of asthma represents a definite increase in these conditions. Salimi et al. showed that MPDS categories are followed by a wide range of FPA by ambulance officers (17). Likewise, the FPA by the ambulance officer has not been validated against the final clinician diagnosis or International Classification of Disease (ICD) codes in emergency department or hospital settings. A study of patients presenting with dyspnoea in New Zealand found the accuracy of the paramedic diagnosis was 79% but differed according to the final diagnosis (48). Other studies of EAD have used different methods to group the FPA and no single validated technique exists. Further research to identify the reasons for EAD dispatch categories and to align FPA categories with ICD-10 codes would increase the validity of these types of analysis.
Type one statistical error may have occurred in our logistic regression, which involved multiple measurements for ambulance dispatch and FPA categories. To reduce the type one error, the results of our hourly analysis of lag times for were all interpreted in the context of the same day and 1-day lag periods, and this is consistent with similar air pollution studies.

Finally, we used interpolation to estimate the PM$_{2.5}$ concentration at the case locations from the neighbouring BLANKET station and we did not adjust for other weather conditions, such as wind direction, therefore it is possible that there were some inaccuracies in the exposure estimates. Given that 95 per cent of the Tasmanian population reside within 20 kilometres of a BLANKET station (49) our estimate is likely to be close to the actual concentration experience by the cases.

4.4. Public health significance

During the study period, 24-hour average PM$_{2.5}$ concentrations of up to 500 µg/m$^3$ were recorded by BLANKET network air monitoring stations, 50-fold higher than an increase of 10 µg/m$^3$ in PM$_{2.5}$ which we used to determine significance in our analysis. The highest recorded concentration of PM$_{2.5}$ during the study period was 1910 µg/m$^3$.

For stroke, an odds ratio of 1.1 at 1-day lag corresponds to a 10 per cent increase in EAD for stroke for every 10 µg/m$^3$ rise in PM$_{2.5}$. This would equate to a 100 per cent increase—or doubling—of stroke-related EAD following an increase of 100 µg/m$^3$ in PM$_{2.5}$. For asthma, the odds ratio of 1.2 at 1-day lag corresponds to a 20 per cent increase in EAD for asthma for every 10 µg/m$^3$ rise in PM$_{2.5}$ and a 200 per cent increase following a 100 µg/m$^3$ rise in PM$_{2.5}$.

In real numbers a rise in PM$_{2.5}$ of 100 µg/m$^3$ across Tasmania for two days would be expected to increase the number of EAD for the dispatch category of stroke from four to eight per day and for the FPA of asthma to increase from one to three per day. These changes may not have an impact on ambulance services given there are daily fluctuations in the number of ambulances required across the state. However, if our findings applied to smoke events in other large cities in Australia, such as Melbourne or Sydney, the impact could be far greater. A recent study investigating the impact of smoke-related PM$_{2.5}$ on all-cause
mortality and hospitalisations for cardiovascular and respiratory conditions in Sydney (population of approximately five million, 10-fold greater than Tasmania) estimated that there were 29 cardiovascular hospitalisations and 14 deaths due to hazard reduction burns during a single month in 2016 (50).

Landscape wildfires, which are the greatest natural disaster risk posed to Tasmania, are expected to increase in frequency and severity due to global warming (51, 52). The fires that occurred in this study period caused the second largest loss of vegetation in the state in recorded history (52). In addition to the ecological and economic impact of landscape fires, the contribution of landscape fire smoke to the global burden of disease via acute cardiovascular and respiratory events is increasingly being recognised. Preparing for landscape fire events and promoting methods to reduce the harms of smoke exposure, such as through the use of air filters, are important areas for public health officials to focus on into the future. Our findings, in conjunction with other similar studies, can also be used by emergency services to prepare for and estimate demand during bushfires. We recommend targeting priority populations, such as the elderly, who have the highest age-specific rate of ambulance usage, to mitigate potential harms.

5. Conclusion

Our study was designed to detect if there was an increase in all-cause or selected categories of EAD that have previously been associated with acute health effects from exposure to fire smoke. It was prompted by public health interest in the health effects of fire smoke following a summer with several severe smoke events in Tasmania. While there was no increase in all-cause EAD, we found that an increase of 10 µg/m³ in PM$_{2.5}$ during the study period was positively associated with an increase in EAD for the dispatch categories of stroke, breathing problems and diabetic problems at a range of lag times between 12 and 46 hours and the FPA of asthma at lag times between zero and 40 hours. There were also significant increases in the dispatch category of stroke and the FPA of asthma on the same day and at 1-day lag and non-significant associations between the dispatch categories of breathing problems and diabetic problems at 1-day lag.
This study indicates that increased concentrations of PM$_{2.5}$ are associated with an increased demand for selected ambulance dispatch categories. However, the absolute increase is small and may not have an impact on ambulance services unless the PM$_{2.5}$ concentration increase is very high and sustained for several days within or adjacent to a large population, such as in a capital city in mainland Australia.

These findings add to the emerging evidence for acute respiratory and cardiovascular events associated with exposure to landscape fire smoke. Our findings have important public health implications for the emergency sector and public health professionals and support the development of early warning systems, public health alerts and communication plans to prepare for, and respond to, future smoke events.


Appendices

Appendix 2: Copy of the article published in *Fire, July 2018*

*Article*

**Did Fine Particulate Matter from the Summer 2016 Landscape Fires in Tasmania Increase Emergency Ambulance Dispatches? A Case Crossover Analysis**

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**Abstract.** During summer in early 2016, over 70 landscape fires in Tasmania (Australia) caused several severe episodes of fire smoke across the island state. To assess the health impact of the fire smoke, a case crossover analysis was performed, which measured the association between increased concentrations of PM 2.5 and emergency ambulance dispatches (EAD) from 1 January to 31 March 2016. Control days were matched by latitude and longitude, day of the week and calendar month. Exposure data were obtained from air quality monitoring stations at lag times of 1–48 h and for the 24-h mean on the same day and 1-day lag. Positive associations were observed between an increase of 10 μg/m³ in PM 2.5 and EAD for stroke on the same day (OR 1.10, 95% CI 1.02–1.19) and at 1-day lag (OR 1.10, 95% CI 1.02–1.18). Furthermore, there were non-significant increases in breathing problems (OR 1.04, 95% CI 1.00–1.08) and diabetic problems (OR 1.11, 95% CI 0.99–1.22) at 1-day lag. The EAD for all causes were not increased. These findings will be used for ambulance service planning and public health risk communication in future landscape fire events.

**Keywords:** particulate matter; landscape fire smoke; emergency ambulance dispatches

1. **Introduction**

During an unusually hot and dry summer in early 2016, over 70 landscape fires within a 60-day period in Tasmania (Australia) caused severe episodes of fire smoke across the island state. The concentrations of fine particulate matter (microscopic particles with diameters of less than 2.5 micrometers that are suspended in the air; PM 2.5) were recorded to have an average of up to 500 μg/m³ over 24 h, which are far higher than the Australian National Environment Protection Measure (NEPM) standard of an average 24-h concentration of 25 μg/m³. Given the emerging evidence for acute health effects of landscape fire smoke exposure [1], the aim of this study was to investigate if smoke from the Tasmanian landscape fires caused an increase in acute health events.

The health effects of air pollution are predominately due to PM 2.5 generated during combustion. These include acute effects, such as asthma exacerbations, myocardial infarction and stroke, and chronic...
effects, such as chronic obstructive pulmonary disease (COPD) and lung cancer. Globally, ambient air pollution is the leading environmental cause of death, resulting in 4.2 million deaths each year (7.6% of all deaths) [2]. The major global causes of death that are attributable to ambient air pollution include COPD (27.1%), lung cancer (16.5%), ischemic heart disease (17.1%) and cerebrovascular disease (14.2%) [2]. Among the global burden of disease from ambient air pollution, 340,000 deaths each year have been attributed directly to landscape fire smoke [3].

The previous studies in the setting of landscape fire smoke exposure have shown an increase in acute respiratory conditions [4,5], cardiac arrest [6], cardiovascular mortality [1], non-traumatic emergency department attendances [7] and all-cause mortality [18,9], with the elderly and people with pre-existing health conditions being most at risk [5].

Few epidemiological studies have assessed the health effects of air pollution in Australia. One study in Sydney, the largest city in Australia, attributed 2.1% of all deaths to PM$_{2.5}$ and ozone exposure [10]. The Global Burden of Disease Study estimated that ambient air pollution causes 12.7 deaths per 100,000 per year in Australia, including 5.8% of deaths due to COPD, 5.6% of deaths from ischemic heart disease, 3.8% of stroke deaths, 4.4% of lower respiratory infection deaths and 2.5% of lung cancer deaths [11]. Acute health conditions are often recorded in hospital or emergency department settings. However, these data are limited to the location at which the patient is treated and do not provide information on the exposure of cases to PM$_{2.5}$.

Emergency ambulance dispatches (EAD) provide information on acute health events and offer an advantage in the studies of environmental exposures by providing geospatial information for cases. The studies of fire smoke exposure and EAD have shown an increase in cardiovascular events, including out-of-hospital cardiac arrest [6,12–14] and chest pain [15]; respiratory problems [16,17]; diabetic symptoms [18]; syncope/fainting [18] and all non-traumatic causes combined [19,20].

The aim of this study was to determine if the increased concentrations of PM$_{2.5}$ from fire smoke in Tasmania from 1 January to 31 March 2016 were associated with an increase in all-cause, respiratory-related or cardiovascular-related EAD.

2. Materials and Methods

2.1. Setting

Tasmania is an island state in Southern Australia with a land mass of 68,000 km$^2$ and an estimated resident population of 518,000 in 2016. Tasmania has low concentrations of air pollution during summer with occasional peaks during landscape fires. The NEPM standards are exceeded periodically during winter months in the towns situated in plateaus or valleys due to domestic woodfire emissions. Very little air pollution is generated from industrial sources or traffic [21].

2.2. Study Design

A time-stratified case crossover design was used to measure the association between exposure to PM$_{2.5}$ and EAD. The case crossover design is used in environmental epidemiology to measure the effect of short-term environmental exposures on acute health conditions [22]. In this methodology, the cases also act as their own control. The cases included all individuals who required an EAD during the study period of 1 January to 31 March 2016. The cases were matched to controls according to the day of the week within the same calendar month, which resulted in three or four controls per case.

2.3. Exposure Data

Air pollution data were obtained from the Base Line Air Network of EPA Tasmania (BLANKeT), which is a network of 29 stations established to measure PM$_{2.5}$, along with meteorological variables obtained in the major cities and towns of Tasmania (Figure 1). BLANKeT data provides a good estimate of the population exposure to PM$_{2.5}$ with 95% of the Tasmanian population residing within 20 km of a station [15]. Hourly exposure data of PM$_{2.5}$, air temperature and relative humidity were extracted.
from the location (latitude and longitude) of the cases and controls. Exposures between the monitoring stations were estimated using inverse distance weighted (IDW) interpolation of the BLANKeT network data, using the gstat packaging in R 3.4 [23]. Exposure values were calculated at lag times of 0–48 h prior to the EAD and the 24-h average on the same day (0–24 h prior) and at 1-day lag (24–48 h lag).

![Location of the 21 Base Line Air Network of EPA Tasmania station. Most stations are located in the towns and cities in northern coastal, northeastern and southeastern Tasmania.](image)

**Figure 1.** Location of the 21 Base Line Air Network of EPA Tasmania station. Most stations are located in the towns and cities in northern coastal, northeastern and southeastern Tasmania.

### 2.4. Outcome Data

The primary endpoint of interest was EAD. An EAD was defined as an ambulance dispatched within Tasmania during the study period with information recorded on the dispatch category. EAD data were received from the Tasmanian Ambulance Service Computer Aided Dispatch System (CAD), which uses trained operators to answer emergency calls and dispatch ambulances. CAD is based on the 37 Medical Priority Dispatch System (MPDS) categories. The MPDS categories, which were developed by the International Academies of Ambulance Dispatch, are used throughout Australia and in comparable countries, such as the United Kingdom and the United States [15,24]. The data that were available included the time of the call, location of the incident, age and sex of the case and the MPDS category. Data on inter-facility transfers or motor vehicle crash notifications were not received. Cases that were categorized as “Standby” or that did not have an MPDS category were excluded. All-causes, all non-trauma causes and the MPDS categories that have previously been associated with acute health effects from PM [15,20,25] were analyzed. The categories included: chest pain; heart problems (non-chest pain); stroke; cardiac or respiratory arrest or death; breathing problems; diabetic problems; and unconscious or fainting.

### 2.5. Statistical Analysis

Population data from the Australian Bureau of Statistics [June 2015] were used to calculate age-specific and regional rates of ambulance usage. Statistical analyses were performed using Stata version 14.2 (Statacorp). A conditional multivariate logistic regression was performed to calculate adjusted odds ratios for the association between an increase of 10 μg/m³ in PM2.5 and EAD at the time of the event and at 1-h lag periods from 1–47 h prior to the EAD and for the same day (mean of 0–24 h prior to EAD) and at a 1-day lag (mean of 24–48 h prior to EAD). Covariates were the preceding 24-h
mean temperature and 24-h mean relative temperature. Odds ratios were considered to be significant if the 95% confidence interval did not cross 1 and p-values were <0.05.

2.6. Ethics

The study was approved by the Tasmanian Health and Medical Human Research Ethics Committee (Reference number H0012974) and the Australian National University Human Research Ethics Committee (Protocol 2016/603).

3. Results

Data were received on 14,512 EAD, of which 36 were excluded (these categorized as “Standby” or did not have an MPDS category). This resulted in a final total of 14,476 cases. The matching of cases to controls according to the day of the week within the month resulted in 48,984 controls. Males and females were equally represented (approximately 50% each). About half (7513; 52%) were from Southern Tasmania, which corresponds to a similar proportion of the Tasmanian population (262,500; 51%) (Table 1).

The average daily frequency of EAD across the study period was 160. Age-specific EAD was highest among the 85 and older age group with an average of 144 EAD per 100,000 population per day during the 91-day study period. This was 16-fold higher than the lowest age group of 5–14 years, which had an average of 9 EAD per 100,000 population per day over the study period. The most common MPDS categories were sick person (1925; 13%), chest pain (non-traumatic) (1788; 12%) and falls (1585; 11%) (Table 2).

<table>
<thead>
<tr>
<th>Total EAD</th>
<th>Number (%)</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAD</td>
<td>14,476 (100)</td>
<td>NA</td>
</tr>
<tr>
<td>Median Age (years)</td>
<td>57</td>
<td>42</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7216 (49.8)</td>
<td>255,728 (49.4)</td>
</tr>
<tr>
<td>Male</td>
<td>7174 (49.6)</td>
<td>261,860 (50.6)</td>
</tr>
<tr>
<td>Unspecified</td>
<td>86 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>3747 (26.0)</td>
<td>143,537 (27.7)</td>
</tr>
<tr>
<td>Northwest</td>
<td>3145 (21.8)</td>
<td>111,566 (22.0)</td>
</tr>
<tr>
<td>South</td>
<td>7513 (52.1)</td>
<td>262,485 (50.7)</td>
</tr>
</tbody>
</table>

Table 1. Demographic features, location and timing of the cases and the Tasmanian population.

<table>
<thead>
<tr>
<th>MPDS Category</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sick person</td>
<td>1925 (13.3)</td>
</tr>
<tr>
<td>Chest pain (non-traumatic)</td>
<td>1788 (12.4)</td>
</tr>
<tr>
<td>Falls</td>
<td>1585 (10.9)</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>1292 (8.9)</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>961 (6.6)</td>
</tr>
<tr>
<td>Abdominal pain/problems</td>
<td>913 (6.3)</td>
</tr>
<tr>
<td>Evaluation—interfacility</td>
<td>743 (5.1)</td>
</tr>
<tr>
<td>Traffic/transportation accidents</td>
<td>579 (4.0)</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>485 (3.4)</td>
</tr>
<tr>
<td>Convulsions/fitting</td>
<td>446 (3.1)</td>
</tr>
<tr>
<td>Hemorrhage/lacerations</td>
<td>421 (2.9)</td>
</tr>
<tr>
<td>Overdose/poisoning</td>
<td>408 (2.8)</td>
</tr>
<tr>
<td>Stroke</td>
<td>365 (2.5)</td>
</tr>
</tbody>
</table>

Table 2. Number and proportion of EAD by MPDS category in the period of 1 January to 31 March 2016.
During the study period, BLANKeT stations in northern Tasmania recorded two distinct periods of PM$_{2.5}$ that were higher than the NEPM standard (Figure 2). These periods corresponded with the landscape fires, of which most were in northern and northwestern Tasmania. Across the three major urban centers in Tasmania, the NEPM Standard was exceeded on two days in Hobart (southern Tasmania), six days in Launceston (northern Tasmania) and seven days in Devonport (northwestern Tasmania).

![Image](image-url)

**Figure 2.** Mean 24-h PM$_{2.5}$ concentration at Devonport (northwest Tasmania), Launceston (northern Tasmania), Hobart (southern Tasmania) and the NEPM 24-h standard in the period of 1 January to 31 March 2016.

In the multivariable analysis, there was no association between an increase of 10 μg/m$^3$ in PM$_{2.5}$ and all-cause EAD (same day OR 1.00, 95% CI 0.90–1.01, $p = 0.88$; 1-day lag OR 1.00, 95% CI 0.99–1.02, $p = 0.59$) (Table 3). In the analysis conducted according to selected MPDS dispatch categories, EAD for breathing problems were increased at lag times of 40 and 42 h (Figure 3) with a non-significant positive association at 1-day lag (OR 1.04, 95% CI 1.00–1.08, $p = 0.06$) (Table 3).

EAD for stroke were increased at lag times of 12–16, 19–22, 26–31 and 35 h (Figure 3) with significant positive associations on the same day (OR 1.10, 95% CI 1.02–1.19, $p = 0.01$) and at 1-day lag.
times (OR 1.10, 95% CI 1.02–1.18, p = 0.02) (Table 3). Diabetic problems were increased at lag times of 26, 36, 38–40, 45 and 46 h (Figure 3) and there was a non-significant positive association at 1-day lag (OR 1.11, 95% CI 0.99–1.22, p = 0.08) (Table 3).

No associations were observed for an increase of 10 μg/m³ in PM$_{2.5}$ and EAD for cardiac or respiratory arrest, unconscious/fainting, heart problems (non-chest pain) or non-trauma causes (Table 3).

**Table 3.** Adjusted odds ratio, 95% confidence interval and p-value for an increase of 10 μg/m³ in PM$_{2.5}$ for all causes and selected EAD dispatch categories at same day and 1-day lag.

<table>
<thead>
<tr>
<th>Dispatch Category</th>
<th>Number (%)</th>
<th>Same Day Lag (6–21 h)</th>
<th>p-Value</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p-Value</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes</td>
<td>14474 (100)</td>
<td>1.00</td>
<td>0.99–1.01</td>
<td>0.88</td>
<td>1.00</td>
<td>0.99–1.02</td>
<td>0.99</td>
<td>0.99–1.02</td>
<td>0.59</td>
</tr>
<tr>
<td>Non-trauma causes</td>
<td>9219 (63.7)</td>
<td>0.99</td>
<td>0.98–1.01</td>
<td>0.37</td>
<td>1.00</td>
<td>0.98–1.01</td>
<td>0.59</td>
<td>0.99–1.01</td>
<td>0.77</td>
</tr>
<tr>
<td>Chest pain (non-traumatic)</td>
<td>1788 (12.4)</td>
<td>0.98</td>
<td>0.95–1.02</td>
<td>0.34</td>
<td>0.99</td>
<td>0.95–1.01</td>
<td>0.40</td>
<td>0.95–1.01</td>
<td>0.49</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>1292 (8.9)</td>
<td>1.02</td>
<td>0.98–1.05</td>
<td>0.36</td>
<td>1.04</td>
<td>0.99–1.09</td>
<td>0.18</td>
<td>0.95–1.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>961 (6.6)</td>
<td>0.99</td>
<td>0.95–1.03</td>
<td>0.39</td>
<td>0.99</td>
<td>0.95–1.04</td>
<td>0.79</td>
<td>0.95–1.04</td>
<td>0.79</td>
</tr>
<tr>
<td>Stroke</td>
<td>364 (2.5)</td>
<td>1.10</td>
<td>1.02–1.19</td>
<td>0.24</td>
<td>1.10</td>
<td>1.02–1.19</td>
<td>0.02</td>
<td>1.02–1.19</td>
<td>0.02</td>
</tr>
<tr>
<td>Heart problems (non-chest pain)</td>
<td>325 (2.2)</td>
<td>0.99</td>
<td>0.81–1.16</td>
<td>0.84</td>
<td>0.95</td>
<td>0.81–1.08</td>
<td>0.37</td>
<td>0.81–1.08</td>
<td>0.37</td>
</tr>
<tr>
<td>Diabetic problems</td>
<td>157 (1.1)</td>
<td>1.07</td>
<td>0.86–1.32</td>
<td>0.21</td>
<td>1.10</td>
<td>0.96–1.22</td>
<td>0.08</td>
<td>0.96–1.22</td>
<td>0.08</td>
</tr>
<tr>
<td>Cardiac or respiratory arrest/death</td>
<td>128 (0.9)</td>
<td>0.98</td>
<td>0.83–1.14</td>
<td>0.76</td>
<td>1.00</td>
<td>0.88–1.13</td>
<td>0.98</td>
<td>0.88–1.13</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Figure 3. Cont.
4. Discussion

In this study, the elevations in PM$_{2.5}$ concentration were associated with significant increases in EAD for the dispatch categories of breathing problems, diabetes and stroke at hourly lag times of 12–46 h. In the analysis over 24-h time periods, an increase of 10 µg/m$^3$ in PM$_{2.5}$ was associated with a significant increase in EAD for stroke on the same day and at 1-day lag. There were positive associations between an increase of 10 µg/m$^3$ in PM$_{2.5}$ and the dispatch categories of diabetic problems and breathing problems at 1-day lag although these associations did not reach statistical significance.

The lag time between the exposure to elevated concentrations of PM$_{2.5}$ and the acute health event is consistent with findings in other studies as the health effects of landscape fire smoke are usually delayed by hours up to several days. The physiological mechanisms for the lag time is not completely understood but has been shown to occur as a consequence of the direct irritant and pro-inflammatory effects of PM. These effects trigger metabolic processes, involving cytokine release, oxidative stress, thrombosis and coagulation, which take time to have actual health consequences [26–29].

The finding of increased concentrations of PM$_{2.5}$ not being associated with the dispatch category of chest pain is consistent with some, but not all, other studies [15,18]. This may be because the dispatch category of chest pain is not specific and has been shown to have a wide range of causes, including cardiovascular, gastrointestinal and psychological problems [15]. Only a certain proportion of these are likely to be affected by PM$_{2.5}$ exposure. The finding of increased PM$_{2.5}$ concentration not being associated with cardiac arrest contrasts with the results of several other studies [12–14,26,30]. However, the confidence intervals for this category were wide and therefore, the results should be interpreted with caution.

At a population level, an odds ratio of 1.1 for the dispatch category of stroke at 1-day lag corresponds to an increase of 10% in EAD for stroke for every 10 µg/m$^3$ increase in PM$_{2.5}$. This would equate to a 100% increase—or doubling—of stroke-related EAD following an increase of 100 µg/m$^3$ in PM$_{2.5}$. During the study period, 24-h average PM$_{2.5}$ concentrations of up to 300 µg/m$^3$ were recorded (highest single reading of 2000 µg/m$^3$) by the BLANKeT network air monitoring stations, which were 30-fold higher than an increase of 10 µg/m$^3$ in PM$_{2.5}$. These findings could have an impact on ambulance services in Tasmania during severe smoke events. Notwithstanding, the daily average number of EAD for stroke in Tasmania is small and an increase in all-cause EAD was not found, which may have been expected. This suggests that other factors may also contribute. In comparison, a study investigating the impact of smoke-related PM$_{2.5}$ on all-cause mortality and hospitalizations for cardiovascular and respiratory conditions in Sydney (population of approximately 5 million, which is 10-fold greater than Tasmania) estimated that there were 29 cardiovascular hospitalizations,
58 respiratory hospitalizations and 14 deaths due to hazard reduction burns during a single month in 2016 [31].

A major strength of this study was that the PM2.5 concentration was matched geospatially with acute health events as measured by EAD. This information is not available in other settings, such as emergency departments or hospitals, and it provides a more precise estimate of the association between exposure to PM2.5 and EAD. Another strength of this study was the time-stratified case crossover design where cases act as their own controls, thus removing confounding factors, such as age, sex and comorbidities.

A limitation of the study was that it was undertaken over a relatively short time-frame compared with other environmental epidemiological studies, which resulted in small sample sizes within MPDS categories. Another limitation is that MPDS clinical categories are designed to facilitate rapid ambulance dispatch and do not consistently correspond with a final diagnosis that corresponds with the International Classification of Diseases coding system [15]. Therefore, it cannot be concluded that an increase in the dispatch category of stroke, diabetic problems or breathing problems represents a definite increase in these conditions.

This study did not distinguish between the sources of PM2.5 or other air pollutants but it is unlikely that sources other than fire smoke significantly contributed to exposures because of the low population density and limited number of industrial and traffic sources of air pollution in Tasmania. The Tasmanian Environmental Protection Agency report that ambient levels of industrial and vehicle generated pollutants (ozone, nitrogen dioxide, carbon monoxide and sulfur dioxide) are very low, while smoke from landscape fires and domestic wood heaters is the major contributor to air pollution in Tasmania [21]. Screening for these pollutants does take place and concentrations are consistently found to be well below national standards. Fire smoke is a mixture of hundreds of different aerosols and gases. In the context of open burning, PM can be considered as a marker of this mixture and it is recognized as the primary driver of adverse health impacts from fire smoke [1,8].

Finally, a type 1 statistical error may have occurred in the logistic regression at hourly lag times across multiple ambulance dispatch categories. To reduce the type 1 error, the results of each dispatch category analysis were interpreted at hourly lag times in the context of the same day and 1-day lag periods, which has been done in previous studies.

Landscape wildfires, which are the greatest natural disaster risk posed to Tasmania, are expected to increase in frequency and severity due to global warming [32,33]. In addition to the ecological and economic impact of landscape fires, the contribution of landscape fire smoke to the global burden of disease via acute cardiovascular and respiratory events is increasingly being recognized. Preparing for landscape fire events and promoting methods to reduce the harms of smoke exposure, such as through the use of air filters, are important areas for public health officials to focus on into the future.

5. Conclusions

In this study, an increase of 10 µg/m³ in PM2.5 was positively associated with an increase in EAD for the dispatch categories of stroke, breathing problems and diabetic problems at lag times of 12–47 h. There was also an increase in stroke on the same day and at 1-day lag and non-significant associations between breathing problems and diabetic problems at 1-day lag. There was no increase in all-cause EAD. This study indicates that increased concentrations of PM2.5 are associated with an increased demand for selected ambulance dispatch categories. However, the absolute increase is small and may not have an impact on ambulance services unless the PM2.5 concentration increase is very high and is sustained for several days within or adjacent to a large population, such as in a capital city in mainland Australia.

These findings, which were obtained from a relatively small and dispersed population during a period of multiple landscape fires, add to the expanding literature on the acute health effects of exposure to landscape firesmoke. In particular, we found that increased concentrations of PM2.5 from fire smoke are associated with a range of acute health effects and have a significant impact on public
health at a population level. These findings will be used for ambulance service planning and by public health professionals in developing communication plans to prepare for and respond to landscape fires into the future.

**Author Contributions:** Conceptualization, L.E. and F.J.; Methodology, L.E., F.J. and FS.; Validation, F.J. and FS.; Formal Analysis, L.E.; Investigation, L.E.; Resources, C.W. and F.J.; Data Curation, C.W. and L.E.; Writing-Original Draft Preparation, L.E.; Writing-Review & Editing, S.W., M.V. and F.J.; Visualization, L.E.; Supervision, F.J., S.W. and M.V.; Project Administration, F.J.

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**Acknowledgments:** Laura Edwards is a Master of Philosophy in Applied Epidemiology (MAE) Scholar at the National Centre for Epidemiology and Population Health, Australian National University and a Public Health Medicine Registrar at the Department of Health and Human Services, Tasmania. Her position at the Department of Health was funded by the Australian Department of Health Specialist Training Program. The authors would like to acknowledge the contributions of Petre Otabal at Menzies Institute for Health Research for providing statistical advice on the study and John Innis at the Environmental Protection Agency providing feedback on the study findings and report.

**Conflicts of interest:** The authors declare no conflict of interest.

**References**


27. Guarneri, M.; Balnes, J.R. Outdoor air pollution and asthma. Lancet 2014, 383, 1581–1592. [CrossRef]


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Appendix 3: Copy of the slides presented at the TEPHINET international conference in Chiang Mai, August 2017

Background

* Ambient air pollution is the leading environmental cause of death globally. 2.0 million deaths annually.
* 87% of the world’s population live in areas exceeding the World Health Organization’s annual air quality limits.
* Australia: estimated 2.1% of all deaths in Sydney due to air pollution.

Fine particulate matter (PM$_{2.5}$)

* January – February 2016
* Over 70 separate bushfires in Tasmania, Australia
* 2nd largest area of land burnt in recorded history
* PM$_{2.5}$ levels up to 2000 μg/m$^3$ (Standard <25 μg/m$^3$)
* Health effects unknown

Investigation question

 Were concentrations of fine particulate matter from 1 January to 31 March 2016 in Tasmania associated with an increase in emergency ambulance dispatches?

Case crossover study design

Exposure: PM$_{2.5}$ (Bunyaville)

Outcome: Emergency ambulance response

<table>
<thead>
<tr>
<th>Hour</th>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
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<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis

- Adjusted odds ratios for a 10 unit rise in PM\textsubscript{2.5}
  - All causes and category of ambulance dispatch
  - At the time of the event
  - At 1-47 hour lag periods
  - 24 hour mean for same day (0-24 hour) and 1 day (24-48 hour) lag
  - Conditional multivariate logistic regression
  - Covariates: temperature and relative humidity

Results: descriptive analysis

- PM\textsubscript{2.5} range 0-487 µg/m\textsuperscript{3}
- 14,476 emergency ambulance dispatches (average 161 per day)
- 7236 (50%) female
- Median age 57 (range 0-101)

Results: Adjusted odds ratios for a 10 unit rise in PM\textsubscript{2.5} and emergency ambulance dispatch for selected categories at same day and 1 day lag

Discussion

- 1% increase in breathing problems, diabetic problems and stroke at 1 day lag
  - 10 unit rise in PM\textsubscript{2.5} would lead to 1 additional ambulance dispatch per 100
  - 100 unit rise in PM\textsubscript{2.5} would lead to 10 additional ambulance dispatches per 100
- Consistent with several other studies:
  - Air pollution associated with selected health conditions
  - Health effects of air pollution are often delayed by 24 hours

Limitations:

- Relatively small population and short time-frame
- Dispatch categories not validated to represent true diagnosis

Strengths:

- Cases qualified = better estimate of exposure = more accurate results
- Study design eliminates confounding factors between cases and controls e.g. age, sex, comorbidities
Conclusion and recommendations

- Fine particulate exposure was associated with emergency ambulance dispatches for stroke, diabetic problems and breathing problems at different lag times
- Ambulance services recommended to plan for additional requirements during bushfire periods
- Tasmanian Fire Service recommended to ensure appropriate weather conditions before doing prevention burns
- Public Health Unit to develop communication system focusing on at-risk populations e.g. people with asthma

Acknowledgements

- Ray Johnston, Environmental Epidemiologist, Menzies Institute for Medical Research
- Grant Williamson, Spatial scientist, University of Tasmania
- Forhad Satemi, Postdoctoral Fellow, University of Tasmania
- Eleanor Campbell, Project Manager, Menzies Institute for Medical Research
- Mark Velich, MME (EETP) Field Supervisor
- Stephanie Williams, MME (EETP) Academic Supervisor

Questions?

Daily mean concentration of PM$_{2.5}$ at the 3 major cities in Tasmania, January to March 2016

![Graph showing PM$_{2.5}$ concentration over time across major cities in Tasmania.](image-url)
AN OUTBREAK OF \textit{CAMPYLOBACTER} GASTROENTERITIS AT A HIGH TEA IN SOUTHERN TASMANIA
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Abbreviations

_Campylobacter_ spp: _Campylobacter_ species

CI: Confidence Interval

CDPU: Communicable Disease Prevention and Control Unit

DoH: Department of Health

EHO: Environmental Health Officer

NAAT: Nuclear Acid Antigen Testing

NNDSS: National Notifiable Diseases Surveillance System

AOR: Adjusted Odds Ratio

PCR: Polymerase Chain Reaction

RR: Relative Risk

WGS: Whole Genome Sequencing
**Prologue**

**My role**

I was the lead investigator in the outbreak with assistance from the OzFoodNet epidemiologist. I was involved in all aspects of the investigation except for the environmental health and laboratory investigations. My role included coordinating the outbreak response, interviews with attendees, data entry, data analysis, organising meetings with the outbreak team, presenting the findings and writing the outbreak report.

**Lessons learnt**

In this outbreak investigation, I learnt a lot from the Food Safety Officers and OzFoodNet epidemiologist about the nature and limitations of food safety inspections and environmental health aspects of outbreak investigations. I also learnt several lessons in the use of questionnaires in outbreak investigations. We had around six people in the team that administered the questionnaires and the completeness of the data varied. This could have been improved if all the team members had been trained in how to administer the questionnaires. We chose to use paper-based questionnaires because some members of the team preferred to have an original copy in case data were lost but it would have been more efficient to enter the data electronically into EpiInfo or a similar program. In performing the epidemiological analysis for this outbreak, I was able to apply some of the techniques I learnt during course block at NCEPH, such as multivariable analysis using Stata.

**Public health implications**

Like many outbreaks, this one occurred when kitchen staff were busy, under pressure and working in an unfamiliar environment. These reinforce the importance of systems to maintain safe food handling and cooking practices when kitchen staff are under pressure. Ensuring staff receive adequate training and that food preparation premises are routinely inspected will help to reduce the risk of similar outbreaks in the future.
The findings were shared in the Public Health Services quarterly communicable diseases report in June 2016. In the report, medical practitioners were reminded to notify suspected cases of food or waterborne illness to Public Health Services as required under the Tasmanian Guidelines for Notifying Diseases and Food Contaminants.

Acknowledgements

I would like to thank the OzFoodNet Epidemiologist, Michelle Harlock, who initially approached me to become involved in this outbreak. The DoH Food Safety Officers, Stewart Quinn and Sven Rasmussen, shared their knowledge of the environmental health aspects of the outbreak response and the head of surveillance at the time of this outbreak, David Coleman, provided historical context for this outbreak and others. Mark Veitch was the Acting Director of Public Health at the time of this outbreak and my Field Supervisor who contributed to the investigation as well as this report. Finally, Alice Richardson at ANU reviewed the multivariable analysis.

Selection of foods served at the High Tea (photo courtesy of a function attendee)
Abstract

Background

Campylobacteriosis, caused by infection with *Campylobacter* species, is the most common cause of bacterial gastroenteritis globally (1) and the third most common notifiable disease in Australia (2). On 13 and 19 May 2016, two confirmed cases of campylobacteriosis in people who had attended a Mother’s Day High Tea in Southern Tasmania on 8 May 2016 were reported to the Communicable Diseases Prevention and Control Unit (CDPU) at the Tasmanian Department of Health.

Methods

We established an outbreak response team comprising the MAE Scholar, OzFoodNet epidemiologist, Public Health Services Food Safety Officers, local council Environmental Health Officers (EHO) and Communicable Disease Prevention and Control Unit (CDPU) public health nurses. The aims of the outbreak investigation were to identify the source of the outbreak and to prevent further cases of illness. We performed a comprehensive outbreak investigation including epidemiological, environmental and laboratory investigations.

Results

We interviewed 90 of the 111 people who attended the High Tea (response rate 81%). The overall attack rate was 45 per cent (31/90). In the univariable analysis, three variables were associated with a significant relative risk for illness, consumption of sweet potato cupcakes (relative risk [RR] 4.9, 95% Confidence Interval [CI] 1.3 – 18.8, p=0.00), consumption of chicken wontons (RR 4.3, 95% CI 1.1 – 16.5, p=0.01) and attending the second sitting of the High Tea (RR 2.2, 95% CI 1.2 – 4.1, p=0.01). In the multivariable analysis, the only variable significantly associated with illness was the time of attending the High Tea (Adjusted odds ratio 3.6, 95% CI 1.2-10.6, p=0.02). In the environmental investigation it was determined that chicken wontons may not have been adequately cooked. In the laboratory investigation, four clinical specimens from the cases and one sample of leftover chicken mince were found to contain *Campylobacter jejuni*. 
Conclusions

The epidemiological, environmental and laboratory investigations in our study supported our hypothesis that contaminated chicken wontons were the likely source of the outbreak but we could not exclude cross contaminated sweet potato cupcakes as an alternative cause. To prevent future clusters and outbreaks, it is important to ensure food handlers are adequately trained in safe food handling and cooking practices, particularly for poultry. The reason for the high notification rate of campylobacteriosis in Tasmania is not known. Further research would help to identify the reasons for, and inform strategies to reduce, the burden of disease in Tasmania. Ongoing education of healthcare practitioners on the importance of reporting suspected food or water-borne illnesses should be encouraged.
1. Introduction

1.1. Background

*Campylobacter* species are gram-negative bacteria that can infect humans and a wide range of animals (3). Campylobacteriosis—disease caused by infection with species of *Campylobacter*—is reported by the World Health Organization (WHO) to be the most common cause of bacterial gastroenteritis globally (1). It is estimated to cause illness in ten per cent of the world’s population and 33 million deaths each year (1).

There are 26 species of *Campylobacter* of which *Campylobacter jejuni* and *Campylobacter coli* are the most common causes of disease in humans (3-5). Infection occurs following exposure to contaminated food, water or animals (such as pets, live poultry, sheep and cattle) or through person-to-person transmission (6) but almost all food can become cross contaminated with *Campylobacter* spp. In Australia, undercooked meat is the most common source of infection, especially poultry, which is estimated to account for 50-70% of infections (5).

Many cases of infection with *Campylobacter* spp. are subclinical (3). Children, travellers, adults on acid-suppression treatment (such as proton pump inhibitors) and people who are immunosuppressed are more likely to experience clinical features of disease (3, 7-9). Among those who develop clinical features, symptoms develop after an incubation period of one to ten days—usually two to five days—and are generally indistinguishable from other causes of gastroenteritis. Common symptoms are nausea, vomiting, abdominal pain, watery diarrhoea and fever. Most people recover within seven days, but a small minority (<1%) develop invasive infections, such as bacteraemia, meningitis, pericarditis and myocarditis, which can occasionally lead to death (3, 4). Up to five per cent of cases also develop post-infectious sequelae including Guillain-Barré syndrome, reactive arthritis and irritable bowel syndrome (1, 10-12).

As the disease is usually self-limiting only a minority of cases seek medical attention or have diagnostic testing. Indications for testing include suspected outbreaks, severe infection, prolonged infection or returned travellers (13). The
diagnosis is confirmed by molecular testing (polymerase chain reaction [PCR] or nucleic acid antigen testing [NAAT]) or culture of a stool specimen. Occasionally, other specimens, such as blood cultures, are used (14). Antibiotic therapy is recommended for severe or prolonged infections and in infants, the frail elderly, immunocompromised people and for pregnant women in the third trimester (13).

Most cases of campylobacteriosis appear to be sporadic although outbreaks also occur (15). In recent decades, outbreaks following consumption of undercooked chicken and duck liver products, such as pâté or parfait, have been increasingly reported (16-21). In Australia, campylobacteriosis is a notifiable disease under state and territory public health legislation. There were 13,424 cases of campylobacteriosis notified to the National Notifiable Disease Surveillance System (NNDSS) in 2017 making it the third most common notifiable disease in Australia (2).

Tasmania had the highest notification rate of campylobacteriosis in Australia in 2015 and 2016 with 201 cases per 100,000 in 2015 and 205 cases per 100,000 in 2016, above the national notification rate of 147 cases per 100,000 in 2016 (2). Reasons for the high notification rates in Tasmania are not known but studies have found high prevalence of *Campylobacter* spp. in raw chicken products in Tasmania (22).

In Tasmania, laboratories are required to notify confirmed cases of campylobacteriosis under the *Public Health Act 1997* (Tas). Notifications from laboratories are sent by facsimile to the Communicable Diseases Prevention and Control Unit (CDPU) within Public Health Services, Tasmania Department of Health (DoH). In addition to laboratory-notifiable cases of campylobacteriosis, suspected food or waterborne illnesses are also required to be notified to the Director or Public Health Officer by medical practitioners. Details are specified in the Tasmanian Guidelines for Notifying Diseases and Food Contaminants (23).

Individual cases are not routinely investigated due to the large number of notifications and high frequency of sporadic cases but staff within CDPU review the number and location of notifications at fortnightly surveillance meetings with the aim of detecting clusters in time or place or outbreaks. Suspected
clusters or outbreaks of gastroenteritis are investigated by staff within the CDPU and usually coordinated by the OzFoodNet epidemiologist. The aims of outbreak investigations are to identify the source of the outbreak to prevent further cases of campylobacteriosis and to introduce public health measures to prevent further outbreaks occurring.

1.2. Outbreak identification

On 11 May 2018 a phone call was received by a staff member at the Communicable Diseases Prevention and Control Unit (CDPU) from a woman who reported two cases of gastroenteritis following attendance at a Mother’s Day High Tea in Southern Tasmania. She reported symptoms of gastroenteritis in herself and her daughter, who had been admitted to hospital and diagnosed with campylobacteriosis. Following the report, an inspection of the food premises at which the High Tea had taken place was undertaken on 13 May by the local council Environmental Health Officer (EHO). Telephone contact was made with the daughter on 16 May by the OzFoodNet epidemiologist, but she declined to be interviewed. No further action was taken until three days later, on the 19 May 2016, when a Food Safety Officer at DoH was notified from a local council staff member of another confirmed case of campylobacteriosis in a woman who had attended the same Mother’s Day High Tea.

The three cases were recognised as a suspected outbreak as defined in the Tasmanian Guidelines for the investigation of foodborne outbreaks of gastroenteritis as “the occurrence of disease or a health event in excess of the expected number of cases for a given time or place” (23)

2. Methods

2.1. Aims and objectives

The aims of our outbreak investigation were to identify the source of the outbreak and to prevent further cases of illness. Our objectives were:

- To confirm the existence of an outbreak of gastroenteritis among attendees at the Mother’s Day High Tea on 8 May 2016
• To generate a hypothesis and test it using analytical epidemiology to identify the most likely source of the outbreak

• To perform an environmental health investigation to assist in identification of the source of the outbreak

• To perform a laboratory investigation to confirm the organism implicated in the outbreak and to supplement epidemiological and environmental investigations

• To institute immediate prevention and control measures if the results of the environmental inspection or food samples revealed there was an ongoing risk of further cases of gastroenteritis.

• To improve understanding of the epidemiology of gastrointestinal pathogens and to ensure the results of the investigation were shared with other jurisdictions through the OzFoodNet network

2.2. Outbreak response

We initiated an investigation following the Tasmanian Guidelines for Investigation of Foodborne Outbreaks of Gastroenteritis (23). Our outbreak response team included the MAE Scholar, OzFoodNet epidemiologist, Public Health Food Safety Officers, local council Environmental Health Officer (EHO) and CDPU Public Health nurses. We informed the Director of Public Health and the CDPU surveillance coordinator of the suspected outbreak and provided them with regular updates throughout the investigation.

2.3. Epidemiological investigation

2.3.1. Hypothesis generation

Following receipt of the menu from the restaurant owners we developed our initial hypothesis, that undercooked chicken served in chicken wontons at the Mother’s Day High Tea were contaminated with *Campylobacter* spp and resulted in an outbreak of gastroenteritis. This was based on the previous experience that undercooked chicken is a common cause of campylobacteriosis and the recognition that chicken wontons were the only poultry served at the function.
2.3.2. Study design

We undertook descriptive analysis and a retrospective cohort study of the High Tea participants using information provided by cases and non-cases. Cases were defined according to the outbreak case definitions for probable or confirmed cases. Non-cases were people who attended the High Tea on 8 May 2016 who did not meet the criteria for a probable or confirmed case.

2.3.3. Case definitions

Case definitions for probable and confirmed cases included:

**Probable case:** a person who experienced diarrhoea (three or more bowel motions within 24 hours) on or after 8 May 2016 who ate at the Mother’s Day High Tea on 8 May 2016

**Confirmed case:** a laboratory-confirmed case of campylobacteriosis notified to CDPU on or after the 8 May 2016 in a person who ate at the Mother’s Day High Tea on 8 May 2016

2.3.4. Case ascertainment

We requested a booking list from the restaurant owners for the High Tea. We then contacted the attendees by telephone and asked them to participate in a telephone questionnaire. We also asked for the details of other members in their group at the function. If we were unable to contact an attendee by telephone, we left voicemail messages asking them to call back to provide information. Up to four attempts were made to contact cases. Once we were able to contact the attendees, we provided information on the reason for the study and the confidential nature of their participation. We then obtained verbal consent to participate. Participants were invited to contact the Public Health Unit if they wanted to follow up the final results of our investigation.

2.3.5. Data collection

We conducted telephone interviews with the High Tea attendees who agreed to participate using a standard paper-based gastrointestinal illness questionnaire and an additional questionnaire developed from a list of menu items obtained from the function organisers. In addition to the food and drinks consumed at the High Tea, the questionnaire also included information on demographic
characteristics; clinical features, including symptoms, onset, duration and medical visits; and laboratory investigations. A copy of the questionnaire is in Appendix 4.

2.3.6. Data analysis

We performed a t-test (for age) and Pearson’s chi-squared test (for sex) to determine if there were significant differences between the cases and non-cases. We calculated the attack rates and relative risk of illness for each food item consumed at the High Tea. Relative risks were considered significant if the 95% confidence interval did not cross one and the p-value was less than 0.05 (five per cent). We then conducted stratified and multivariable analysis for the factors identified in the univariate illness to be associated with a significantly elevated relative risk for illness and other potential confounders including age and sex.

2.4. Environmental health investigation

The first site visit was performed by a local council EHO after the initial phone call to CDPU to report two cases of gastroenteritis in attendees at the High Tea but before it was recognised that an outbreak had occurred. The EHO inspected the restaurant kitchen storage, food preparation and cooking facilities. Following the identification of the outbreak a DoH Food Safety Officer performed a second site visit. This inspection entailed a more detailed interview with the restaurant owners in relation to the storage, transport, cooking and temperature monitoring of foods served at the High Tea and a food safety inspection of the kitchen where the food was prepared and examination of the food handling practices by the kitchen staff. The menu and booking lists were also obtained.

2.5. Laboratory investigation

We obtained the laboratory results for all the cases that had a specimen collected in association with their illness. We also sent samples of any leftover food from the High Tea to the public health laboratory for microbiological testing.
2.6. Ethics

Formal ethical approval from a Human Research Ethics Committee for the study was not required as the investigation and outbreak response were consistent with the requirement of the Director of Public Health to investigate and manage suspected outbreaks under the Public Health Act 1997 (Tas).

3. Results

3.1. Epidemiological investigation

3.1.1. Descriptive epidemiology

There were 111 attendees at the Mother’s Day High Tea. Of the people who had attended, 90 were able to be contacted by telephone and consented to be interviewed for the investigation resulting in a response rate of 81%. The first sitting of 12pm was attended by 46 (51%) of the respondents and the second sitting time of 2pm was attended by 44 (49%) of the respondents. The ages of participants ranged from one to 83 years with a median age of 35 years.

Of the 31 cases that met the case definition there were four confirmed cases and 27 probable cases resulting in an overall attack rate of 45 per cent. Cases were slightly younger than non-cases (median age 32 versus 37 years) and more likely to be female (61% versus 39%) but these differences were not statistically significant (Table 15).

Aside from diarrhoea, which was in the case definition, the commonly reported symptoms were abdominal pain (77%), nausea (71%) and headache (61%) (Table 15). Among those that did not meet the case definitions for a probable or confirmed case, there were several people who reported diarrhoea (less than three loose stools within 24 hours), nausea, vomiting and abdominal pain.
Table 15: Summary of the demographic and clinical characteristics of the cases and non-cases in the cohort study

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Cases</th>
<th>Non-cases</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%)</td>
<td>Number (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total respondents</td>
<td>31 (34)</td>
<td>59 (66)</td>
<td>—</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (39)</td>
<td>14 (24)</td>
<td>0.13</td>
</tr>
<tr>
<td>Female</td>
<td>19 (61)</td>
<td>45 (76)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>1-74</td>
<td>2-83</td>
<td>—</td>
</tr>
<tr>
<td>Median</td>
<td>32</td>
<td>37</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Clinical characteristics

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Non-cases</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visited GP</td>
<td>10</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Diarrhoea (any)</td>
<td>31 (100)</td>
<td>2 (6)</td>
<td>—</td>
</tr>
<tr>
<td>Diarrhoea (3 or more stools in 24 hours)</td>
<td>31 (100)</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Bloody stool</td>
<td>3 (10)</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Nausea</td>
<td>22 (71)</td>
<td>5 (8)</td>
<td>—</td>
</tr>
<tr>
<td>Vomiting</td>
<td>6 (19)</td>
<td>1 (2)</td>
<td>—</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>24 (77)</td>
<td>7 (12)</td>
<td>—</td>
</tr>
<tr>
<td>Headache</td>
<td>19 (61)</td>
<td>3 (5)</td>
<td>—</td>
</tr>
<tr>
<td>Lethargy</td>
<td>24 (77)</td>
<td>6 (19)</td>
<td>—</td>
</tr>
</tbody>
</table>

The time between attendance at the High Tea and illness onset ranged from zero to six days with a mean of 2.1 days. The peak in the epidemic curve was one day after the function with around one third of cases (32%) reporting an onset of illness of one day. Most (90%) cases reported illness onset within the three days immediately after the function (Figure 1).
Among the food items that were consumed at the High Tea, the highest attack rates were for sweet potato cupcakes with vanilla frosting (44%), sweet potato and sunflower pie (44%), chicken wontons (43%), and chilli popcorn (43%) (Table 16).

### 3.1.2. Univariate analysis

The attack rate and relative risk for illness for each food item is shown in Table 16. Two foods had a relative risk for illness that reached statistical significance, sweet potato cupcakes (relative risk [RR] 4.9, 95% Confidence Interval [CI], 1.31–8.8, \( p = 0.00 \)) and chicken wontons (RR 4.3, 95% CI, 1.1–16.5, \( p = 0.01 \)). People who attended the second sitting were also more likely to become ill (RR 2.2, 95% CI, 1.2–4.1, \( p = 0.01 \)).
Table 16: Attack rate of illness for each of the food items consumed at the High Tea and relative risk of illness for consumption versus non-consumption, 95% confidence interval and p-value

<table>
<thead>
<tr>
<th>Foods consumed</th>
<th>Ate</th>
<th>Did not eat</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Total</td>
<td>Attack rate (%)</td>
</tr>
<tr>
<td>Banoffee pie</td>
<td>19</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>Panna Cotta</td>
<td>25</td>
<td>68</td>
<td>37</td>
</tr>
<tr>
<td>Sweet potato cupcake</td>
<td>27</td>
<td>61</td>
<td>44</td>
</tr>
<tr>
<td>Crème fraiche scone</td>
<td>27</td>
<td>69</td>
<td>39</td>
</tr>
<tr>
<td>Chocolate peanut biscotti</td>
<td>25</td>
<td>61</td>
<td>41</td>
</tr>
<tr>
<td>Chocolate mousse</td>
<td>4</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>Sweet potato pie</td>
<td>8</td>
<td>18</td>
<td>44</td>
</tr>
<tr>
<td>Green tea jelly</td>
<td>2</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Pumpkin pie</td>
<td>18</td>
<td>49</td>
<td>37</td>
</tr>
<tr>
<td>Mushroom Pea Slider</td>
<td>23</td>
<td>58</td>
<td>40</td>
</tr>
<tr>
<td>Chicken wonton</td>
<td>27</td>
<td>63</td>
<td>43</td>
</tr>
<tr>
<td>Miso cured salmon</td>
<td>20</td>
<td>53</td>
<td>38</td>
</tr>
<tr>
<td>Chickpea butter ribbon</td>
<td>2</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Chilli popcorn</td>
<td>3</td>
<td>7</td>
<td>43</td>
</tr>
<tr>
<td>Junior burger</td>
<td>4</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td>Frozen banana</td>
<td>3</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Food</td>
<td>Cases</td>
<td>Total</td>
<td>Attack rate (%)</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
<td>-------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Kids cupcake</td>
<td>2</td>
<td>9</td>
<td>22</td>
</tr>
<tr>
<td>Kids Fruit salad</td>
<td>4</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>Caramel popcorn</td>
<td>3</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Tea</td>
<td>23</td>
<td>63</td>
<td>37</td>
</tr>
<tr>
<td>Coffee</td>
<td>4</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>Sparkling Wine</td>
<td>9</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Berry Mojito</td>
<td>6</td>
<td>13</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 17: Attack rate of illness for the time of attending the High Tea and relative risk of illness among group 2 attendees, 95% confidence interval and p-value.
3.1.3. Stratified analysis

We were unable to perform stratified analysis to determine the relative risk of illness among the 29 cases who consumed chicken wontons or sweet potato cupcakes because all the cases reported eating both chicken wontons and sweet potato cupcakes or had eaten neither chicken wontons or sweet potato cupcakes (Table 18).

Table 18: Number of cases who reported eating or not eating chicken wontons and sweet potato cupcakes

<table>
<thead>
<tr>
<th>Variable</th>
<th>No sweet potato cupcake</th>
<th>Ate sweet potato cupcake</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (%)</td>
<td>Number (%)</td>
<td></td>
</tr>
<tr>
<td>No chicken wontons</td>
<td>2 (100)</td>
<td>0 (0)</td>
<td>2</td>
</tr>
<tr>
<td>Ate chicken wontons</td>
<td>0 (0)</td>
<td>27 (100)</td>
<td>27</td>
</tr>
</tbody>
</table>

3.1.4. Multivariable analysis

In our multivariable analysis, attending the second group time of 2pm was the only variable that had a significantly elevated adjusted odds ratio (Table 19). However, when we repeated the multivariable analysis with chicken wontons and sweet potato cupcakes separately, both were associated with significantly elevated adjusted odds ratios (Table 20 and Table 21). Our sample size was too small to include age categories. Inclusion of age as a binary outcome (adult or child) and sex did not affect the results.

Table 19: Adjusted odds ratios, 95% confidence interval and p-value following multivariable analysis of age, sex and selected foods

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted Odds Ratio</th>
<th>95% Confidence interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (≥18 years)</td>
<td>4.8</td>
<td>0.4-58.3</td>
<td>0.22</td>
</tr>
<tr>
<td>Female sex</td>
<td>2.1</td>
<td>0.7-7.1</td>
<td>0.21</td>
</tr>
<tr>
<td>Group time (2pm)</td>
<td><strong>3.6</strong></td>
<td><strong>1.2-10.6</strong></td>
<td><strong>0.02</strong></td>
</tr>
<tr>
<td>Chicken wonton</td>
<td>5.8</td>
<td>0.5-69.5</td>
<td>0.16</td>
</tr>
<tr>
<td>Sweet potato cupcake</td>
<td>6.2</td>
<td>0.7-51.2</td>
<td>0.09</td>
</tr>
</tbody>
</table>
3.2. Environmental investigation

The initial inspection of the premises on 13 May by the local council EHO revealed that the restaurant owners that ran the function were operating under satisfactory conditions. They had held the High Tea at a function centre they did not regularly use as a standalone event for Mother’s Day.

The second detailed inspection by the DoH Food Safety Officer on 19 May following identification of the outbreak determined from the food company owners that chicken wontons, each containing approximately one teaspoon of chicken mince, had been prepared two days prior to the High Tea in the restaurant owned by the function organisers. The wontons were transported to the function centre the day prior to Mother’s Day in a refrigerated vehicle and stored in a cool room overnight. Aside from the cool room, there was no fridge at the function centre to store frequently accessed items. The chicken wontons were then cooked in boiling water without temperature monitoring and a timer was not used to ensure they were adequately cooked. It was reported that there may have been mixing of the wontons at different stages of cooking due to staff being under pressure to serve food, which may have resulted in some undercooked chicken wontons being served. The only leftover food from the function was frozen chicken mince which had been used to make the chicken wontons.
During our interviews with attendees, several individuals reported that they had noticed pink chicken mince in the chicken wontons they were served, although this was not specifically included in the study questionnaire.

Figure 21: Chicken wontons served at the High Tea (photo courtesy of a function attendee)

3.3. Laboratory investigation

Four cases had stool specimens collected which were positive for *Campylobacter jejuni*. A single sample of leftover frozen chicken mince was sent for laboratory testing on 19 May and was also positive for *Campylobacter jejuni*.

3.4. Outbreak management

We followed the *Tasmanian Guidelines for the Investigation of Foodborne Outbreaks of Gastroenteritis* (23) and informed the Director of Public Health of our findings at regular meetings of the outbreak investigation Team. As there were no items of food that had been taken home by attendees and no other items from the High Tea that continued to be served at the owner’s usual restaurant aside from frozen chicken mince, the ongoing public health risk from the outbreak was deemed to be very low. We decided not to issue a Public Health Alert or to take any formal action against the restaurant, but the owners were reminded of the importance of safe food handling practices and to ensure adequate cooking for any further use of the mince. The leftover chicken mince
that remained in the freezer at the restaurant was not recommended to be discarded as chicken meat is commonly contaminated with *Campylobacter* spp.

4. Discussion

Our original hypothesis, that consumption of contaminated chicken wontons served at the Mother's Day High Tea on May 8 2016 resulted in a point source outbreak, was developed by the outbreak team following receipt of the menu of the foods served at the High Tea. It was based on previous outbreaks being linked to undercooked poultry and because of the high prevalence of *Campylobacter* spp. in raw chicken products in Tasmania. Many, but not all, of our investigations supported this hypothesis.

The steep rise in the shape of the epidemic curves is consistent with a point source outbreak and the finding that the majority of cases of illness occurred within 24 hours and up to six days after the function is consistent with the incubation period of *Campylobacter* spp. of one to ten days. A systematic review of the incubation period of *Campylobacter* spp. found that the average incubation period ranged from 2.5 to 4.3 days (24), which is slightly longer than the average incubation period of 2.1 days in our study.

One probable case in this outbreak occurred on the same day of the function, which is shorter than the incubation period reported in the systematic review (3). Possible explanations for this short time to symptom onset are that the case was misclassified and was in fact due to an alternative diagnosis or pathogen, that it was due to a different source not associated with the High Tea or because the incubation period was shorter than is commonly reported. Short incubation periods of less than 24 hours in outbreaks of campylobacteriosis have been described with one Australian outbreak investigation reporting that 71% of cases (12/17) had onset within 24 hours (25). In addition to the single probable case with rapid onset, several people we interviewed reported that they had vomiting or diarrhoea within hours of attending the High Tea. These cases did not meet the case definition of three or more loose stool within 24 hours and were not included in the investigation. It is possible that they were misclassified or that there was a separate illness, such as Norovirus, that also occurred.

In our cohort study, the highest attack rate occurred among people who consumed chicken wontons and sweet potato cupcakes and both these food
items had a significantly elevated relative risk for illness among the High Tea attendees. We were not able to perform a stratified analysis of these two foods because of the high degree of collinearity between them. This also affected our multivariable analysis whereby sweet potato cupcakes and chicken wontons were individually associated with an increased risk of illness, but not when included in the logistic regression together. Given that poultry and dairy are the most commonly reported cause of outbreaks of *Campylobacter* spp, resulting in 41 and 29 per cent of outbreaks respectively in a systematic review of campylobacteriosis outbreaks (24), it is also possible that the sweet potato cupcakes, which were iced with vanilla frosting, may also have been contaminated with *Campylobacter*. We were unable to test either of the two food items, so we will never know the with certainty the true source of the outbreak.

The only variable that was significantly associated with an increased risk of illness in our multivariable analysis was the time of attendance at the High Tea, with attendees at the second sitting more likely to report illness. This may have occurred because of a change in cooking or food hygiene practices during the second sitting or because leftover food from the first function that had not been refrigerated may have been served.

The environmental investigation supported our initial hypothesis that *Campylobacter jejuni* in undercooked chicken wontons was the likely cause of the illness but did not rule out an alternative contaminated source. During interviews with patrons and staff it was revealed that the function was very busy, and the food service was delayed. We were informed by staff that there was no temperature monitoring or timers used to ensure the chicken wontons were adequately cooked and there were anecdotal reports from patrons of having observed pink chicken mince in the wontons. Additionally, staff shortages and unfamiliarity with the kitchen, which was not their usual restaurant, may have resulted in a breakdown in food hygiene and safe cooking practices.

Our laboratory investigation also supported our hypothesis. The laboratory confirmation of *Campylobacter jejuni* among four cases and in a sample of frozen chicken suggests the chicken mince was the source of the outbreak but, as with the other investigations, does not exclude another contaminated source.
In this outbreak, ten of the 31 cases sought medical attention and one case was hospitalised, but none of the medical practitioners involved in the clinical management of the cases notified CDPU of a potential outbreak. The outbreak was only detected following two separate phone calls to CDPU from different attendees who had confirmed campylobacteriosis.

Despite the requirement for healthcare practitioners to report suspected cases of food or water-borne illness in Tasmania under the Public Health Act 1997, notification to CDPU by health practitioners is uncommon. This may be due to a range of factors such as cases seeing different healthcare professionals, the frequency of self-limiting viral gastrointestinal illnesses and a lack of awareness or history-taking in relation to a possible foodborne outbreak. There are also few incentives for medical practitioners to detect outbreaks as it does not usually affect the clinical management of individual cases although it is important from a public health perspective to prevent further cases or outbreaks.

Ongoing education of healthcare practitioners on the importance of reporting of suspected food or water-borne illness and, in suspected outbreak situations, microbiological testing of stool specimens should be encouraged. Dissemination of the findings from outbreak investigations to healthcare practitioners, such as through a quarterly bulletin, may help to raise awareness and encourage notification in the case of future outbreaks, which in turn will result in earlier detection and response.

The reason for the high incidence rates of campylobacteriosis in Tasmania compared to the national average are not known. A likely explanation relates to the high prevalence of Campylobacter spp. in poultry farms and therefore in raw poultry products. One unpublished study of raw chicken in Tasmania found that 68 of 311 samples (61%) were positive for Campylobacter spp suggesting this might be the case (22). Several strategies to reduce the burden of disease in campylobacteriosis have been investigated using a paddock to plate approach.

An Australian investigation into the common transmission routes and vehicles that cause Campylobacter outbreaks in Australia recommended policy-level measures to reduce Campylobacter disease burden at commercial premises, aged care facilities and school camps (26). Further research to understand the
main transmission routes and causes of outbreaks of campylobacteriosis in Australia is in progress using data from the Outbreak Register.

Interventions in poultry farms and at the primary processing stage, such as disinfection and biosecurity measures, have been shown to be the most cost-effective strategies to reduce the burden of disease of Campylobacter (27-29). Unpasteurised milk is a common source of Campylobacter internationally, but consumption of unpasteurised milk in Australia is rare and therefore it is an uncommon source of campylobacteriosis (26). No vaccines are currently available to prevent Campylobacter infection in animals or humans, but a conjugate vaccine has been shown to reduce C. jejuni colonisation in chickens, and a vaccine for use in human vaccine is under manufacture and soon to be tested in a Phase one clinical trial (30).

A range of approaches to reduce the prevalence of Campylobacter spp. have successfully been implemented in New Zealand where there were very high rates of Campylobacter infection in the past. The measures included: changes in the procedures for catching and transporting chickens; cleaning transport crates; regular monitoring and reporting of the prevalence of Campylobacter spp. in poultry samples; enhanced consumer education; use of leak-proof packaging and implementation of an updated industry Code of Practice for primary processing of poultry (31). These measures have been implemented to varying degrees in Australia.

4.1. Strengths

Following the detection of this outbreak, a rapid response ensued, and we were able to ascertain quickly that there was no ongoing public health threat. We performed a comprehensive investigation, supplementing our environmental and laboratory investigations with an analytical epidemiological study. We also had a good response rate for the study, which reduces the chance of selection bias.

4.2. Limitations

There were some limitations to our study. Firstly, we conducted the interviews with the attendees of the High Tea approximately two weeks after the initial
functions which may have resulted in less accurate or incomplete recall by participants of the foods they had consumed at the function. The format of the function, whereby people sat in groups and were served a set menu with only minor variations based on dietary preferences, resulted in most people eating most items and this limited our ability to discern the specific item that was associated with the highest risk.

In compiling the data for our analysis, we found that there were several incomplete questionnaires. This is likely to have occurred because the questionnaires were completed by staff members, including local council EHOs, who did not receive training in the administration of the questionnaire. Completeness of the data may have been improved by a training session for the interviewers or by reducing the number of interviewers.

Stratified and multivariable analyses are designed to address confounding, but there was a high degree of collinearity between sweet potato cupcakes and chicken wontons, which meant we were unable to analyse these items separately. This affected our multivariable analysis, which indicated that the group time was the only significant variable unless we included chicken wontons and sweet potato cupcakes separately in the logistic regression model.

It is not routine practice for CDPU to send positive specimens of *Campylobacter* for whole genome sequencing in suspected outbreaks. However, the use of WGS may have been useful in this outbreak to confirm the cases and food specimen were linked. WGS is often used for outbreaks of *Salmonella* species and should be investigated as part of the routine investigation protocol for future outbreaks of *Campylobacter* in Tasmania to provide additional support for the causative agent.

Finally, we did not perform an economic analysis of this outbreak including the number of days of work or study missed, treatments sought and long-term sequelae, which may have provided additional information on the impact of the outbreak.

4.3. Recommendations

Ensuring safe food-handling practices are used by food handlers is a priority in preventing further outbreaks of campylobacteriosis. Currently, registered food
businesses in Tasmania are inspected regularly by local council EHOs but there are no mandatory training courses or modules to ensure all staff comply with current standards and there are no requirements for a supervisor to oversee kitchen staff. One option to improve food handlers understanding of the risks of food poisoning and importance of safe food handling is to have a dedicated food safety supervisor at each registered food business. The supervisor could then be responsible for overseeing food handling processes and ensure food safety standards are met.

In this outbreak, there appeared to be a discrepancy between knowledge and the process of cooking chicken wontons by kitchen staff, which is likely to have resulted in inadequately cooked chicken being served at the function. It was reported that the High Tea occurred in an environment that staff were unfamiliar with and the cooling facilities were inadequate. Ensuring staff are adequately prepared to work in new environments and that there are sufficient staff for the size of the function may also have helped to prevent this outbreak.

Methods to reduce the prevalence of Campylobacter spp. at their source, such as in farms and during processing warrant further investigation in Tasmania as they have been shown to lead to the greatest reduction on the burden of disease from Campylobacter spp. However, such measures are unlikely to be adequate given that there is such a high prevalence of Campylobacter spp. in poultry in Tasmania. Food safety measures to ensure poultry is sufficiently cooked and to prevent cross-contamination continue to be the most effective public health interventions.

Finally, ongoing education of clinicians to maintain a high index of suspicion for food or waterborne illness outbreaks will assist with early detection, and early public health response for future outbreaks.

5. Conclusion

In our investigation, which used epidemiological, environmental and laboratory techniques, we found that undercooked chicken wontons or contaminated sweet potato cupcakes served at a Mother’s Day High Tea on 8 May 2016 were the likely source of the point-source outbreak of campylobacteriosis. These findings are consistent with the known characteristics of Campylobacter spp. and
previous outbreak investigations. While there was no ongoing public health risk identified in this outbreak investigation, there were several important lessons learned.

The high attack rate of illness among attendees at the function of 45 per cent demonstrates the ability of *Campylobacter* species to cause large outbreaks of disease in Australia. Given the high level of contamination by *Campylobacter* species of raw chicken in Tasmania, ensuring staff are trained in safe food handling and cooking practices to reduce the risk of foodborne illness is essential to prevent further outbreaks of disease. Health practitioners also need to be reminded to be vigilant for possible food and water-borne outbreaks and reminded of the requirement to report suspected food and water-borne outbreaks to public health officials. Dissemination of surveillance data and outbreak investigation reports may help to raise awareness among health practitioners. Efforts to raise awareness among the public on practices to reduce the risks of foodborne illnesses should also be encouraged.

Tasmania has a high incidence of campylobacteriosis. Most cases are thought to be sporadic, but it is likely that clusters and outbreaks have occurred without being detected. Ongoing surveillance of *Campylobacter* spp. notifications to understand the epidemiology of campylobacteriosis in Tasmania should continue and research into the common causes and measures to reduce transmission will help to identify potential interventions in the future.

Prevention of cases through hygienic food handling and safe cooking practices is the most effective method to reduce the incidence of campylobacteriosis in Tasmania in the absence of comprehensive food chain measures which would require significant government and private industry investment. Introducing new methods, such as whole genome sequencing, to detect outbreaks of disease may assist in preventing and early detection of future outbreaks.
References


Appendices

Appendix 4: Copy of the outbreak investigation questionnaire

Gastroenteritis Outbreak Investigation Questionnaire

| Attempts to Contact Case | Date | Time | Comments | Date of Interview: .../.../...
|--------------------------|------|------|----------|-------------------------------
|                          |      |      |          | Interviewer: ....................
|                          |      |      |          | Person interviewed (if not the case) ..................................

Privacy Message: The information you provide in this questionnaire is for the purpose of trying to prevent further cases of illness. We do this by trying to find out what is likely to have caused your illness and also by providing you with information to reduce the spread of illness to others.

Case Details

<table>
<thead>
<tr>
<th>Surname/ Family Name</th>
<th>First Name</th>
<th>Street Address</th>
<th>Suburb</th>
<th>Post Code</th>
<th>Name of Parent/Guardian (if applicable)</th>
<th>Contact Details</th>
<th>Date of Birth</th>
<th>Sex</th>
<th>Country of birth</th>
<th>Language spoken at home</th>
<th>Occupation</th>
<th>High Risk Group?</th>
<th>Date Last Attended/ Returned to work/ child care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Home Tel:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes or No</td>
<td>Workplace/child care address:</td>
</tr>
</tbody>
</table>
### Treating doctor/hospital

Name of treating doctor:  
Address:  
Post code:  
Contact telephone:  
Facsimile:  
Consent given by doctor to interview  
- Yes  
- No  
Date consent provided:  
Did the case present to hospital?  
- Yes  
- No  
If yes, date presented:  
Was the case admitted to hospital?  
- Yes  
- No  
Name of hospital:  
Address:  
Date of admission:  
Date of discharge/death:  
Hospital URN (MRN):  

### Illness Summary

Onset Date:  
Time of onset:  
Date of Specimen collection:  
Type of specimen:  
- Faeces  
- Blood  
- Urine  
- Other  

#### Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhoea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Nausea</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Abdominal Pain</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Lethargy</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Headache</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other symptoms:

Total duration of illness:  hours/days

### Treatment

Were antibiotics given to treat the illness?  
- Yes  
- No  
If yes, what antibiotics:  
Are you still taking antibiotics?  
- Yes  
- No  
What date did you last take the antibiotics?  
Comments on treatment:  

...
## Contacts

In the two weeks **before or after** the onset of illness, did the case:

- Have contact with a family member with a similar illness?  
  - Yes  
  - No  
  - If yes, give details in the table below

- Have contact with a friend or work/school colleague with a similar illness?  
  - Yes  
  - No  
  - If yes, give details in the table below

<table>
<thead>
<tr>
<th>Name</th>
<th>Relationship</th>
<th>Address and Phone</th>
<th>Occupation/Childcare/School</th>
<th>Onset Date</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**Note:** A **sporadic gastroenteritis (cause unknown)** form should be completed for identified ill cases/contacts.

How well did the case recall the information (doctor's details, illness history and contacts)?  
- Very well  
- Well  
- Not Well  
- Not at all

## Food /Activity History

<p>| | | | |</p>
<table>
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</tbody>
</table>
If case is associated with a point source outbreak

- Attach Menu from the venue / common exposure
- Record all items eaten from the exposure

<table>
<thead>
<tr>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of interviewer (please print clearly)</td>
</tr>
<tr>
<td>Signature</td>
</tr>
<tr>
<td>Date / /</td>
</tr>
<tr>
<td>How long did this questionnaire take to complete?</td>
</tr>
</tbody>
</table>

Investigation notes

- Attach extra investigation notes if necessary
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you / your child eat food at the Mother's Day High Tea at Pear Ridge on the 8 May 2016?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>There was a choice of two menus and a separate children's menu. Did you / your child have the regular menu, the special dietary needs menu, or the kids menu?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>Regular Menu</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>Dietary Menu</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>2C</td>
<td>Children's Menu</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>

Did you (i your child) eat any of the following items from the menu? If you did not eat part of the item please specify the details about what wasn’t eaten.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Banoffee Pie</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Orange &amp; cardamom panna cotta, beetroot, lemon thyme.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sweet potato cupcake with vanilla bean frosting, rosemary</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Crème fraîche scone with apple jam and rose cream</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>6A</td>
<td>Crème fraîche scone</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>6B</td>
<td>Apple Jam</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>6C</td>
<td>Rose Cream</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Chocolate peanut biscotti</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chocolate Mousse, banana and bacon</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Sweet potato and sunflower pie</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Green tea, rose, blueberry jelly</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Scone with apple jam and rose cream</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>11A</td>
<td>Scone</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>11B</td>
<td>Apple Jam</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>11C</td>
<td>Rose Cream</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Spiced Maple Pumpkin Pie</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Mushroom Pea Slider</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Chicken wonton with palm sugar and pomegranate</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Miso cured salmon with pickled ginger, wasabi</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>15A</td>
<td>Miso cured salmon</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>15B</td>
<td>Pickled ginger</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>15C</td>
<td>Wasabi</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>16</td>
<td>Lemon and dill chick pea butter ribbon</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td></td>
<td>Item</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
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<tr>
<td>17</td>
<td>Chilli popcorn, palm sugar, pomegranate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Salmon sashimi, pickled ginger, wasabi</td>
<td></td>
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</tr>
<tr>
<td>18A</td>
<td>Salmon sashimi</td>
<td></td>
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<tr>
<td>18B</td>
<td>Pickled ginger</td>
<td></td>
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</tr>
<tr>
<td>18C</td>
<td>Wasabi</td>
<td></td>
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<tr>
<td>19</td>
<td>Jr ice</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>Frozen banana, chocolate (kids menu)</td>
<td></td>
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<tr>
<td>21</td>
<td>Cupcake (kids menu)</td>
<td></td>
<td></td>
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<tr>
<td>22</td>
<td>Fruit Salad (kids menu)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Caramel popcorn (kids menu)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>24</td>
<td>Were there any other foods eaten by you / your child at the High Tea function that I have not asked you about?</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
<td></td>
</tr>
<tr>
<td>24A</td>
<td>If Yes, please provide details of these foods:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Coffee</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Sparkling Wine</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>28</td>
<td>Berry Mojito</td>
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<td>29</td>
<td>Water</td>
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<td>Where there any other drinks consumed by you / your child that I have not mentioned?</td>
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<td>No</td>
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<td>30A</td>
<td>If yes, please provide details</td>
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EVALUATION OF THE TASMANIAN REAL-TIME PRESCRIPTION MONITORING SYSTEM
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Abbreviations

AHPRA: Australian Health Practitioner Regulation Agency
ANU: Australian National University
CDC: Centre for Disease Control
CMO: Consultant Medical Officer
CNCP: Chronic non-cancer pain
DAPIS: Drugs and Poisons Information System
DMR: Digital Medical Record
DORA: Drugs and Poisons Information System Online Remote Access
DoH: Department of Health
EAP: Expert Advisory Panel
ERRCD: Electronic Recording and Reporting of Controlled Drugs
IDU: Intravenous Drug Use
NCEPH: National Centre for Epidemiology and Population Health
NCIS: National Coronial Information System
NDARC: National Drug and Alcohol Research Centre
NHMRC: National Health and Medical Research Council
OMED: Oral Morphine Equivalent Dose
PBS: Pharmaceutical Benefits Scheme
PDMP: Prescription Drug Monitoring Program
PHT: Primary Health Tasmania
PSB: Pharmaceutical Services Branch
PSA: Pharmaceutical Society of Australia
RACGP: Royal Australian College of General Practitioners
RTPM: Real Time Prescription Monitoring
SA3: Statistical Area Level 3
THS: Tasmanian Health Service
Prologue

My role

The idea to evaluate the Tasmanian real-time prescription monitoring system (RTPMS) came up during a tea room conversation at Public Health Services between myself and the Chief and Deputy Chief Pharmacist. As a GP, I had a basic understanding of the remote access platform of the system available to GPs but had never used it. The topic of this evaluation appealed to me because opioid-related harms are a major public health issue and it aligned with my clinical interests. I led all aspects of the evaluation including its design, ethics applications, convening stakeholder meetings and writing the evaluation report. The final report was prepared for the Department of Health and for this thesis.

Lessons learnt

This was the most challenging and time-consuming of all my MAE projects. I found the RTPMS to be a complex system that has evolved over time and has many components that don’t immediately make sense to someone unfamiliar with the system. I had to develop, with stakeholders, the objectives and health events under surveillance based around the overall aim of the system. Recruitment of participants to interview and the process of analysing the interviews was logistically challenging and time consuming but rewarding and I learnt a lot through completing my thematic analysis of the interviews. I also found that adapting the CDC Guidelines for evaluating surveillance systems to the Tasmanian RTPMS was difficult, but the process taught me a lot about the important aspects of surveillance systems and evaluation in general.

Throughout this process I have read countless articles on opioid prescribing and real-time prescription monitoring, so I have developed sound content knowledge on the topic, which I have used in my role as a Public Health Physician at Primary Health Tasmania in providing Continuous Quality Improvement initiatives for GPs. I was also asked to provide Consultant Medical Advice to PSB to assess complex authority to prescribe applications.
Public health implications

This is the first evaluation of the Tasmanian RTPMS and its findings are relevant nationally as a national system is currently in development. It is the first time that the low participation rates of GPs that use the remote access platform have been measured and reported. We identified several reasons for the low participation rates and make several recommendations to improve participation. Our evaluation also demonstrates that staff that operate the RTPMS are valued for the support they provide to health practitioners and their rapid response to opioid-dispensing events in breach of authorised limits, such as doctor shopping.

We identified several limitations with the Tasmanian RTPMS such as the absence of objectives for the system and definitions for the information collected. We also identified several data limitations and the current absence of data analysis and interpretation that we have recommend be addressed.

Acknowledgements

I would like to thank all the stakeholders who participated in this evaluation and staff at the Pharmaceutical Services Branch of the Department of Health who have been consistently helpful in answering questions and providing information. Thanks also to the GPs and pharmacists who agreed to be interviewed and my supervisors who kept this evaluation on track.
Abstract

Background

The number of opioid prescriptions in Australia increased 15-fold between 1992 and 2012 (1) and Tasmania has the highest rate of opioid prescribing of all the states and territories in Australia (2). Harms associated with prescription opioids are a major public health issue and include adverse effects, increased risk of accidents, overdose and death (3). From 2001 to 2012, prescription opioid-related deaths in Australia increased by an average of six per cent each year from 21.9 per million population in 2001 to 36.2 per million population in 2012 (4).

Real-time prescription monitoring systems (RTPMS) monitor controlled drug dispensing events and provide information that enables the detection of doctor shopping and other inappropriate requests for controlled drugs. The aim of this evaluation was to determine if the Tasmanian RTPMS, known as the Drugs and Poisons Information System (DAPIS) and its remote access platform for clinicians, the Drugs and Poisons Remote Access Platform (DORA) is achieving its aim of reducing the harms associated with controlled drugs in Tasmania.

Methods

We performed a mixed methods evaluation following the United States Centre for Disease Control and Prevention Updated Guidelines for Evaluating Surveillance Systems (5). We structured the evaluation around assessment of the usefulness and attributes of the Tasmanian RTPMS. For our quantitative analysis, we observed DAPIS in action and gathered information from stakeholders and staff at the Pharmaceutical Services Branch (PSB) of the Tasmanian Department of Health (DoH). Where possible, we extracted data from DAPIS or other sources. For the qualitative analysis, we interviewed operators of the system at PSB and a representative sample of general practitioners (GPs) and pharmacists.

Results

DAPIS/DORA is a simple, stable and representative system. It has high sensitivity for detecting doctor shopping and excessive supply of opioids. It has
moderate acceptability among pharmacists but low acceptability among GPs as demonstrated by very low participation rates of less than one third of GPs. The positive predictive value could not be calculated. Data quality and timeliness vary across the different components of the system.

Two of five objectives of DAPIS/DORA have been achieved, to assess and monitor controlled drug dispensing events in real-time and to provide information that supports advice and recommendations from PSB staff to Tasmanian pharmacists and medical practitioners in relation to controlled drugs. Support provided by PSB staff, including advice and restrictions on opioid prescribing, was valued by GPs and pharmacists. Data collected by DAPIS/DORA are not analysed and disseminated. We identified several limitations in the storage of data including the use of an external host who charge a fee for extractions and the manual format of large amounts of data.

**Conclusions**

Insufficient evidence was available to determine if DAPIS/DORA has achieved its overall aim of a reduction in opioid-related harms in Tasmania. As a monitoring system, DAPIS/DORA enables PSB staff to detect doctor shopping and excessive supply of opioid medications. It also provides useful information to enable PSB staff to assess authority to prescribe applications by medical practitioners.

Our recommendations are based on the following five priority areas: 1) develop objective measures for the operation of DAPIS/DORA, 2) convert DAPIS/DORA from a monitoring system into a surveillance system, 3) improve the timeliness and quality of the data collected by DAPIS/DORA, 4) improve participation rates and acceptability of DORA by ensuring health practitioners have access and understand how and when to use it, and 5) enhance the role of the PSB in the quality use of opioids in Tasmania.
1. Introduction

1.1. Overview

This report describes the findings of an evaluation of the Tasmanian real-time prescription monitoring system, the Drugs and Poisons Information System (DAPIS) and its remote access platform for clinicians, the Drugs and Poisons Information System Online Remote Access platform (DORA).

The mixed-methods evaluation was performed using the Updated Guidelines for Evaluating Surveillance Systems, developed by the United States Centre for Disease Control (the CDC guidelines)(5). DAPIS/DORA is a system that enables the monitoring of controlled drugs in Tasmania and it has many of the elements of a surveillance system. However, it does not provide continuous analysis and interpretation of health data therefore it does not currently fulfil all the criteria for surveillance as defined by the World Health Organization as “the continuous, systematic collection, analysis and interpretation of health data needed for the planning, implementation and evaluation of public health practice” (6). For this reason, assessment of the data analysis and interpretation components of the system that would normally be included in a surveillance system evaluation have not been performed.

This report begins with information on the public health importance of prescription opioids and their related harms in Australia. The stakeholders involved in the evaluation are then listed followed by a description of the methods used for the evaluation. A detailed description of DAPIS/DORA follows including the purpose and operation of DAPIS/DORA and the resources used for its operation. We then describe the evidence regarding the utility and attributes of DAPIS/DORA. Finally, the significance of the findings are discussed in relation to the Australian and international context and a series of recommendations are provided.

1.2. Explanatory notes

In this evaluation, we have used the term opioid to refer to all controlled (Schedule 8) drugs and drugs of misuse potential. These include some non-opioid drugs, such as dexamphetamines and benzodiazepines. For situations
that refer just to opioid medications, we have used the term prescription opioids.

We refer to DAPIS and its remote access platform, DORA, available to registered health practitioners, as DAPIS/DORA throughout this evaluation. In situations that refer specifically to DAPIS or DORA, the individual names have been used. Details of the two platforms are described in System Components (page 181).

1.3. Background

1.3.1. Overview of opioid prescribing in Australia

Prescription opioids first became available in Australia in the 1950s but were not widely used until the 1990s, when a rapid increase coincided with pharmaceutical industry promotion of several new products, such as OxyContin, as safe, effective and non-addictive (7). Details on the adverse effects, harms of long-term use and the lack of evidence supporting the use of opioids for chronic non-cancer pain became recognised in the early 2000s. Despite this, the number of opioid prescriptions continued to rise during the 1990s and 2000s with a 15-fold increase in Australia between 1992 and 2012 (8, 9).

Tasmania has the highest rate of opioid prescribing in Australia, with the latest publicly available data reporting that 73,631 opioid prescriptions were dispensed through the Pharmaceutical Benefits Scheme (PBS) in 2013-14 per 100,000 people, 30 per cent higher than the Australian average of 55,126 prescriptions per 100,000 people (2). Four of 15 regions (statistical area level 3 [SA3]) in Tasmania are in the top ten areas with the highest rates of opioid prescriptions in Australia. Among these, the Central Highlands SA3 is highest at 110,172 prescriptions per 100,000 population in 2013-14, over ten times higher than the area with the lowest rate of prescribing, Darwin-Tiwi-West Arnhem SA3 at 10,945 opioid prescriptions per 100,000 population (Figure 22). The reasons for such wide variation in prescribing practices across Australia are not fully understood but attitudes towards pain, knowledge and training of medical practitioners, social pressures to prescribe opioid medications, access to pain specialists and effective alternatives to opioid medications have been identified as contributory factors (10-12).
1.3.2. Opioid-related harms

Harms associated with medical and nonmedical use of prescription opioids include direct adverse effects and an increased risk of accidents, overdose and death. Higher doses and frequent use of opioids are associated with a greater risk of harms, mental health disorders, underemployment and lower socioeconomic status (2, 13). The cost to the Australian government of prescription opioid misuse is estimated to be over $271 million annually (9).

Adverse effects of long-term use of opioids include tolerance, dependence, hyperalgesia, androgen deficiency, erectile dysfunction, sleep-disordered breathing and increased risk of myocardial infarction and fractures (7, 14, 15). Accidental and intentional poisoning from opioids are common causes of
hospitalisation and death and have increased in Australia in the last decade (4, 16).

From 1998 to 2009, the annual number of opioid-related hospitalisations in Australia increased from 605 to 1464 (9). Since 2001, prescription opioid hospitalisations have outnumbered heroin-related hospitalisations (9). In Tasmania, the number of hospital separations due to poisoning by opioids increased from 102 in 2010-11 to 176 in 2016-17 with only five deaths attributed to heroin suggesting that prescription opioids are a greater public health problem than non-prescription opioids in Tasmania (17).

An analysis of data from the National Coronial Information System estimated there were 4963 deaths in Australia from accidental and intentional pharmaceutical opioid overdoses between 2001 and 2012 (average 414 per year) (4). Over the same period, the annual incidence rate of deaths increased by an average of six per cent per year from 21.9 deaths per million in 2001 to 36.2 deaths per million in 2012. The highest incidence rates were among men and adults aged between 45 and 54 years (4).

1.3.3. Poisons legislation in Australia

Australian states and territories are responsible for legislation to regulate medicines and poisons. To ensure uniformity in their classification, the Australian Government maintains the Australian Government Standard for the Uniform Scheduling of Medicines and publish this list in the Poisons Standard (18). Currently all drugs in Australia are classified into Schedule 2 through 10. Schedule 8 drugs (controlled drugs) are defined as ‘those that require restriction of manufacture, supply, distribution, possession and use to reduce abuse, misuse and physical or psychological dependence’. In Tasmania, Schedule 8 drugs are regulated under the Poisons Act 1971 (Tas) and can only be prescribed by a medical practitioner or, in certain circumstances, only by selected specialist medical practitioners, such as pain or addiction specialists.

1.3.4. Real-time prescription monitoring systems

Real-time prescription monitoring systems (RTPMS) monitor and track controlled drug dispensing events in real-time with the aim of reducing misuse and diversion of controlled drugs thus leading to a reduction in opioid-related
harms. They provide information that enables the detection by health practitioners of inappropriate requests for controlled drugs, such as doctor shopping. RTPMS also provide information for regulators to enable them to monitor dispensing events, to determine if a medical practitioner is prescribing controlled drugs without a valid permit and to make decisions on the provision of permits to health practitioners to prescribe controlled drugs. RTPMS are a subset of prescription drug monitoring programs (PDMP).

PDMP are designed to collect and store information on prescription drugs for health practitioners and regulators to access, but not all PDMP provide information in real-time. PDMP, which are common in the United States and some areas in Europe, vary widely in their operation. There are differences in the type and volume of data that are collected, the timeliness of the data, the mechanisms used to alert potential drug misuse, the regulatory oversight, the requirement for use by health practitioners and the information they aggregate, analyse and share with health practitioners and the public.

Tasmania is the only jurisdiction in Australia to have introduced a RTPMS, the Drugs and Poisons Information System (DAPIS) and its associated DAPIS Online Remote Access (DORA) system. Other Australian states and territories, including New South Wales, the Australian Capital Territory and Victoria have progressed plans to implement state-based systems with the Victorian System scheduled to commence in late 2018. A national system, known as the Electronic Recording and Reporting of Controlled Drugs (ERRCD), is also planned with $16 million allocated to its establishment in 2017.

Professional organisations including the RACGP and the Pharmaceutical Society of Australia (PSA) support a national RTPMS but caution that administrators and clinicians should be clear about the intended objectives, risks and benefits prior to implementation (19). In addition, at least 21 separate coronial investigations have recommended a national RTPMS in Australia (20) and GPs and pharmacists have been found to support a RTPMS (19, 21).

1.3.5. Impact of prescription monitoring programs

Internationally, PDMP are used widely in the United States (in all but one state) and in some areas in Europe (22). Despite their widespread use, there is limited evidence in support of the effectiveness of PDMP at reducing opioid-related
harm. Several studies have found positive associations between PDMP and opioid-related measures including reductions in the number of opioid prescriptions (23-27), reduction in inappropriate controlled drug prescriptions (28), reduced average dose of opioids prescribed (29), increased confidence of prescribers (30), reductions in doctor shopping (28, 31), a levelling off in the increasing trend of emergency department presentations and hospitalisations for opioid overdose (24), reductions in opioid overdose morbidity and mortality (24, 32, 33) and a reduction in opioid-related deaths (34, 35).

In contrast, other studies have found no impact or mixed results on prescription opioid initiation, abuse and dependence (31); number of opioid prescriptions (36, 37); number of patients receiving inappropriate or high-dose prescriptions; combined use of benzodiazepines and opioids; prescriptions from multiple prescribers (25), nonmedical use of opioids (31); doctor shopping (25); opioid-related emergency presentations (38), overdose events (25) and opioid-related deaths (39, 40). Negative impacts associated with PDMP have included an increase in total quantity of opioids in the supply chain (24), increase in heroin overdose (24) and increased opioid-related deaths (40).

It is difficult to compare studies because of the lack of consistency in the PDMP design and range of study types used. Many studies are cross-sectional or observational, therefore bias and confounding may have influenced their results. To our knowledge, no systematic studies of the impact of PDMP have been performed. A scoping review of the evidence regarding the impact of PDMP on opioid-related health outcomes in the United States concluded that the evidence for the impact of PDMP on opioid prescribing behaviour, diversion and supply, misuse and morbidity and mortality was mixed (32). Evaluating the clinical, public health and economic impacts of PDMP have been identified as a key research priorities (41).

1.3.6. Rationale for the evaluation

Since its introduction in 2009, DAPIS/DORA has not been formally evaluated. A major review of opioid prescribing in Tasmania undertaken by the National Drug and Alcohol Research Centre (NDARC) in 2010 recommended an evaluation be undertaken (21) as have other experts in an editorial published in the Medical Journal of Australia in 2013 (42). This evaluation coincides with
planning for the ERRCD and the state and territory-based systems, thus the findings from this evaluation may provide information which can be used by other jurisdictions in the development and implementation of RTPMS across Australia.

2. Stakeholders

Stakeholders that contributed to this evaluation included representatives from Public Health Services, Tasmanian Department of Health (DoH), Primary Health Tasmania (PHT), the Tasmanian Health Service (THS), Tasmanian General Practitioners, Tasmanian community pharmacists and the National Centre for Epidemiology and Population Health (NCEPH), Australian National University (ANU).

The following stakeholders from Public Health Services contributed to this evaluation: Specialist Medical Advisor/MAE Scholar (lead investigator), Director of Public Health, Deputy Director of Public Health, Chief Pharmacist, Deputy Chief Pharmacist, Pharmaceutical Services Branch (PSB) pharmacists and administrative staff. Stakeholder roles and contributions are provided in Table 22.

The Pharmaceutical Services Branch (PSB) of Public Health Services is responsible for the regulation of controlled substances in Tasmania and administration of the Poisons Act 1971 (Tas). Approximately eight full-time pharmacists at PSB perform the following functions in relation to the safe prescribing of controlled drugs as delegates under the Poisons Act 1971 (Tas):

- Assess applications to prescribe controlled drugs under Section 59E of the Poisons Act, and issue authorities to prescribe (S8 permits)
- Convene meetings with medical specialists to obtain advice on complex Section 59E applications
- Provide advice, support and education to prescribers and suppliers of controlled drugs
- Monitor opioid dispensing events in the RTPMS
- Intervene when potentially high-risk prescriptions or supply of opioids are detected via the RTPMS
- Complete investigations and take appropriate regulatory actions where significant non-compliance with the *Poisons Act* has occurred.

Specialist Medical Advisors and the Director of Public Health provide support for PSB’s roles and functions. The Director and Deputy Director of Public Health have delegations assigned by the Minister of Health under the *Poisons Act 1971* (Tas) Section 92 and the *Poisons Regulations 2008* (Tas) Regulation 85.

Primary Health Tasmania provides and commissions a range of community-based services, networks, education and health information in primary health care including continuous quality improvement activities for healthcare practitioners. Stakeholders at Primary Health Tasmania contributed to the design of the evaluation and providing data on opioid-related hospitalisations in Tasmania. The lead investigator is co-located at DoH and Primary Health Tasmania. Tasmanian community pharmacists and General Practitioners are the main users of DORA. Their role in the evaluation was to provide their views on DORA and make recommendations on how it could be improved.

As this project also fulfilled one of the requirements of a Master of Philosophy in Applied Epidemiology, academic supervision was provided by the Australian National University National Centre for Epidemiology and Population Health.
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<td>Chief Pharmacist and Deputy Pharmacist</td>
<td>Provided information on purpose, operation and resources of DORA</td>
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<td></td>
<td>Contributed to the design of the evaluation</td>
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<td>Interviewed to provide information on the usefulness and attributes of DORA</td>
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<td>Contributed to the evaluation report</td>
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<tr>
<td>DoH PSB, Pharmacists, senior pharmacists and administrative staff</td>
<td></td>
<td>Provided information on operation of DORA</td>
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<td></td>
<td>Interviewed to provide information on usefulness and attributes of DORA</td>
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<tr>
<td><strong>DoH Population Health Services</strong></td>
<td>Specialist Medical Advisor and MAE Scholar</td>
<td>Lead Investigator</td>
</tr>
<tr>
<td></td>
<td>Deputy Director of Public Health</td>
<td>Assisted with development of interview questions</td>
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<td>Contributed to the evaluation report</td>
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<td>Director of Public Health and MAE field supervisor</td>
<td>Advised on the design of the evaluation</td>
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<td><strong>Tasmanian Health Service</strong></td>
<td>Alcohol and Drug Physician</td>
<td>Contributed to the design of the evaluation</td>
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<tr>
<td><strong>Primary Health Tasmania</strong></td>
<td>Public Health Physician</td>
<td>Lead investigator co-located at Primary Health Tasmania</td>
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<td></td>
<td>Data analyst</td>
<td>Provided epidemiological data</td>
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<td><strong>Community Pharmacists</strong></td>
<td>Users of DORA</td>
<td>Interviewed to assess the usefulness and attributes of DORA</td>
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<td><strong>General Practitioners</strong></td>
<td>Users of DORA</td>
<td>Interviewed to assess the usefulness and attributes of DORA</td>
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<td><strong>ANU</strong></td>
<td>Academic Supervisor</td>
<td>Advised on the design of the evaluation</td>
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3. Methods

3.1. Framework

We used the Updated Guidelines for Evaluating Public Health Surveillance Systems 2001 that provide a framework for the comprehensive evaluation of surveillance systems, to undertake this evaluation (5). The five components of the framework are:

1. Engage the stakeholders in the evaluation
2. Describe the surveillance system to be evaluated
3. Focus the evaluation design
4. Gather credible evidence regarding the performance of the surveillance system
5. Justify and state conclusions and make recommendations
6. Ensure use of evaluation findings and share lessons learned

3.2. Aims and objectives

Our primary aim was to determine if DAPIS/DORA is achieving its purpose of reducing the harms associated with controlled drugs in Tasmania. The objectives were:

1. To determine whether the DAPIS/DORA is achieving its objectives
2. To assess the utility and attributes of the DAPIS/DORA
3. To describe the views and attitudes of the PSB staff that use DAPIS and the health practitioners DORA
4. To make recommendations based on the above objectives to improve the DAPIS/DORA

3.3. Standards for assessing performance

3.3.1. Overview

We performed a mixed methods evaluation. To describe the purpose and operation of DAPIS/DORA we observed DAPIS/DORA in action and gathered information from stakeholders and PSB staff. To evaluate the utility and
attributes of DAPIS/DORA, we collected information from PSB staff during observation of DAPIS and, where possible, using data extracted from DAPIS or other sources. To supplement the descriptive and quantitative analyses of the utility and attributes, we interviewed a sample of operators of DAPIS (PSB staff) and users of DORA (pharmacists and GPs) to identify their views and attitudes.

3.3.2. Qualitative analysis

Recruitment of interview participants

We invited all pharmacists who were working at PSB in January 2018 (PSB staff) to be interviewed. To recruit GPs and pharmacists, we used an online random number generator to shortlist approximately 50 GPs and 50 pharmacists from a list of all 842 registered users of DORA (43). For each of the shortlisted participants, we calculated the number of times DORA had been accessed in the preceding six months for GPs and preceding three months for pharmacists. We then allocated potential study participants into three categories: 1) registered but never accessed DORA, 2) registered and who used DORA sometimes and 3) registered and routinely accessed DORA.

We contacted shortlisted pharmacists and GPs by telephone at their workplace to invite them to participate in the evaluation. Up to three follow up contact attempts were made by phone or email to invite them to participate in the study. We continued to contact GPs and pharmacists on the shortlist until we had an adequate sample for thematic analysis, which was estimated to be six GPs and six pharmacists. Participants were given the option to be interviewed in person or via telephone. All the interviews were transcribed directly onto a laptop during the interview. A copy of the participant information sheet is in Appendix 6.

Exclusion criteria

We excluded GPs who had not prescribed any opioids in the preceding six months and pharmacists who had not dispensed any opioids in the preceding three months. We also excluded hospital-based health practitioners and specialist medical practitioners because they comprise a small minority of registered users of DORA.
**Semi-structured interviews**

We designed the semi-structured interviews based on the CDC Guidelines with closed and open-ended questions on the utility and attributes of DAPIS/DORA. We collected demographic information on the participants' occupation, age-group, time in their profession and practice location. We asked pharmacists and GPs to estimate information on their use of DORA including the year of registration, frequency of access, reasons for access and the barriers to access. We also asked GPs to estimate the number of patients they had commenced on, and ceased, opioids for chronic non-cancer pain in the past 12 months.

To assess the attitudes of pharmacists and GPs attitudes towards PSB, we asked several questions on the role of PSB in overseeing opioid prescribing and the process of applying for authorities to prescribe controlled drugs.

To inform the evaluation recommendations, we asked for the participants views on how DAPIS/DORA could be improved or expanded, situations for which they supported mandatory use of DORA and their views on how to reduce opioid-related harms in Australia. Copies of the semi-structured interview questions with PSB staff, GPs and pharmacists are provided in Appendix 7, Appendix 8 and Appendix 9.

### 3.3.3. Assessment of utility and attributes

**Utility**

The CDC Guidelines define usefulness (utility) as the ability of a surveillance system to contribute to the prevention and control of adverse health events, including an improved understanding of the public health implications of such events.

We assessed utility by reviewing the objectives of DAPIS/DORA and assessing against the following criteria selected from the CDC Guidelines:

- Does DAPIS/DORA detect health events of public importance in a timely way to permit accurate identification, prevention or treatment?
- Does DAPIS/DORA provide estimates of the magnitude of morbidity and mortality related to the health event under surveillance, including the identification of factors associated with the event
- Does DAPIS/DORA detect trends that signal changes in the occurrence of health events
- Does DAPIS/DORA lead to improved clinical or policy practices?

**Attributes**

We analysed all the attributes listed in the CDC Guidelines including acceptability, simplicity, representativeness, sensitivity, positive predictive value, data quality, timeliness, flexibility and stability. Details on how we assessed each attribute are provided are in Table 23.

3.3.4. Analysis

We performed quantitative analyses in Stata version 15.1 (Statacorp, TX). We used Microsoft Excel for the thematic analysis of interview transcripts.

3.3.5. Ethics

Ethics approval for this evaluation was granted by the Human Research Ethics Committee’s at the Australian National University (Protocol 2017/703) and the University of Tasmania (Reference H0016970).
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Definition</th>
<th>Key aspects assessed</th>
<th>How it was assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptability</td>
<td><em>The willingness of persons and organisations to participate in the surveillance system</em></td>
<td>Proportion of Tasmanian pharmacists and general practitioners registered with DORA</td>
<td>Ratio of registered users to total number of pharmacists and general practitioners registered with the Australian Health Practitioner Regulation Agency (AHPRA) in Tasmania.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participation rate of users</td>
<td>Systematic sample of registered pharmacies and medical practices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Manual review and count of the number of times selected pharmacists and medical practitioners had viewed patients on DORA in the last 6 months (for medical practitioners) and 3 months (for pharmacists)</td>
</tr>
<tr>
<td>Barriers and enablers to participation</td>
<td></td>
<td>Barriers and enablers to participation</td>
<td>Interviews with users and PSB staff</td>
</tr>
<tr>
<td>Simplicity</td>
<td>The simplicity of its structure and ease of operation</td>
<td>Operator interface simplicity</td>
<td>Consultation with PSB staff</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------------------------------------------------</td>
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<tr>
<td></td>
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<td>Observation of DAPIS</td>
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<td></td>
<td>Interviews with users and PSB staff</td>
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<td>User interface simplicity</td>
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<td></td>
<td></td>
<td></td>
<td>Interviews with users</td>
</tr>
<tr>
<td>Representativeness</td>
<td>The ability to accurately describe the occurrence of a health event over time and its distribution in the population by place and person</td>
<td>Proportion of pharmacies real-time reporting dispensing event information</td>
<td>Review of information collected and maintained by PSB staff on pharmacies reporting in real-time</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Review of information collected and maintained by PSB staff on practices with licenses installed to access DORA</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Review and descriptive analysis of registered users</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Simplicity</th>
<th>The simplicity of its structure and ease of operation</th>
<th>Operator interface simplicity</th>
<th>Consultation with PSB staff</th>
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<td></td>
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<td>Observation of DAPIS</td>
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<td>Interviews with users and PSB staff</td>
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<td>User interface simplicity</td>
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<td>Interviews with users</td>
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<td></td>
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<td></td>
<td>Review and descriptive analysis of registered users</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th><strong>Sensitivity</strong></th>
<th>The proportion of cases of the health events detected, and The ability to detect outbreaks, including the ability to monitor changes in the number of cases over time</th>
<th>Proportion of health events detected</th>
<th>Consultation with PSB staff</th>
<th>Observation of DAPIS</th>
<th>Interviews with users and PSB staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive predictive value</strong></td>
<td>The proportion of reported cases that actually have the health event under surveillance</td>
<td>Proportion of cases of health events detected compared with total time used by PSB staff and users</td>
<td>Interviews with users and PSB staff</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data quality</strong></td>
<td>The completeness and validity of the data recorded in the surveillance system</td>
<td>Completeness of dispensing event information</td>
<td>Observation of DAPIS</td>
<td>Interviews with PSB staff</td>
<td></td>
</tr>
<tr>
<td><strong>Completeness and validity of the data collected by DAPIS</strong></td>
<td><strong>Observation of DAPIS</strong></td>
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<td><strong>Observation of DAPIS</strong></td>
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<tr>
<td><strong>Interviews with PSB staff</strong></td>
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<table>
<thead>
<tr>
<th><strong>Completeness and validity of information on the health events under surveillance</strong></th>
<th><strong>Observation of DAPIS</strong></th>
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<tbody>
<tr>
<td><strong>Observation of DAPIS</strong></td>
<td></td>
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<tr>
<td><strong>Interviews with PSB staff</strong></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Completeness and validity of the information available in DORA</strong></th>
<th><strong>Interviews with pharmacists and GPs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interviews with pharmacists and GPs</strong></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Timeliness</strong></th>
<th><strong>The speed between steps in a surveillance system</strong></th>
<th><strong>Time intervals between prescribing opioids, dispensing opioids and any interventions</strong></th>
<th><strong>Observation of DAPIS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Interviews with users and PSB staff</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Stability</strong></th>
<th><strong>The reliability and availability of the surveillance system</strong></th>
<th><strong>Unscheduled outages</strong></th>
<th><strong>Consultation with PSB staff and the IT Provider</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Time required to collect and manage data</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Flexibility | The ability to adapt to changing information needs or operating conditions with little additional time, personnel or allocated funds | Observation of how DAPIS/DORA responded to new demands | Consultation with PSB staff
Observation of DAPIS
Interviews with PSB staff and users |
4. Description of DAPIS/DORA

4.1. Purpose and operation

4.1.1. Aims and objectives

The overall aim of DAPIS/DORA is to reduce the harms associated with controlled drugs in Tasmania. As there were no pre-defined objectives, the following were identified in consultation with the evaluation stakeholders:

1. To monitor controlled drug dispensing events in real-time in Tasmania
2. To provide information that supports advice and recommendations from PSB to Tasmanian pharmacists and medical practitioners in relation to controlled drugs
3. To minimise the nonmedical use of controlled drugs in Tasmania
4. To reduce inappropriate prescribing of controlled drugs in Tasmania
5. To monitor the epidemiology of controlled drugs in Tasmania

4.1.2. Health events under surveillance

The following definitions for the health events under surveillance were adapted from a targeted review of the literature and following discussion with the evaluation stakeholders.

1. Doctor shopping: ‘obtaining prescriptions for controlled substances from three or more healthcare practitioners within one month’
2. Excessive opioid supply: ‘receiving opioid medications in excess of the prescribed quantities listed in an S8 permit’
3. Nonmedical opioid use: ‘use of a prescription drug, whether obtained by prescription or otherwise, other than in the manner or for the time period prescribed, or by a person for whom the drug was not prescribed’ (44)
4. Inappropriate opioid prescribing: ‘prescribing opioids at doses greater than, or for reasons outside of, those recommended by professional standards’
5. Opioid-related harms: ‘adverse events associated with prescription opioids, including loss of life through overdose and accidents, negative mental and physical health effects, family and social problems, psychological and emotional difficulties, and legal and financial problems’ (19)

4.1.3. Legal authority for the data collection

PSB administer the *Poisons Act 1971* (Tas) and its associated regulations. PSB staff assess applications made by medical practitioners to prescribe opioids under Section 59E of the *Poisons Act* (Tas). Regulation 93 of the *Poisons Regulations 1971* (Tas) requires all pharmacies to provide a record of all S8 opioid analgesic dispensing events in Tasmania, except for inpatient hospital treatment (45). Staff at PSB are bound by the *Personal Information Protection Act 2004* (Tas).

During the registration process and each time health practitioners access DORA, they are required to accept the terms and conditions which are compliant with the national *Privacy Act 1988* (Commonwealth). Inappropriate S8 prescribing can result in criminal prosecution, financial penalties, the loss of a doctor’s authority to prescribe S8 drugs or disciplinary action (3).

4.1.4. Components of DAPIS/DORA

*Population under surveillance*

All individuals who have received an opioid prescription in Tasmania and all medical practitioners who have prescribed opioids in Tasmania since 2009 are monitored by DAPIS/DORA.

*Duration of the data collection*

Data have been collected in real-time by DAPIS/DORA since 2009. Prior to real-time monitoring, electronic collection of opioid prescribing information in authority to prescribe applications by PSB commenced in the mid 1990’s.

*Structure and flow of information*

The Tasmanian RTPMS has two platforms: the centralised server (DAPIS), which is designed to be used by PSB staff and hosts all the information collected.
by the system; and DAPIS Online Remote Access (DORA), the remote access platform, available for registered health practitioners, which provides a selection of the information collected by DAPIS. A schematic representation of the two platforms is in Figure 23.

Data on dispensing events are collected automatically from Tasmanian pharmacies in real-time using locally installed software and sent securely to DAPIS using Public Key Infrastructure encryption. All pharmacies in Tasmania are required to report in real-time under the Poisons Act 1971 (Tas). Two processes occur as data enters DAPIS that detect situations requiring a response by PSB staff. These processes are referred to as matching and breaches.

**Matching**

DAPIS uses pre-defined algorithms to assess if the dispensing event information matches an existing patient record, drug name, prescribing medical practitioner and medical practice. If one or more of these fields is not recognised, a matching error occurs. The error then needs to be manually matched by a PSB staff member to a patient and/or medical practitioner record.

**Breaches**

Once the information is matched to an existing patient record or following a new record being created, DAPIS validates if the patient for whom the opioids were dispensed is approved to receive opioids under Section 59E of the Poisons Act 1971 (Tas). This is an automated process that determines if the prescribing practitioner has an authority to prescribe (S8 permit) for the patient. Following this validation, DAPIS checks whether the conditions listed in the authority have been met. Discrepancies between any of these conditions and the dispensing events are referred to as breaches. The situations that trigger a breach are listed in Table 24.
Figure 23: Schematic representation of the points of interaction between DAPIS, DORA, PSB staff and health professionals
Breaches are classified as low, medium, high or extreme risk according to the pre-defined patient risk category (explained under Risk classification page 185) except for regulation 19 medications (e.g. Fentanyl and psychostimulants) and doctor shopping, which are both classified as high or extreme risk. Breaches are also categorised into four drug groups, amphetamines, Schedule 8 opioids, benzodiazepines and Schedule 4 opioids (Figure 25). The response to breaches is prioritised according to the assigned risk category and provided by PSB administrative staff, for low and medium risk breaches, and pharmacists, for high and extreme risk breaches. Every Monday to Friday from 8am to 5pm one to two pharmacists and one to administrative staff are allocated to actively monitoring and responding to the breaches. Response times for breaches are discussed in timeliness (page 223).

The mechanisms by which PSB staff respond to breaches vary. For high and extreme risk breaches, PSB staff commonly make an urgent phone call to the dispensing pharmacist or prescribing practitioner to prevent a medication being supplied or to adjust the quantity of medication supplied. If a medical practitioner is found to be prescribing without a permit, PSB staff send an authority to prescribe application to the prescribing practitioner. If there are safety concerns—such as in situations of repeated requests for excessive supply

### Table 24: List of situations and conditions that trigger breaches in DAPIS

<table>
<thead>
<tr>
<th>Situation</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the prescriber does not have a valid authority to prescribe</td>
<td>Greater than two months of a S8 drug have been dispensed</td>
</tr>
<tr>
<td></td>
<td>A Regulation 19 drug has been prescribed (e.g. Fentanyl, Dexamphetamine)</td>
</tr>
<tr>
<td></td>
<td>The patient has been documented to be drug dependent or a drug seeker in DAPIS</td>
</tr>
<tr>
<td></td>
<td>There have been three or more prescribers within one month</td>
</tr>
<tr>
<td>Conditions listed in an authority to prescribe do not match or are not met</td>
<td>Prescriber is from outside of the listed Practice</td>
</tr>
<tr>
<td></td>
<td>Drug dose, type or quantity are not authorised</td>
</tr>
</tbody>
</table>
of medications or drug diversion—a circular to pharmacies or medical practices or a do not prescribe notice may be issued (Figure 24).

**Figure 24: Flow chart of the information collected in DAPIS**

**Risk classification**

To estimate the risk of nonmedical opioid use, accidental or intentional overdose and death, all patients in DAPIS are assigned to a risk level of low, medium, high or extreme. PSB pharmacists manually assign the risk level to patients and periodically update the category as they become aware of any changes in the patient’s behaviour that fits within a higher risk category. The full risk classification document could not be included in this report because of sensitivities in the information it contains but it is based on the following criteria:

- Age of the patient
- Type of opioid or psychostimulant being taken
- Daily oral morphine equivalent dose (OMED) being taken
- Whether they are receiving two or more controlled drugs e.g. opioids and dexamphetamines
- Personal history of:
  o aberrant behaviour e.g. early requests for medications, lost or stolen prescriptions or tablets, repeated requests for variations to authority conditions
  o nonmedical use of opioids
  o alcohol or another drug dependency
  o illicit substance use
  o treatment for drug addiction
  o being declared a drug seeker by a medical practitioner under Section 59B of the *Poisons Act 1971* (Tas)
  o having a drug circular issued to pharmacists or GPs
- If they have a child receiving regular psychostimulants
- Close contacts have a history of any of the above

In general, patients are classified as: 1) low risk if they are on low-dose opioids and have no risk factors for nonmedical opioid use, overdose or death; 2) medium risk if they received 10-30mg OMED per day and have no risk factors for nonmedical use, overdose or death; 3) high risk if they receive greater than 30mg OMED per day, regulation 19 substances, a combination of opioids and other high risk controlled drugs, or have risk factors for nonmedical opioid use, overdose or death; and 4) extreme risk if they have a personal history of any aberrant behaviour, nonmedical use of opioids or drug dependency. The validity of the risk classification process is discussed in the section on data quality (page 218).
The use of DORA by health practitioners who prescribe or dispense opioids is voluntary, unlike real-time reporting of opioid dispensing events from pharmacies, which is mandatory and occurs automatically. Health practitioners are encouraged to register with DORA by PSB staff at events, such as during orientation workshops for GP registrars, and opportunistically, such as during phone calls from PSB staff in relation to opioid prescribing. The registration process is initiated by completing an online application. PSB staff then verify the health practitioners AHPRA details and assist practice managers or dispensing software provider support services to install a license onto designated computers. Following the registration process, users can log on to a website to access DORA from the designated computers.
Health practitioners are not required to advise PSB when they no longer have a valid reason to access DORA, such as if they stop practicing in Tasmania. As DORA is only available from verified computers within registered practices health practitioners are not able to access DORA from a non-registered practice location.

**Data collected by DAPIS and DORA**

**DAPIS**
Data have been collected in real-time by DAPIS on S8 drugs dispensed since 2009. Schedule 4 (S4) drugs (codeine-containing products, dextropropoxyphene and tramadol) were added in February 2018. Data are collected on patients, health practitioners who prescribe controlled drugs and all registered medical practices and pharmacies, regardless of whether the patient or medical practitioner has registered to access DORA. A list of the information available in DAPIS is shown in Table 25. Screen shots of the DAPIS pages for patients and medical practitioners are shown in Figure 26 and Figure 27.

**DORA**
DORA contains selected information from DAPIS on S8 and S4 dispensing events including patient details, prescriber name, drug name, drug dose, date the drug was dispensed, and the quantity dispensed. Health practitioners can also look up their pending, cancelled and approved S8 permits on the DORA website. A screen shot of the DORA secure website is shown in Figure 28.

**Data management and reporting**
The DoH Data Release Policy applies to the release of data from DAPIS. The Chief or Deputy Chief Pharmacist releases data to external providers who have been granted ethics approval from a Human Research Ethics Committee in Australia. Currently data collected by DAPIS are not analysed or reported to stakeholders.
<table>
<thead>
<tr>
<th>Information available</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Name, DORA identification number, date of birth, aliases</td>
</tr>
<tr>
<td>Risk classification level</td>
<td>Low, medium, high or extreme</td>
</tr>
<tr>
<td>Recent authorities (S8 permits)</td>
<td>Type, status, date of application, date of approval, expiry date</td>
</tr>
<tr>
<td>History of drug dependence of drug seeker</td>
<td>Yes or no</td>
</tr>
<tr>
<td>S8 dispensing events</td>
<td>Drug name (including generic and trade name), dose, quantity, date dispensed</td>
</tr>
<tr>
<td>Breach actions</td>
<td>Discrepancies between authority to prescribe conditions and dispensing events</td>
</tr>
<tr>
<td>External contacts</td>
<td>Free text tab for PSB staff to provide information about any correspondence they have had in relation to the patient</td>
</tr>
<tr>
<td>PSB notes</td>
<td>Free text tab for PSB staff to outline other important information, including relatives, circulars and pertinent information from digital medical records, such as overdose events</td>
</tr>
<tr>
<td>Correspondence</td>
<td>Uploaded scanned copies of documents relating to the patients care such as applications to prescribe, S8 permits issued, specialist reports</td>
</tr>
<tr>
<td>Viewing history</td>
<td>Date, time and name of individuals who have accessed patient records via the DORA website</td>
</tr>
<tr>
<td>Additional information on medical practitioners</td>
<td>Work locations, AHPRA restrictions on prescribing, list patients receiving opioids under an authority, history of DORA files viewed</td>
</tr>
</tbody>
</table>
Figure 26: Screenshot of a patient record in DAPIS
Figure 27: Screenshot of a medical practitioner record in DAPIS
Figure 28: Screenshot of the DORA platform available to registered health practitioners
4.1.5. Program logic of inputs, activities and outputs

To summarise the operation of DAPIS/DORA and its impacts, activities and outcome, we developed a program logic, which is provided in Figure 29.
Figure 29: Program logic of DAPIS/DORA inputs, activities, outputs, impacts and outcomes

*Not currently occurring
4.2. Resources

4.2.1. Funding sources

Funding for DAPIS/DORA is provided by the Tasmanian Government.

4.2.2. Personnel requirements

**PSB staff**

Each day from 8am to 5pm, excluding weekends and public holidays, one or two administrative staff members and two to four pharmacists monitor DAPIS by correcting matching errors and responding to breaches. The number varies depending on availability, demand and priorities. When a pharmacist or administrative staff member is uncertain about the course of action, they seek advice from a senior PSB pharmacist.

In addition to the direct monitoring of DAPIS, one or two other pharmacists assess and respond to authority to prescribe applications. To complete the assessment, the patient’s dispensing history on DAPIS is viewed. For complex applications, such as if a patient has a history of injecting drug use, a decision is made in consultation with a Consultant Medical Officer (CMO), a GP, psychiatrist or addiction specialist employed to assist with the applications. If there are serious safety concerns, decisions are referred to the Expert Advisory Panel (EAP), where the case is assessed by a multidisciplinary team comprising a pain physician, addiction specialist, a GP and PSB pharmacists. The EAP meet approximately every two weeks. A flowchart of the process for assessing authority to prescribe applications is provided in Appendix 5.

Additional operational requirements vary in their frequency and time commitment. Major changes to DAPIS/DORA, such as the inclusion of prescriber details or addition of Schedule 4 opioids, are planned and coordinated by the Chief Pharmacist and Deputy Chief Pharmacist. Currently, no staff are analysing and preparing data for dissemination to stakeholders or the public.
Views of PSB staff

The six PSB staff members that we interviewed estimated that they each spend up to 36 hours per week (median 18 hours) working directly with DAPIS/DORA to correct matching errors and respond to breaches. On a typical day, PSB staff estimated that they each respond to between five and 500 (median 190) breaches. The median number of interventions to change or withhold medications per day was estimated to be 20. The estimated proportion of breaches responded to by PSB staff resulting in an intervention is therefore 10% (20/190). The most common reasons provided for PSB staff interventions were: intervals between prescriptions were too short; medical practitioners had prescribed without an authority or outside the authority conditions; and staged supply conditions (such as daily or weekly pickup) not being adhered to.

Summary of PSB staff requirements

The total personnel requirement per year allocated to monitoring DAPIS is:

- 2 pharmacist years
- 1 administrative staff member years
- 0.1 senior pharmacist years

Additional personnel assigned to assessing authority to prescribe applications using DAPIS include:

- 1 pharmacist year
- 1 administrative staff year
- 0.1 senior pharmacist years
- 0.35 CMO years (for CMO and EAP meetings)

4.3. Summary

The overall purpose of DAPIS/DORA is to reduce opioid-related harms in Tasmania. As there were no pre-existing objectives for DAPIS/DORA, the objectives and health events identified in this evaluation were chosen in consultation with evaluation stakeholders based on its purpose.

Data on dispensing events are extracted from pharmacies and sent securely to DAPIS. Discrepancies between the opioid dispensing event and conditions in
the opioid regime stored in DAPIS are detected and acted upon by PSB staff. PSB staff also use DAPIS during assessment of authority to prescribe opioid applications. DORA is the secure platform which registered health practitioners can access and it contains selected information from DAPIS.

DAPIS is operated by PSB who are funded by the Tasmanian Government. The legal basis for the data collection is outlined in the Poisons Regulation 1971 (Tas) and the Poisons Act 1971 (Tas).

5. **Evidence regarding the performance of DAPIS/DORA**

All results in this section are from key informants and observation of DAPIS in action unless specified to be collected from formal interviews with PSB staff, pharmacists and GPs.

**5.1. Response rate**

All six pharmacists working at PSB in January 2018 agreed to be interviewed for the evaluation. From our shortlist of 50 GPs and 50 pharmacists, five of the six pharmacists we contacted agreed to participate in an interview and five of the 13 GPs we contacted agreed to be interviewed. Most GPs declined because they were too busy or because they did not use DORA and did not want to comment on its usefulness or attributes. Among the five pharmacists we interviewed, two reported using DORA daily, two used it weekly and one had not used it in the last 12 months. Among the five GPs we interviewed, two reported using DORA daily, one reported using it monthly, and two had not used it for at least 12 months.

**5.2. Utility**

**5.2.1. Has DAPIS/DORA achieved its aims and objectives?**

We could not determine if the overall aim of DAPIS/DORA—to reduce opioid-related harms in Tasmania—has been achieved. Firstly, DAPIS/DORA is not designed to collect data on opioid-related harms and secondly, many other factors outside of real-time prescription monitoring contribute to opioid-related harms. From our search of available white and
The Coronal Division of Tasmania maintain a Register of Overdose Deaths in Tasmania. Data are not publicly available, but between 2007 and 2016, 410 overdose deaths were reported to Tasmanian coroners according to the findings of a publicly available report by the coronial division into an accidental death (46). Among the 60 deaths from drug overdoses that occurred in Tasmania in 2016, two thirds (40/60) were attributable to pharmaceutical drugs only pharmaceutical drugs contributed to the overdose in 90% (46).

The most recent publicly-available data on opioid-related deaths in Australia, Australia’s Annual Overdose Report 2018, published by the Penington Institute reports that Tasmania had the equal lowest rate of accidental deaths with the Australian Capital Territory from pharmaceutical opioids in Australia at 1.6 deaths per 100 000 population in 2012-16 but that the incidence rate has increased from 1.2 accidental deaths per 100 000 population in 2002-06 and the total number of deaths each year increased between 2006 and 2016 from 13 per year to 19 per year (47).

Other factors that may contribute to opioid-related harms in Tasmania are the availability and potency of illegal sources of pharmaceutical and non-pharmaceutical opioids, access to services for chronic pain and addiction, changes in the supply or dose of opioids provided by medical practitioners, changes in the use of combinations of opioids with other drugs, the use of Naloxone to reverse opioid overdoses by community members or changes in response times by ambulance are likely to have contributed (4).

Two of the five objectives of DAPIS/DORA have been achieved: to assess and monitor controlled drug dispensing events in real-time in Tasmania; and to provide information that supports advice and recommendations from PSB to Tasmanian pharmacists and medical practitioners in relation to controlled drugs. These two objectives correspond with the main function of DAPIS/DORA, which is to provide a tool which can be used for the monitoring of controlled drugs.

We could not determine if two of the objectives: to minimise the nonmedical use of controlled drugs in Tasmania, and to reduce inappropriate opioid prescribing, have been achieved because DAPIS does not detect or monitor these health events.
The final objective: to monitor the epidemiology of controlled drugs in Tasmania, has been partially achieved. Currently, the use of an external IT provider impedes access to the data and no resources have been allocated to the analysis and reporting of data collected by DAPIS. Two indicators that are collected by PSB that provide limited information on the epidemiology of controlled drugs in Tasmania are the number of authorities to prescribe opioids issued by PSB and the average OMED approved in the authorities.

Since its introduction in 2009, the number of authorities to prescribe opioids in Tasmania increased by 62 per cent, from 6462 to 10458, despite no major changes to the number of GPs and only a slight increase in the population (Figure 30). During the same period, the average daily OMED approved in the authorities reduced by 31 per cent from 51 milligrams to 35 milligrams (Figure 31).

![Figure 30: Total number of authorities to prescribe opioids issued by PSB in Tasmania, 2009 to 2017](image-url)
PSB staff reported that the increase in the number of authorities is due to increased prescribing of opioids for chronic non-cancer pain and that medical practitioners occasionally prescribed opioids in the past for chronic non-cancer pain without an authority and this is now being followed up more closely by PSB. Possible explanations for the reduced OMED are increased awareness of the risks of high dose opioids by medical practitioners and an increase in older adults over 85 years for whom lower dose opioids are more likely to be prescribed.

5.2.2. Does DAPIS/DORA detect health events of public importance in a timely way?

PSB staff report that doctor shopping and excessive opioid supply are identified as breaches in real-time in DAPIS. High-risk and extreme risk breaches are responded to rapidly by PSB staff, usually within a few minutes. By observing DAPIS in action and based on the information provided on the automated processes for detecting breaches, we were able to substantiate this claim.

Nonmedical use of opioids and inappropriate opioid prescribing are periodically identified by PSB staff and recorded in free text fields in DAPIS, but the system is not designed to systematically detect these events. Nonmedical use of opioids
is suspected if there have been aberrant behaviours by a patient or their immediate family members (such as repeated lost tablets, burglaries or requests for variations in authority to prescribe conditions) but is rarely proven. Situations where nonmedical use is detected occur in the case of positive urine drug screen results for non-prescribed medications, documentation from health practitioners in their correspondence with PSB or if listed in the hospital digital medical record (DMR).

Inappropriate prescribing may be observed by PSB staff but it is not routinely recorded in DAPIS. One of the challenges in capturing inappropriate prescribing is the difficulty in its definition. A number of guidelines have been developed to increase the appropriate prescribing of opioids, such as the Royal Australian College of General Practitioners (RACGP) Prescribing Drugs of Dependence (19). However, the guidelines are not enforced, and opioids continue to be widely used, and authorised, for chronic non-cancer pain outside of the parameters described in the guidelines.

Opioid-related harms, such as overdoses and accidents, are periodically reported to PSB staff in authority to prescribe applications, at which time information is supplied by the requesting medical practitioner. They may also be detected by PSB staff when reviewing the patient’s DMR, which contains emergency department attendance records, admission notes, pathology, radiology and specialist outpatient letters. Although nonmedical use of opioids and opioid-related harms are entered into DAPIS by PSB staff into free text fields, case definitions are not applied therefore it is not possible to measure or analyse the number, frequency or rate of these conditions.

In addition to operating DAPIS, PSB also convene an Expert Advisory Panel (EAP), which also aims to reduce opioid-related harms under the delegations of the Chief Pharmacist authorised in the Poisons Act 1971 (Tas). The EAP comprises a pain specialist, addiction specialist, GP and PSB pharmacists that meet fortnightly to review and make recommendations to the Chief Pharmacist in situations with serious safety concerns. In cases where the EAP advise there is highly inappropriate prescribing, the Chief Pharmacist may provide detailed advice on the case or require the medical practitioner to undergo a period of mentorship.
5.2.3. Does DAPIS/DORA provide estimates of the magnitude of morbidity and mortality of the health event under surveillance?

Large amounts of data are collected in DAPIS on patients who receive opioids and clinicians who prescribe opioids, but they are not currently collected in a format that enables estimation of the magnitude of opioid-related harms in Tasmania. For prescribing clinicians, data are collected on their practice location, the dose and frequency of each S8 drug prescribed (recorded at the time of being dispensed in a pharmacy), and the number of authorities to prescribe they have applied for and had authorised. For individuals who have received opioids, information is collected on the type, dose and frequency of all opioids they had dispensed since 1996. These data have the potential to provide a feedback loop to individual clinicians on their prescribing practices and pharmacists on their dispensing practices.

One of the main system shortcomings of DAPIS/DORA is that it is hosted by an external Information Technology (IT) provider, which limits access to the data. The IT provider does not provide routine extracts of the data and charges a fee for ad hoc extracts. Additional shortcomings are that many data, such as the medical indication for the opioid prescribed in an authority, are not recorded electronically but stored in paper files scanned into DAPIS. There are also insufficient staff with the skills, knowledge or time to clean and analyse the data, and produce reports for individual prescribers, the community or DoH.

Researchers at the University of Tasmania are undertaking several projects to analyse ten years of approved authority to prescribe indications, doses and co-prescribed therapies. They report several barriers to accessing opioid-related data including the fees charged by the IT provider for data extracts and the format of many data, such as drug doses and indications, which need to be extracted manually.

5.2.4. Does DAPIS/DORA detect trends that signal changes in the occurrence of health events

DAPIS/DORA has the capacity to detect trends that signal changes in the occurrence of health events, such as doctor shopping, but, aside from the
operational use of DAPIS/DORA to detect such events, there are no processes for systematic review of trends.

5.2.5. Does DAPIS/DORA lead to improved clinical or policy practices?

DORA is a tool that clinicians can use to make informed clinical decisions resulting in improved clinical practices. However, underutilisation by clinicians limits this function (further discussed in acceptability, page 207). DAPIS is reported by PSB staff to detect all cases of doctor shopping and excessive supply of opioids as breaches. According to PSB staff, these mechanisms have resulted in the elimination of doctor shopping other than cases that occur when DAPIS is not monitored, such as over weekends, or for up to one month if the pharmacy dispensing the opioid is not reporting in real-time. PSB staff also report that the supply of excessive quantities of opioids in Tasmania has been substantially reduced since the introduction of DAPIS/DORA. While these statements are likely to be accurate, we were unable to substantiate them with data collected by DAPIS. Elimination of doctor shopping and excessive supply of opioids in turn contributes to a reduction in nonmedical use of opioids and subsequent reduction in opioid-related harms the extent of which could not be assessed.

Several additional activities undertaken by PSB staff contribute to a reduction in inappropriate prescribing. PSB staff review information in DAPIS as part of the assessment of authority to prescribe applications. In some circumstances, where the risk of harms from an opioid regime for a patient are considered extreme, the application to prescribe is refused. All external contacts, such as a pharmacist reporting concerns regarding nonmedical use of opioids, are recorded in free text in the DAPIS patient file to aid future decision making. Past applications to prescribe opioids are also stored in DAPIS.

Despite these measures, inappropriate opioid prescribing can still occur. For example, a GP may request an authority to prescribe opioids for an indication outside of currently recommended standards, such as fibromyalgia. PSB staff can make recommendations to GPs in relation to the current professional standards and absence of evidence for treatment of fibromyalgia—or chronic non-cancer pain—with opioids, but currently they do not intervene beyond providing information in the authority to prescribe response letter unless there are serious safety concerns.
In addition, opioids may still be used for nonmedical purposes even when dispensed as prescribed. For example, if a patient has chronic back pain and receives regular prescription OxyContin from their GP they may choose to sell their medication, but DAPIS would be unable to detect this.

5.2.6. How often does DAPIS/DORA result in changes to clinical practices?

DAPIS does not collect information to determine if it results in changes to clinical practice. Pharmacist and GP views on whether DORA changed their clinical practices is discussed in acceptability (page 207).

5.2.7. Views of PSB staff, pharmacists and GPs regarding utility

Benefits of DAPIS/DORA

The main benefits of DAPIS/DORA reported during our interviews with PSB staff and pharmacists were the elimination of doctor shopping and nonmedical use of opioids and a reduction in inappropriate opioid prescribing. In contrast, all the GPs we interviewed were unsure if DAPIS/DORA had caused a reduction in the nonmedical use of opioids or inappropriate opioid prescribing in Tasmania. GPs reported that the ability to detect doctor shopping in their own patients and throughout Tasmania by PSB as the main benefits of DAPIS/DORA.

Pharmacists and GPs had mixed views on whether DAPIS/DORA results in a reduction in prescription opioid related harms. Around half of those we interviewed thought that this was the case, but several others were unsure. The two reasons provided were because of the decision support that DORA and PSB staff provide and as a secondary effect of a reduction in doctor shopping.

All the pharmacists and four of the five GPs we interviewed were positive about the role of PSB in supporting opioid-prescribing. Clinical support and quality control, such as through restrictions or recommendations in S8 permits, were identified as additional of PSB:

“I'm making a more informed clinical judgement and it's protecting me from inadvertently supplying medication”
“quite often it is difficult to tackle a doctor on their prescribing. Often the backflow to that pharmacist or business can be quite severe. It is useful to outsource that to PSB and they understand the commercial environment in which we operate”

“people know that it is being policed [it is] not as easy to write the prescription knowing the extra policing is there”

“Authority recommendations e.g. for urine drug screens are appreciated”

“I think that having a real-time monitoring system that is monitored [by PSB] is in the best interest of the general public and the individual patients”

In summary, the main benefits of DAPIS/DORA reported by GPs and pharmacists were the ability to check individual patients on DORA and the contributions of PSB staff in providing clinical support, monitoring opioid dispensing events and making recommendations in authorities.

**Shortcomings of DAPIS/DORA**

For pharmacists and GPs, the time and effort required to access DORA were identified as shortcomings. None of the participants reported any negative impacts for patients and it was noted that most patients are not aware that DAPIS/DORA exists. The only shortcoming identified by PSB staff was the time required to document information.

Two GPs reported experiencing limitations in the information provided by PSB and the process of applying for an S8 permit:

“It’s usually me ringing them and asking about a specialist who has prescribed an S8 and I don’t have any information about it”

“It became frustrating recently because I had been filling in forms for seven years for a patient and suddenly they wanted the justifications for why the patient was in so much pain which I had already sent them previously”

One pharmacist commented that they hadn’t always found the advice from PSB to be clear:

“sometimes their information is a bit sitting on the fence”
In summary, the shortcomings that were identified by PSB staff were the time involved with monitoring DAPIS and, for health practitioners, the time and effort involved in accessing DORA and completing paperwork for an authority to prescribe application.

5.2.8. Summary of utility

- Key informants had the view that doctor shopping and excessive opioid supply are detected in real-time by DAPIS and that actions by PSB staff in response to breaches detected by DAPIS have led to the elimination of doctor shopping and excessive opioid supply in Tasmania other than opportunistic occasions.

- Data collected by DAPIS are not currently analysed, interpreted and disseminated. Data collected by DAPIS are stored by an external IT provider who charge a fee for data extractions limiting the availability of data for analysis. Researchers have identified that the manual format of data stored in DAPIS limits the ability to perform analyses.

- DAPIS has the capacity to detect trends in the occurrence of health events, but few events are being recorded. Two opioid-related prescribing events that are monitored are the number of S8 permits approved and the average daily OMED prescribed by medical practitioners.

- Activities by PSB staff using information in DAPIS contribute to a reduction in inappropriate opioid prescribing, nonmedical use of opioids and opioid related harms, but the extent of this reduction is not measured. Opioid-related harms, such as overdoses, accidents and deaths are not detected or monitored by DAPIS.

- The benefits of DAPIS/DORA reported by PSB staff and pharmacists were elimination of doctor shopping and nonmedical use of opioids and a reduction in inappropriate opioid prescribing. The main benefit reported by GPs was the elimination of doctor shopping. Other benefits identified by GPs and pharmacists were the support provided by PSB staff in monitoring DAPIS, providing advice and placing restrictions on opioid prescribing in S8 permits.
5.3. System Attributes

5.3.1. Acceptability

*Number of health practitioners registered to use DORA*

At the time of this evaluation, 842 health practitioners were registered to access DORA. Most were pharmacists and GPs but there are a small number of medical practitioners working in non-GP settings, such as emergency departments, persistent pain clinics and alcohol and drug services and a limited number of nurses and nurse practitioners mostly working in emergency departments. The number of each type of health practitioner is not known but senior PSB staff estimate from their experience of working with DORA that approximately half the registered users are general practitioners and half are pharmacists. Based on this estimation and using data from the Australian Health Practitioners Regulation Agency (AHPRA) on the number of registered general practitioners and pharmacists in Tasmania in 2017, we estimate that the proportion of GPs in Tasmania registered to use DORA is 67 per cent (421/632) and the proportion of pharmacists is 57 per cent (421/738).

*Participation rates*

Participation rates are low among medical practitioners and moderate among pharmacists. Approximately one third (22/62; 35%) of DORA-registered medical practitioners in our sample had accessed DORA in the preceding six months while most (66/76; 87%) pharmacists had accessed DORA in the preceding three months. Among the health practitioners that had accessed DORA, medical practitioners had accessed it on a median of three occasions (range 1-18) in a six-month period compared with a median of 38 occasions (range 1-160) for pharmacists.

An analysis of opioid prescribing in General Practice in Australia found that at least one opioid was prescribed or supplied at approximately five per cent of GP consultations (48). If Tasmanian GPs have similar prescribing rates, we estimate that GPs in Tasmania prescribe three to four opioid prescriptions per week (83 over 6 months) and the proportion of opioid-prescribing occasions during which DORA is checked is approximately two per cent (based on an average 1.6 DORA views out of an estimated 83 patients receiving opioid
medications over a six-month period). This is based on health workforce information that GPs work on average 0.53 full time equivalence (49) and a conservative estimate that they perform 24 consultations per day resulting in 64 patients each week on average.

**Views of pharmacists and GPs**

Among the five pharmacists interviewed, two reported using DORA routinely for all S8 dispensing events, two reported using it if they were suspicious of excessive opioid supply or doctor shopping and one reported using it to check medication strengths, quantities or the authority restrictions.

Among the five GPs interviewed, two reported using DORA routinely for all S8 prescription requests, two reported using it based on a suspicion of doctor shopping or nonmedical use, one reported using it if patients requested excessive supplies of opioids, and one reported using it for new patients. More than half the pharmacists and GPs interviewed had used DORA in situations of requests for non-S8 medications, such as tramadol or Panadeine forte.

All the pharmacists and GPs interviewed were supportive of DAPIS/DORA and, valued the contributions of PSB staff in monitoring DAPIS during business hours. All agreed it made them more confident to identify doctor shopping, inappropriate S8 requests and to supply S8 drugs in a safe manner.

> “I think the system as a whole, having PSB, does help doctor shopping”

> “It gives you more complete information so you can pick a safer course of action with more confidence”

> “you can hand it out knowing that you have prescribed at the right time and they are safe to have it”

> “it backs up what you already suspect”

> “most helpful when I was new to the practice and didn’t know any of the patients”

Four of the five pharmacists interviewed reported that DORA had provided information that changed their management of a patient. The most common reason provided was a change to supply (ie. the patient been advised to return on a different date to have their medication dispensed). Only one of five GPs reported that using DORA had changed their management of a patient,
reporting that two patients had received random urine drug tests following information provided in DORA. The other two GPs that were current users of DORA reported that using it had never changed their clinical management of a patient.

**Barriers to participation**

The most common barriers to participation reported by pharmacists and GPs related to technical issues, particularly around the registration process and access to the DORA platform. Several GPs had forgotten their password and were unsure how to reset it and several GPs and pharmacists found it frustrating to have to enter their details and accept the terms and conditions every time they logged on to the system. Several pharmacists noted that they had limited access to DORA, for example it was common to only have one computer set up in the pharmacy with DORA access and that computer was frequently used for other purposes. Both pharmacists and GPs described confusion with the search function.

Other barriers described were time pressures, being out of the habit of using DORA, having a regular patient base therefore feeling it was not necessary and a perception that, at the time of the interview, important drugs were not listed on DORA, notably codeine, benzodiazepines and tramadol.

**Views on options to increase participation rates**

Pharmacists and GPs had mixed views on whether checking DORA should be mandatory for health practitioners prior to prescribing or dispensing opioids under the *Poisons Act 1971* (Tas)(Table 26). The most common scenario for which mandatory use was supported was for new patients to a pharmacy or medical practice (3/5 pharmacists and 4/5 GPs). Most (4/5) pharmacists supported a mandatory check of DORA for all patients on a high OMED or for all patients assessed as high risk of opioid-related harms. The details of how this would be enforced were identified as additional obstacles to overcome if the use of DORA became mandatory, as has been proposed for the national ERRCD.

A number of challenges were identified if the use of DORA became mandatory either for all S8 prescribing or dispensing events or under specific situations. In
particular, how it would be integrated with existing prescribing and dispensing software and how it would be monitored and enforced by PSB staff.

Table 26: Pharmacist and GP views on situations for which DORA could be mandatory

<table>
<thead>
<tr>
<th></th>
<th>Pharmacist Yes</th>
<th>Pharmacist No</th>
<th>Pharmacist Unsure</th>
<th>GP Yes</th>
<th>GP No</th>
<th>GP Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>For all S8 prescription events</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>For all new patients to the practice</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>For all patients seeing a GP in the</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>practice for the first time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For all patients on a high OMED (e.g.</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>&gt;100mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For all patients assessed as high</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>risk of opioid-related harms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under other circumstances e.g. every</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not asked

Recommendations by PSB staff to increase participation rates

- Allocate additional time and resources to the education of health practitioners
- Enhance decision support for pharmacists and GPs through educational resources and integrated alerts within prescribing or dispensing software
- Investigate modifications to the Poisons Act 1971 (Tas) that would make the use of DORA mandatory for pharmacists that dispense opioids and medical practitioners that prescribe opioids

Recommendations by pharmacists and GPs to increase participation and acceptability

- Introduce a mechanism for the automatic registration with DORA of all GPs who commence practicing in Tasmania
- Provide support from PSB staff, practice managers or pharmacists to ensure all pharmacy and medical practice computers have DORA installed

- Provide support for practices to use DORA from PSB staff, practice managers or pharmacists

- Provide education sessions for health practitioners on how to use DORA

- Simplify the login process by removing the requirement to enter user details every time DORA is accessed

- Embed links to DORA into medical and dispensing software

- Integrate alerts to check DORA into medical and dispensing software when S8 medications are prescribed or dispensed

- Integrate DORA with the national My e-health record

- Investigate the option of introducing repercussions for inappropriate opioid prescribing

**Summary of acceptability**

- We estimate that 67 per cent (421/632) of GPs and 57 per cent (421/738) of pharmacists are registered to access DORA

- One third (22/62; 35%) of a sample of DORA-registered GPs had used DORA in a six-month period on a median of three occasions (average 1.6, range 1-18)

- Most DORA-registered pharmacists (66/76; 87%) in the systematic sample had used DORA in a three-month period on a median of 38 occasions (average 27, range 1-160)

- We estimate that GPs check DORA during two per cent (1.9%) of opioid prescribing occasions on average

- Common barriers to using DORA reported by pharmacists and GPs were technical issues, computer access and time

- Pharmacists and GPs had mixed views on whether the use of DORA should be mandatory

- User participation could be increased through simplifying the registration and login processes, embedding links to DORA in medical
and dispensing software and integrating alerts to check DORA into medical and dispensing software

5.3.2. Simplicity

Case definitions of health events under surveillance

None of the health events under surveillance were defined prior to this evaluation. Breaches, used as a proxy for health events to guide a response by PSB staff, are clearly defined (see Table 24). The categories in the risk classification process whereby patients are classified into low, medium, high or extreme risk, are chosen by PSB staff based on a list of criteria, many of which are difficult to measure, such as aberrant behaviour. The categories have between seven and 11 criteria. A summary of the criteria used for this process are in the system components (page 185) and they are discussed further in data quality (page 218).

Only two of the five health events under surveillance have clear case definitions, doctor shopping and excessive opioid supply. Nonmedical use of opioids, inappropriate opioid prescribing and opioid-related harms have broad definitions, which contributes to the inability of DAPIS/DORA to detect or monitor their occurrence.

Data management

Several inefficiencies in the data quality management aspects of DAPIS were identified that result in matching errors. Firstly, the patient, health practitioner and drug names received from pharmacies often have minor errors or are not recognised by DAPIS and result in a matching error that needs to be manually corrected by PSB staff. Secondly, the method used by DAPIS to determine if there has been excessive supply of medications dispensed uses the calendar month rather than the number of days and frequently results in a breach occurring in error.

Integration of DAPIS/DORA with other systems

Currently, DAPIS/DORA does not integrate with any other systems and an external IT provider maintains the server therefore there are no requirements for DoH in relation to storing and backing up data.
**Views of PSB staff, pharmacists and GPs**

All 16 of the interviewed pharmacists, GPs and PSB staff reported they found DAPIS/DORA simple and easy to use. Several barriers to accessing DORA were identified. These included the short time to DORA logging out and the limited computers with DORA access within practices. Several pharmacists and GPs reported that they no longer access DORA because they had forgotten their password, or they had moved to a practice that did not have DORA access.

The reported time to access individual patients records on DAPIS was less than 15 seconds for PSB staff. Among the eight active pharmacists and GPs, five estimated that access to DORA took less than 30 seconds, two estimated it took them 30 to 60 seconds and one estimated it took over one minute.

Suggestions made to simply DAPIS/DORA from GPs and pharmacists were to simplify the search function in DORA and the prescription interval calculator in DAPIS.

**Summary of simplicity**

- Breaches, used as a proxy for health events, are detected automatically but the number and type of breaches that occur is not monitored
- Clear case definitions for doctor shopping and excessive opioid supply were developed by evaluation stakeholders
- Nonmedical use of opioids, inappropriate opioid prescribing and opioid-related harms are difficult to define
- Inefficiencies in data management were identified that produce matching errors and require PSB staff resources
- DAPIS/DORA does not integrate with any other systems
- All the GPs, pharmacists and PSB staff interviewed find DAPIS/DORA simple to use

**5.3.3. Representativeness**

**Reporting of dispensing events by pharmacies**

All pharmacies are required to report their S8 dispensing event information in real-time to DAPIS by the *Poisons Act 1971* (Tas) but not all pharmacies can
meet this requirement because of technical issues (such as expired IT
certificates) or physical issues (such as a new pharmacy opening). A Microsoft
Excel spreadsheet of all pharmacies and whether they are reporting in real-time
is maintained by PSB staff and updated monthly. At the time of the evaluation,
16 of 164 (10%) of pharmacies in Tasmania were not submitting dispensing
event information in real-time. All pharmacies not reporting in real-time
provide data monthly to DAPIS.

**Distribution of practices with licenses to access DORA**

At the time of this evaluation, 54 per cent (85/157) of pharmacies in Tasmania
and 56 per cent (88/158) of general practices in Tasmania had installed a
license to access DORA on at least one computer in the practice enabling
registered health practitioners to access DORA. These pharmacies and medical
practices are evenly distributed across the four regions of Tasmania. Most
registered practices correspond to the population distribution with the
exception of West and North West Tasmania, which has 15 per cent of registered
pharmacies despite 22 per cent of the Tasmanian population, and Launceston
and the North East region, which has only 18 per cent of medical practices
despite having 28 per cent of the Tasmanian population (Table 27).

### Table 27: Location of pharmacies and medical practices registered with DORA and
comparison with the Tasmanian population distribution

<table>
<thead>
<tr>
<th></th>
<th>Pharmacies</th>
<th>Medical Practices</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (%)</td>
<td>Number (%)</td>
<td>Number (%)</td>
</tr>
<tr>
<td>Hobart</td>
<td>44 (52)</td>
<td>38 (43)</td>
<td>224462 (43)</td>
</tr>
<tr>
<td>South East</td>
<td>4 (5)</td>
<td>13 (14)</td>
<td>38023 (7)</td>
</tr>
<tr>
<td>Launceston and North East</td>
<td>24 (28)</td>
<td>16 (18)</td>
<td>143537 (28)</td>
</tr>
<tr>
<td>West and North West</td>
<td>13 (15)</td>
<td>21 (24)</td>
<td>111566 (22)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>85</strong></td>
<td><strong>88</strong></td>
<td><strong>517588</strong></td>
</tr>
</tbody>
</table>
**Health events under surveillance**

DAPIS/DORA does not accurately describe the occurrence of any of the health events under surveillance over time and their distribution by place and person because these data are not collected in a format that can be analysed.

**Summary of representativeness**

- Approximately 90 per cent of pharmacies provide dispensing event information in real-time to DAPIS
- Approximately 54 per cent (85/157) of pharmacies and 56 per cent (88/158) of general practices have installed a license to access DORA.
- Medical practices and pharmacies with DORA installed are evenly distributed across Tasmania
- DORA does not describe the occurrence of the health events under surveillance

5.3.4. Sensitivity

**Overview**

It is not possible to calculate the sensitivity of DAPIS at detecting the health events under surveillance because the events are not being recorded in a format that can be objectively assessed. However, DAPIS is designed to detect selected health events as breaches (e.g. if a health practitioner prescribes without a permit or if they prescribe outside the permit conditions) and provide information to health practitioners to assist with decision making in relation to opioid prescribing and dispensing. Its sensitivity to detect these events and the views of users of DORA can be described.

**Events detected**

DAPIS is designed to detect all breaches in authority to prescribe conditions (i.e. if a health practitioner prescribes without a permit or if they prescribe outside the permit conditions), doctor shopping and excessive supply of opioids. Detection of these events occurs through automated processes that occur at the point of information being sent from pharmacies in real-time following a dispensing event. PSB staff report that DAPIS is 100% sensitive at detecting
breaches in authority conditions, doctor shopping and excessive supply of opioids acknowledging that this is delayed on weekends, public holidays and among pharmacies not reporting in real-time.

**Events not detected**

DAPIS/DORA is not able to detect inappropriate opioid prescribing, nonmedical use of opioids and opioid-related harms despite the objective to reduce their occurrence and the overall purpose of DAPIS/DORA to reduce opioid-related harms. Further research could be conducted to determine the extent of inappropriate opioid prescribing in Tasmania using data collected by DAPIS/DORA if case definitions were developed and applied routinely.

Limited information is collected indirectly by PSB staff on nonmedical use of opioids and opioid-related harms and stored in free text fields in DAPIS for the purposes of assisting with decision making by PSB staff in assessing authority to prescribe applications. These data are incomplete, subjective and cannot be assessed in their current format. No information is collected on opioid-related overdoses and deaths.

**Views of PSB staff**

All but one PSB staff member reported that DAPIS detects nonmedical opioid use and inappropriate opioid prescribing. Most (4/6) PSB staff agreed that DAPIS collects sufficient information to intervene to reduce opioid-related harms. Explanations to support their answers included:

“we have proven that – there are fewer opioid-related deaths in Tasmania”

“the average dose [of each S8 prescription] has reduced by 30mg OME per day”

Two of six PSB staff interviewed viewed DAPIS as too sensitive at detecting breaches in authority conditions although most (4/6) reported it was appropriately sensitive.

“I think the balance is about right. You need a human to scan the file and say that’s okay”
Views of pharmacists and GPs

Interviewed pharmacists and GPs had mixed views as to whether DAPIS/DORA detected nonmedical use of opioids. It was recognised that the PSB staff provided additional support for this with one pharmacist reporting

“that’s usually something we find PSB are picking up”

There were also mixed views among pharmacists as to whether DAPIS/DORA was able to detect inappropriate opioid prescribing. An example of potentially inappropriate opioid prescribing described by one pharmacist:

“we had a patient today with 10 prescriptions for OxyContin all written by the same doctor on different dates”

Summary of sensitivity

- The sensitivity of DAPIS to detect the health events under surveillance could not be calculated because data are not recorded on the events. Assessment of sensitivity was based on system observations
- PSB staff report that DAPIS detects all breaches in authority conditions, cases of doctor shopping and excessive supply of opioids
- DAPIS has low sensitivity at detecting inappropriate opioid prescribing, nonmedical use of opioids and opioid-related harms
- Most PSB staff (4/6) had the view that the sensitivity of DAPIS to detect breaches was appropriate
- Pharmacists and GPs had mixed views on the ability of DAPIS/DORA to detect nonmedical use of opioids and inappropriate opioid prescribing

5.3.5. Positive predictive value

The positive predictive value of DAPIS/DORA could not be calculated. Firstly, the absence of clear case definitions for three of the events under surveillance (nonmedical opioid use, inappropriate prescribing and opioid-related harms) prevents comparison of the number of reported cases and the number of true cases. Secondly, data on the two health events with clear case definitions (doctor shopping and excessive supply) are not collected in a format that can be monitored or analysed.
Summary of positive predictive value

- The positive predictive value could not be calculated

5.3.6. Data quality

Completeness of dispensing event information

Dispensing event information is extracted from pharmacies and provides complete information on dispensing events. Dispensing event information is automatically compared against criteria established by PSB to identify breaches which appear valid (e.g. discrepancies in authority conditions or doctor shopping).

Completeness and validity of data collected by DAPIS

Breaches are detected automatically by DAPIS and classified according to the patient risk level or, in the case of doctor shopping, as high or extreme risk. The risk classification tool used to assign a risk level for patients, which is also used to prioritise breaches, does not have objective criteria supporting its development. Its contents could be validated by assessment against the National Health and Medical Research Council levels of evidence and grading system for recommendations.

Monitoring of health events

We identified several areas whereby data quality could be improved. Firstly, if the health events had specific and measurable case definitions and were recorded systematically according to their case definitions, surveillance could then occur. Secondly, storing authority to prescribe information digitally, such as drug names and doses, would enable surveillance for opioid prescribing practices in Tasmania. Additionally, collecting information on breaches, such as the nature of the breach and the response times by PSB staff, would enable monitoring of response times, which could then be reviewed periodically to ensure PSB staff resource allocations are appropriate and that staff are working efficiently. Currently, no key performance indicators exist for the operation of DAPIS/DORA.

Given the challenges in identifying three of the health events of interest, resources should be allocated towards clearly identifying which aspects of the
health events DAPIS could collect and to identify other information sources, such as the Pennington overdose report and hospitalisation data, that could be used as alternative data sources. In addition, the review and development of new objectives for DAPIS would result in more realistic and measurable objectives for the future.

**Views of PSB staff**

PSB staff reported that many breaches would not occur if pharmacists and GPs checked DORA prior to prescribing or dispensing opioids. There was unanimous agreement among PSB staff that DORA collects sufficient information for doctors to modify their practices but that doctors needed to check DORA to access the information. It was also identified that information is not sufficient to prevent harms as doctors also need to have the knowledge of what to do with the information that DORA provides. All PSB staff reported having concerns about specific prescribers inappropriate prescribing of opioids:

“probably only two that really concern me as in they should probably not be practicing”

“[I have] serious concerns for at least 5”

All PSB staff supported regular reports being produced based on the information collected in DAPIS. These could be for internal DoH purposes, including spatial and temporal analysis of opioid prescribing (e.g. rate of prescribing, type of opioid or OMED), the number of interventions by PSB, and opioid-related harms, such as hospitalisations and deaths. A separate report for health practitioners was also supported, which could include S8 prescribing practices (drugs, doses and frequency), comparisons with colleagues, the number of approved authorities to prescribe, whether there has been any miscorrelation between the authority and dispensing or any red flags or alerts.

**Views of pharmacists and GPs**

In general, pharmacists and GPs were satisfied with the information provided in DORA to guide their decision making. Suggestions were made to include the dose prescribed and instructions as well as information on staged supply conditions. The completeness of information was also noted as a positive attribute:
“It expresses quite clearly how much medication people can have and what the pickup restrictions are”

**Potential expansion**

Almost all of the pharmacists and GPs (9/10) supported DORA being expanded to include benzodiazepines and S4 opioids (Tramadol and Panadeine forte) but users had mixed views about other drugs (Table 28).

Table 28: Pharmacist and GP views on whether additional classes of drugs should be available in DORA

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzodiazepines</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>S4 opioids</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Nonbenzodiazepine hypnotics (zopiclone and zolpidem)</td>
<td>8</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Gabapentinoids</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Tricyclic antidepressants</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Atypical antipsychotics</td>
<td>2</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Other drugs suggested by users to be included in DORA included Duromine (phentermine) and testosterone.

**National RTPMS**

All but one of the 16 health practitioners interviewed supported a national RTPMS in Australia. Most recommended that the national system be based on DAPIS/DORA. Several health practitioners emphasised the importance of ensuring the national system was adequately supported:

“as long as it remains relevant, easy to use and you can have confidence in it and there is support”

“it’s so good having it as a local thing where you can talk to.....or.....or and they know where you are coming from, they know the way you think, and you have the rapport, you have extra confidence”

A uniform approach to poisons legislation by states and territories was also noted as important in the implementation for a national RTPMS to ensure consistency across jurisdictions.
Recommendations of PSB staff, pharmacists and GPs

Other suggestions made by interviewees as to how DORA could be improved included:

- Integrate alerts for high-risk substances such as Fentanyl
- Automatically flag patients on high OMED
- Include the indication for the opioid
- Include the directions on the dosing
- Include the dispensing pharmacist
- Match brand and drug names
- Secure messaging

Summary of data quality

- Data on dispensing events are extracted automatically from pharmacies with completeness close to 100 per cent.
- Data on the health events being monitored are incomplete because they did not have case definitions prior to the evaluation. Several of the health events intended to be monitored such as nonmedical use of opioids are recorded opportunistically using free text, which limits the ability to assess their validity even if case definitions are developed and applied.
- The risk classification tool has not been validated against the National Health and Medical Research Council levels of evidence which means that the current classification system for risks of harm are subjective
- No key performance indicators have been developed for the operation of DAPIS
- PSB staff support regular reports being produced based on information in DAPIS
- Pharmacists and GPs were satisfied with the information provided in DORA to guide their decision making
Almost all the GPs and pharmacists interviewed supported DORA being expanded to include benzodiazepines, S4 opioids and nonbenzodiazepine hypnotics.

All but one of the 16 health practitioners we interviewed supported a national RTPMS in Australia.

5.3.7. Timeliness

At the time of this evaluation, 90% of pharmacies were sending dispensing event information in real-time and the other 10% were providing the information monthly. For the 10% of pharmacies reporting monthly, the time to detect and respond to doctor shopping and excessive supply are delayed. Further, DAPIS is only monitored during business hours. No staff are available on weekends or public holidays to respond to the health events under surveillance which delays the response times.

For the 90% of pharmacies reporting in real-time, in situations where it is deemed inappropriate for a patient to be supplied with medication, PSB staff need to intervene rapidly to prevent a dispensed opioid from being supplied to a patient. The frequency of PSB interventions is recorded in free text in DAPIS and could not be analysed. Two processes which affect the PSB staff response times are matching and breaches.

In relation to matching, PSB staff need to manually correct matching errors before they can respond to breaches. While they report that this process is quick and only takes a few minutes, it delays the response time to breaches and can contribute to opioids being supplied to patients inadvertently.

The time between each of the breaches being detected by DAPIS and responded to by PSB staff is not recorded in a format that could be assessed. The number of unactioned breaches is reviewed each morning and discussed at the PSB staff meeting but is not recorded. PSB staff report that the time between detection of a breach and the response is usually two to three minutes for extreme risk breaches and less than ten minutes for high risk breaches.

The time between an S8 being prescribed and dispensed is not captured in the current system and this may potentially result in delays in detecting doctor shopping and excessive opioid supply. For example, if a patient attends multiple doctors and receives multiple opioid prescriptions this would not be detected.
through DAPIS/DORA until they request the medication be supplied from a pharmacy. However, if GPs routinely checked DORA prior to prescribing opioids, some occasions could be prevented.

**Views of PSB staff, GPs and pharmacists**

PSB staff reported they were able to intervene to prevent opioid dispensing events from occurring if they acted upon breaches before the patient has left the pharmacy but often they do not respond in time. If pharmacists checked DORA prior to every opioid dispensing event it is possible that some of the breaches, such as excessive supply, would not occur and timeliness would be improved. Only one GP pointed out time delays in receiving information from PSB as an issue during the interviews:

“there was a delay of six to eight months between when the issues occurred with the patient and them notifying us”

**Summary of timeliness**

- Information on opioid dispensing events is provided in real-time from 90% of pharmacies in Tasmania
- Response times to breaches by PSB staff are extended on weekends and public holidays
- The time between breaches occurring and being responded to could not be assessed
- If GPs checked DORA routinely, some instances of doctor shopping would be identified earlier than they are currently
- If pharmacists checked DORA routinely, some of the breaches would be prevented and timeliness would be improved through reduced PSB staff workload

**5.3.8. Stability**

PSB staff reported that DAPIS/DORA had been stable throughout its lifetime without any unscheduled outages or repairs required.
5.3.9. Flexibility

The addition of Schedule 4 drugs to DAPIS/DORA in February 2018 did not cause any outages or maintenance issues. Interviews with PSB staff were done prior to the addition of Schedule 4 drugs in February 2018, therefore it is not known by how much their workload increased following this change. When asked to consider potential expansion of DAPIS/DORA to include other drugs, it was noted that, while it would be useful to have the additional drugs, expansion would increase the workload of PSB staff and the simplicity of the system may be reduced.

“[there is a] risk with expanding to other drug groups, we don’t want to dilute the message”

“not sure if PSB would need to monitor that information because of the workload involved”

Summary of flexibility

- Schedule 4 drugs were added to DAPIS/DORA in February 2018 without any adverse effects

6. Discussion

6.1. Significance of the findings

Two of five objectives of DAPIS/DORA identified for this evaluation have been achieved but we were unable to find objective evidence in support of the overall aim of DAPIS/DORA, to reduce opioid-related harms. These findings suggest that the aims and objectives of DAPIS/DORA need to be reviewed and refined. For future objectives to be useful they need to be specific, measurable and achievable.

The health events being monitored by DAPIS/DORA did not have case definitions prior to this evaluation, which limited our ability to evaluate its utility and attributes. For DAPIS/DORA to perform surveillance for actual health events, outside of the breaches in dispensing events which are currently monitored, case definitions for each of the health events of interest need to be used systematically. We also identified limitations in the collection, storage and
analysis of data that, if modified, would results in substantial improvements in many aspects of DAPIS/DORA and its ability to operate as a surveillance system.

The main benefit of DAPIS/DORA reported by PSB staff was the elimination of doctor shopping in Tasmania except for episodes that occur when PSB staff are not monitoring DAPIS, such as on weekends and public holidays, and during periods when pharmacies are not reporting dispensing data in real-time. This has occurred through actions taken by PSB staff based on information received by DAPIS on dispensing events. Direct monitoring of dispensing events requires approximately three full-time staff members each year.

If pharmacists and medical practitioners used DORA routinely, it is likely that situations of doctor shopping and requests for early or excessive supply of opioids would be detected at the point of prescribing or dispensing. This would result in the medical practitioner or pharmacist declining to prescribe or dispense the opioid medications and would reduce the number of breaches detected by DAPIS and thus the workload of PSB staff. The major factor we identified preventing this from occurring is the low participation among GPs.

**Participation rates**

Among pharmacists and GPs who had voluntarily registered with DORA, there were wide variations in participation rates. Pharmacists were more likely to use DORA often or routinely while medical practitioners were more likely never to use it. We estimate that registered GPs use DORA during two per cent of opioid prescribing occasions on average. These findings are consistent with international studies of non-mandatory PDMP that also report low participation rates (50, 51). The pharmacists and GPs we interviewed either accessed DORA routinely or if they had a suspicion that the patient was doctor shopping or using opioids for nonmedical purposes. Similarly, other studies have found that clinicians are most likely to access a PDMP if they suspect a patient of abuse or diversion but are less likely to access it for new or regular patients (52). Our finding that pharmacists find RTPMS acceptable and useful is consistent with other studies (53, 54).
Opioid prescribing trends

Since its introduction in 2009, there has been an increase in the rate of opioid prescribing in Tasmania (2). This has occurred despite a major review of opioid prescribing in Tasmania in 2010 by the NDARC that identified the greatest priority for Tasmania to reduce the harms associated with opioid prescribing was to address the high prevalence of use of long-term opioids for chronic non-cancer pain (21).

Data collected by PSB reveals that the number of permits to prescribe opioids in Tasmania has increased since the introduction of DAPIS/DORA and approximately 95% of authority to prescribe applications are for chronic non-cancer pain. Concurrently, the daily OMED prescribed over this period has reduced, suggesting there has been a change in practice by medical practitioners in the last nine years. Given that all authorities are reviewed and issued by PSB, it is possible these changes have occurred partly because of the recommendations or restrictions provided by PSB.

Strategies recommended by the NDARC review to reduce the nonmedical use of opioids in Tasmania, have been implemented inconsistently. These included education for doctors and patients about the risks of dependence and overdose; providing guidelines on the use of opioids for chronic non-cancer pain; enhancing RTPMS; ensuring restrictions are placed on pharmaceutical companies marketing opioids; and increasing access to opioid substitution therapy for people who use opioids illicitly (21). Several of the recommendations are beyond the statutory responsibility of PSB. However, through this evaluation, we have identified opportunities to address some of the them.

A major factor affecting opioid prescribing practices are the knowledge and practices of GPs, which were reported by PSB staff to vary widely. We confirmed this through our interviews with a small sample of GPs who reported a wide variation in opioid prescribing practices, from never initiating prescription opioids, through to commencing 50 or more patients on opioids in a single year. Education programs for GPs exist but all are voluntary. It is possible that GPs who have established practices of frequently prescribing opioids for chronic non-cancer pain are accounting for a high proportion of opioid prescriptions. This view was supported by PSB staff who all expressed concerns about a small number of individual prescribers in Tasmania.
To date, no systematic approaches have been used to ensure all GPs are following evidence-based practices. Further research to identify variations in prescribing practices may help to address this issue. The data collected by DAPIS, if modified, are ideally placed to be used for this purpose. The interpretation of such analyses needs to be approached carefully because clinicians vary widely in their scope of practice. For example, identifying medical practitioners who work in setting where opioids are used more commonly, such as by palliative care practitioners or opioid-replacement therapy prescribers, needs to be included in any such analysis.

A recent effort by the Australian Government Department of Health to raise awareness of opioid prescribing practices by sending letters from Australia’s Chief Medical Officer to the 20 per cent of GPs who have the highest rate of opioid prescriptions in Australia was widely criticised (55). In their criticism, the RACGP raised concerns around the methods used to identify practitioners and the limitations in such a blanket approach that did not consider practitioners using opioids commonly but appropriately, such as in palliative care settings. We are not aware of whether the Department of Health intends to follow up if there is any impact on prescribing practices by the GPs that were sent letters.

PSB administer the Poisons Act 1971 (Tas), the legislation to regulate medicines and poisons in Tasmania and administer permits to prescribe opioids under Section 59E of the Act. It’s role in relation to the quality use of medications is not well defined. With the increases in authority applications and the rates of opioid-prescribing over the last ten years, the resource and personnel requirements at PSB have increased, which may have impacted on the ability to provide training and education. The addition of S4 medications to DAPIS/DORA in February 2018 is likely to have increased the number of breaches being responded to by PSB staff. Developing methods to monitor the workload of PSB staff will assist in determining resources required in the future for the operation of DAPIS/DORA and assist to determine the feasibility of expansion of other aspects of PSB, such as if the Poisons Act 1971 (Tas) is expanded to require authorities for selected non-opioid drugs, as was recommended in a recent coronial investigation (46).
Optimising prescriber use of RTPMS

The Pew Charitable Trust in the United States has produced eight evidence-based practices to optimise prescriber use of RTPMS with the goal of achieving the United States White House Office of National Drug Control Policy of doubling the number of health practitioners registered with PDMP (56). These include: 1) prescriber use mandates, 2) delegating access to PDMP from prescribers to other staff, 3) unsolicited reports, 4) data timeliness, 5) streamlined enrolment, 6) educational and promotional initiatives, 7) health information technology integration and 8) enhanced user interfaces. All these recommendations apply to DAPIS/DORA and each warrants a brief discussion.

Mandating RTPM system use under specific circumstances, such as for new patients or every six months, has been shown to be effective at increasing RTPM use by prescribers, reducing the numbers of patients seeing multiple prescribers and reducing opioid prescriptions overall (56). Mandating RTPM use has been opposed by various groups in the United States, therefore ensuring buy-in from professional bodies, such as the RACGP and PSA is essential. The increased workload required to monitor prescribers to ensure they are adhering to professional Standards and follow up those who fail to meet the Standards also needs to be carefully determined.

Delegation of the task of accessing RTPM from medical practitioners to practice staff, including practice nurses and pharmacists, would eliminate the barrier described by several prescribers of insufficient time during a consultation and has the potential to encourage practice-based approaches to the regular use of RTPM. Using delegates has been shown to be cost effective (57) and desired by users (58, 59). It is possible that the use of delegates may result in disengagement by prescribers and we are not aware of any studies that have found the use of delegates was associated with overall reductions in the opioid-related health-events. The option warrants further discussion and investigation.

Unsolicited reports involve using PDMP data to produce reports on prescribing activity or potentially harmful drug use and proactively sending the information to stakeholders such as prescribers, dispensers, law enforcement and regulators. Unsolicited reports have been reported to be useful by prescribers (60) and have also been shown to reduce a number of outcome measures including the number of opioid prescriptions, the number of prescribers visited, the number
of pharmacies used and average daily oral morphine equivalence (61). Our recommendation for producing reports for clinicians on their prescribing practices and developing surveillance reports to allow for regional and temporal comparisons of controlled drugs also adheres to the principle of an effective surveillance system, that the information should be disseminated back to those responsible for preventing and controlling disease and injury (62).

Data timeliness is important to ensure optimum usefulness of RTPMS data. We found that 90 per cent of pharmacies in Tasmania send dispensing information in real-time to DAPIS. Delays in responding to events occur if the dispensing data does not match the predefined algorithms in PSB and breaches occur which have to be manually checked and corrected by PSB staff. Improvements in this process through more sophisticated electronic processes of checking and matching the information would result in reduced time to act upon potential opioid-related health events.

Streamlined enrolment of healthcare practitioners in the RTPM system is recommended to optimise the number of practitioners able to access the system. In the United States, over 80% of states provide streamlined prescriber enrolment (56). We estimate that approximately two thirds of general practitioners and approximately 57% of pharmacists are registered with DORA therefore increasing the number of registered users and simplifying the process of enrolment is one of our key recommendations. An option is to move to an automatic system, whereby new medical practitioners are automatically registered. This would be most useful for general practitioners and general practice registrars if it were coordinated by general practices with assistance from PSB.

Ongoing training and support, not just at the time of registration with RTPMS, has been identified in studies as beneficial to increase the use of RTPMS (63-65). Educational and promotional initiatives to increase awareness, knowledge and understanding and of DORA are likely to increase the use of the system. Currently, PSB are providing information sessions at general practice registrar orientation systems and opportunistic education during phone calls and in the written authorities to prescribe opioids. However, further improvements could be made in this area. We recommend developing a user’s guide and providing educational material, such as video tutorials, on the use of DORA. A further
recommendation is to develop an accredited Continuing Medical Education program for medical practitioners on the use of DORA that incorporates education on the safe and appropriate use of drugs of misuse potential.

Information technology to support integrated health data—combining PDMP data with other clinical data through technologies that are used to store, communicate and analyse health information, such as electronic health records—is not currently available in DAPIS/DORA. Many of the pharmacists and GPs we interviewed raised integration as one of the key changes that would increase their usage of DORA. The technological aspects of integration with current prescribing and dispensing software is complex, and beyond the scope of this evaluation. However, investigating how this could be achieved, such as through an alert within prescribing software when opioids are prescribed is recommended. Another recommendation is to integrate DAPIS/DORA with shared electronic health records, particularly as Australia implements the opt-out electronic health record in 2018/2019.

Finally, enhanced user interfaces whereby users can access dashboards or mobile applications to access RTPM data in easily understandable formats would be a longer-term goal for DAPIS/DORA. A key aspect of any surveillance system is ensuring that the information collected is provided back to those involved with its collection and RTPM data is no exception. Modern approaches, such as apps accessible from mobile devices, have been developed internationally (66) and may reduce some of the current barriers to accessing DORA.

**Unintended consequences of RTPMS**

Concerns have been raised that RTPMS may lead to a reduction in the availability of strong analgesia for patients who have genuine need, ‘the chilling effect’. Other potential harms are a shift towards illegal sources of opioids or other drugs, or for prescribers to prescribe unmonitored opioids, such as Schedule 4 drugs or benzodiazepines, to avoid scrutiny. We found that the only negative impacts of DAPIS/DORA were the time involved in monitoring the system for PSB staff and some limitations in the information received in the information received from PSB by GPs. We recommend factoring in potential unintended consequences in future data analysis plans, such as monitoring S4 and S8 prescribing trends.
6.2. Limitations

There were several limitations of this evaluation. We were only able to access information on pharmacists and GPs who had registered with DORA and therefore our findings may not apply to health practitioners who have never registered with DORA, which we estimate to be approximately 33 per cent of GPs and 43 per cent of pharmacists. To address this, we interviewed a sample of registered users who are not currently using DORA, but it is possible that pharmacists and GPs who have never used DORA have different views on its usefulness and attributes. We also excluded hospital-based health practitioners and non-GP specialist medical practitioners because they comprise a small minority of users of DORA, but they may also have different views and attitudes than those that were interviewed.

Our estimates for the frequency of use of DORA include both active and inactive users who registered with DORA since its introduction in 2009 as health practitioners are not required to notify PSB when they stop practicing in Tasmania and PSB staff do not remove those who are no longer prescribing or dispensing opioid medications therefore our estimate of the frequency of use of DORA may have been underestimated. Despite this, our estimate of the frequency of use is more likely to be overestimated because several patient views commonly occur while searching for a patient. This occurs because multiple searches are often used to identify the individual of interest and each patient viewed during the search process is recorded in the DORA viewing history as a unique patient view.

Finally, we did not perform an economic analysis to measure the cost effectiveness of DORA which would have provided additional information to support this evaluation.

7. Conclusion

DAPIS/DORA is a useful tool that clinicians can access to make decisions on prescribing or dispensing opioids. DAPIS is acceptable to PSB staff and DORA is moderately acceptable to pharmacists registered to use it but not to GPs who have very low participation rates. All 16 of the PSB staff, pharmacists and GPs that were interviewed supported having a RTPMS in Tasmania and most found
it simple to use. The contributions of PSB staff in monitoring opioid dispensing events and providing support for health practitioners in relation to opioid prescribing were highly valued by the GPs and pharmacists that we interviewed.

DAPIS/DORA has not achieved its aim of reducing opioid-related harms in Tasmania. Two of the five objectives identified for this evaluation have been achieved, to assess and monitor controlled drug dispensing events in real-time in Tasmania and to provide information that supports advice and recommendations from PSB to Tasmanian pharmacists and medical practitioners in relation to controlled drugs. Two objectives, to minimise the nonmedical use of controlled drugs in Tasmania and to reduce inappropriate prescribing of opioids in Tasmania could not be assessed because DAPIS/DORA does not currently detect or monitor these events. The final objective, to monitor the epidemiology of controlled drugs in Tasmania, has been partially achieved.

Two of the five health events under surveillance by DAPIS/DORA are detected—doctor shopping and excessive opioid supply—but they are not recorded using appropriate case definitions. The other three health events, nonmedical use of opioids, inappropriate prescribing and opioid-related harms are not detected systematically by DAPIS/DORA. The principal reasons are that their case definitions are not specific or measurable and data on their occurrence is incomplete.

A large volume of data is collected by DAPIS/DORA, but very little analysis or interpretation is occurring, and information is not provided back to the health practitioners involved in prescribing or dispensing opioids. Enhancing the capacity of DAPIS/DORA to detect and monitor health events and enhancing staff capacity to routinely analyse and interpret data are priority areas recommended for improvement.

RTPMS alone are insufficient to reduce opioid-related harms. Other factors, such as the knowledge and attitudes of health practitioners, access to pain, addiction and other multidisciplinary services and addressing the broader socioeconomic factors that contribute to opioid use and misuse, such as unemployment and education are also required.
We have developed 30 recommendations based on the findings of this evaluation that can improve the purpose and operation of DAPIS/DORA. These findings are arranged into five priorities: 1) to develop objective measures for the operation of DAPIS/DORA, 2) to convert DAPIS/DORA from a monitoring system into a surveillance system, 3) to improve the timeliness and quality of the data collected by DAPIS/DORA, 4) to improve participation rates and acceptability of DORA by ensuring health practitioners have access and understand how and when to use it, and 5) to enhance the role of the PSB and the DoH in the quality use of opioids in Tasmania.

8. Recommendations

1. Develop objective measures for the operation of DAPIS/DORA:

1A. Develop aims and objectives for DAPIS/DORA that are specific, measurable, achievable and time-bound that can be used for planning and resource allocation by senior PSB staff

1B. Develop performance indicators that enable the monitoring of activities performed in relation to DAPIS/DORA

2. Convert DAPIS/DORA from a monitoring system into a surveillance system:

2A. Investigate the feasibility of creating a data warehouse and hosting the DAPIS/DORA sites internally within the DoH rather than by an external provider

2B. Commence regular and systematic analysis of data collected by DAPIS to detect trends and variations in opioid prescribing in Tasmania

2C. Develop a publicly available annual report to share the results of the data analyses and summarise opioid prescribing trends and variations in Tasmania

2D. Develop an annual report for distribution to medical practitioners that prescribe opioids in Tasmania containing information on their prescribing practices and how they compare to other clinicians in the state
2E. Investigate the potential to incorporate administrative datasets, such as emergency department presentations, hospitalisations and coronial information to supplement the information collected by DAPIS

2F. Collaborate with research institutions and other organisations to share data collected by DAPIS in order to better understand opioid-related harms in Tasmania

3. **Improve the timeliness and the quality of data collected by DAPIS:**

3A. Review and assess the risk classification tool that classifies patients into low, medium, high and extreme risk using the National Health and Medical Research Council levels and grades of evidence to determine whether it should continue to be used or an alternative, simpler system put in place

3B. Review and develop new specific and measurable case definitions for the health events under surveillance to enable monitoring and surveillance of the health events to occur

3C. Increase the automation of information being collected by DAPIS, such as patient and drug details, to reduce matching errors

3D. Introduce a function within DAPIS that automatically calculates the OMED and interval between opioid dispensing events

3E. Review the requirement to record comments for all telephone conversations and investigate alternatives, such as categorical variables to record phone conversations

4. **Ensure health practitioners have access to DORA and understand how and when to use it to improve participation rates and acceptability**

4A. Implement a system to automatically register general practice registrars, general practitioners and community pharmacists who commence working in Tasmania

4B. Develop an orientation training package and a user’s guide for new users of DORA

4C. Simplify the login process by saving user details and remove the requirement to accept the site terms and conditions every time DORA is accessed
4D. Embed links to DORA into medical and dispensing software

4E. Integrate alerts to check DORA into medical and dispensing software when S4 or S8 medications are prescribed or dispensed

4F. Collaborate with professional organisations, such as the RACGP and PSA to develop Clinical Standards for the use of DORA. Once developed, providing training and support for the Clinical Standards for the use of DORA

4G. Develop accredited Continuing Medical Education programs for medical practitioners and pharmacists in the use of DORA and the quality use of drugs of misuse potential

4H. Support general practice staff, including practice nurses, practice managers and pharmacists to use DORA and assist GPs to use DORA

4I. Automatically detect inactive users and periodically contact them to determine the reasons for not accessing DORA and provide support or remove them from the list of registered users

4J. Allocate PSB staff members as contact points for each medical practice and pharmacy in Tasmania to ensure all practices have access to DORA

4K. Modify the security requirements to enable the DORA website to be accessible as a secure website from any computer

4L. Develop an App to enable secure access to DORA from Smartphones and other digital devices

4M. Investigate the use of an electronic messaging system between PSB staff and users of DORA

5. **Enhance the role of PSB and the DoH in the quality use of opioids in Tasmania:**

5A. Create a new role for a PSB staff member to provide training and education for health practitioners in the use of DORA and quality use of medications of misuse potential.

5B. Introduce mandatory continuous quality improvement activities for medical practitioners prescribing opioids outside of professional standards
5C. Promote the use of guidelines and resources for the quality use of medicines through existing communication networks, such as the RACGP Tasmanian branch, the PSA Tasmanian branch and Primary Health Tasmania

5D. Collaborate with GPs, addiction experts and pain specialists to develop strategies to assist medical practitioners to deprescribe opioids for chronic non-cancer pain, such as peer-to-peer mentors, education modules and educational events.
References


17. Qlik Sense 3.1 SR4 [Internet]. QlikTech International AB., 2018 [cited 7 August 2018].


Ringwalt C, Garrettson M, Alexandridis A. The effects of North Carolina’s prescription drug monitoring program on the prescribing behaviors of the state’s providers. J Prim Prev. 2015;36(2). Available from: [https://doi.org/10.1007/s10935-014-0381-0](https://doi.org/10.1007/s10935-014-0381-0)


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Appendices

Appendix 5: Overview of PSB process for assessing authority to prescribe applications

Pharmaceutical Services Branch

PROCESS FOR ASSESSING AND GRANTING AUTHORITIES TO PRESCRIBE SCHEDULE 8 DRUGS UNDER SECTION 59E OF THE TASMANIAN POISONS ACT 1971

Process Overview

AUTHORITY APPLICATION RECEIVED FROM THE MEDICAL PRACTITIONER

ASSESSMENT PROCESS AND TRIAGE COMPLETED

DECISION (Record of Reason Form)

LEVEL 1 Delegate

LEVEL 2 Consultant Medical Officer (CMO)

LEVEL 3 Expert Advisory Panel (EAP)

REFUSED

SUPPORTED WITH CONDITIONS (e.g. weekly pickups)

SUPPORTED PENDING ADDITIONAL INFORMATION

APPROVED (all necessary criteria met)

ACCEPTED

REVIEW REQUESTED (Doctor)

REVIEW REQUESTED (Patient)

REVIEW OF DECISION (Process for review of decisions form)
Appendix 6: Participant Information Sheet

Participant Information Sheet

Researcher:
My name is Laura Edwards and I am a General Practitioner in Tasmania. I am doing this research project at the Department of Health and Human Services as part of a Master of Applied Epidemiology at the National Centre for Epidemiology and Population Health, Australian National University.

Project Title: Evaluation of the Tasmanian Opioid Prescription Monitoring System

Investigation team: Dr Laura Edwards, Mr Sam Halliday, Mr Peter Boyles, Dr Adrian Reynolds, Dr Mark Veitch, Dr Stephanie Williams

General Outline of the Project:

- **Description and Methodology:** The aim of this study is to evaluate the Tasmanian Drugs and Poisons Information System (DAPIS). DAPIS is a real-time opioid prescription monitoring system that provides information on Schedule 8 drugs ( opioids and alprazolam) in Tasmania. The evaluation will involve interviews with people who have registered to use DAPIS and analysis data collected by DAPIS.
- **Number of Participants:** 20-30
- **Use of Data and Feedback:** Data from the evaluation will be used to improve DAPIS and will be published in the peer-reviewed literature to inform other states and territories and the national real-time prescription monitoring system. The research also will contribute to a Master of Philosophy thesis. A final report will be sent to participants by email on completion of the project.
- **Project Funding:** This project is supported by the Tasmanian Department of Health and Human Services with no external funding.

Participant Involvement:

- **Voluntary Participation & Withdrawal:** Participation in the research is voluntary and you may decline to take part or withdraw from the research without providing an explanation at any time until data are submitted to the researcher. You can also refuse to answer any questions during the interview. If you choose to withdraw from the study, your data will be destroyed and not used.
- **What does participation in the research entail?** Participation will involve one interview with the lead investigator. If you participate, you will have the option of the interview being audio-recorded or having handwritten notes taken. If you choose to have the interview audio-recorded the information will be transcribed prior to analysis. The questions will focus on your views of the usefulness of DAPIS and how it could be improved.
- **Location and Duration:** You will be contacted by a member of the research team to organise a time for the interview to occur. The interview will last for about one hour and will be conducted in person at a location that is convenient for you or can be done over the phone if you prefer.
- **Risks:** The risk of being involved in this research is very low. There is a very small risk of your information being identifiable but the investigators are using de-identification and aggregation of the information to minimise this risk. The questions will not be of a personal nature but you may be asked to describe some difficult clinical situations. If participating in the study makes you feel uncomfortable or distressed you may wish to contact the following:
  - Pharmacists’ Support Service: Ph 1300 244 910 [www.supportforpharmacists.org.au](http://www.supportforpharmacists.org.au)
RACGP GP Support Program, Ph. 1399 361 008

- Benefits: The benefits of participating in this research will be to identify areas of improvement in DAPIS and to provide information which will inform a national real-time opioid prescription monitoring program. These improvements should ultimately contribute to the goal of a reduction in opioid-related harms in Tasmania.

Confidentiality:
- Confidentiality: Any information collected will be de-identified. Only the nominated researchers will have access to the research material. Information in any publications will be aggregated and the participant work location will not be published. We will keep your identity confidential as far as the law allows.

Privacy Notice:
In collecting your personal information within this research, the ANU must comply with the Privacy Act 1988. The ANU Privacy Policy is available at https://policies.anu.edu.au/ppl/document/ANUP_010007 and it contains information about how a person can:
- Access or seek correction to their personal information;
- Complain about a breach of an Australian Privacy Principle by ANU, and how ANU will handle the complaint.

Data Storage:
- Where: De-identified data will be stored securely at the Tasmanian Department of Health and Human Services under existing data security arrangements.
- How long: The data will be stored for five years from the date of publication arising from the research.
- Handling of Data following the required storage period: Data will be archived following the required storage period and may be used for future research projects.

Queries and Concerns:
- Contact Details for More Information: If you have any queries on the project or would like any further information please contact Dr Laura Edwards, Lead Investigator at laura.edwards@t.dhhs.tas.gov.au or on (03) 6213 8200 or Dr Stephanie Williams, Academic Supervisor at stephanie.williams@anu.edu.au

Ethics Committee Clearance:
The ethical aspects of this research have been approved by the ANU Human Research Ethics Committee (Protocol 2017/703) and the Tasmanian Health and Medical Human Research Ethics Committee. If you have any concerns or complaints about how this research has been conducted, please contact the Ethics Manager, ANU Human Research Ethics Committee, The Australian National University, Telephone: +61 2 6125 3427 Email: HumanEthics.Office@anu.edu.au
Alternatively you can contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 6254 or email human.ethics@t tas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote HREC project number H0016970
### Appendix 7: Semi-structured interview questions for PSB staff

<table>
<thead>
<tr>
<th>Question</th>
<th>Response format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male/female</td>
</tr>
<tr>
<td>How long have you been working at PSB?</td>
<td>Years</td>
</tr>
<tr>
<td>What FTE do you work?</td>
<td>Number</td>
</tr>
<tr>
<td>How many hours a week are you directly involved with monitoring S8 prescription-related events? (include time working with DAPIS but not time related to reviewing S8 authorities)</td>
<td>number</td>
</tr>
<tr>
<td>Please estimate how many patient files you review in a typical morning or afternoon when you are directly working with DAPIS?</td>
<td>number</td>
</tr>
<tr>
<td><strong>Simplicity</strong></td>
<td></td>
</tr>
<tr>
<td>How long does it usually take you to access DAPIS for an individual patient?</td>
<td>less than 10 seconds</td>
</tr>
<tr>
<td>Do you find DAPIS simple to use?</td>
<td>Yes</td>
</tr>
<tr>
<td>Why?</td>
<td></td>
</tr>
<tr>
<td>How could DAPIS be simplified for PSB staff?</td>
<td>open</td>
</tr>
<tr>
<td>How could DORA be simplified for pharmacists and GPs?</td>
<td>open</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
</tr>
<tr>
<td>Do you think DAPIS is able to detect inappropriate opioid requests, opioid misuse or injudicious opioid prescribing?</td>
<td>Yes</td>
</tr>
<tr>
<td>Explain your answer</td>
<td>open</td>
</tr>
<tr>
<td>Do you think DAPIS collects sufficient information for doctors to modify their practices? E.g. reducing frequency or dose of medications</td>
<td>Yes</td>
</tr>
<tr>
<td>If so, how? (please give an example)</td>
<td>open</td>
</tr>
<tr>
<td>Do you think DAPIS collects sufficient information for PSB staff to identify injudicious opioid prescribing?</td>
<td>Yes</td>
</tr>
<tr>
<td>Explain your answer</td>
<td>open</td>
</tr>
<tr>
<td>Do you think DAPIS collects sufficient information for PSB staff to prevent opioid-related harms?</td>
<td>Yes</td>
</tr>
<tr>
<td>Explain your answer</td>
<td>open</td>
</tr>
<tr>
<td>Question</td>
<td>Response Options</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Can you estimate how often your actions result in a change to the medications that a patient receives?</td>
<td>Number (per day)</td>
</tr>
<tr>
<td>Please explain the changes (e.g. change to dose, timing or other)</td>
<td>open</td>
</tr>
<tr>
<td>What additional information could be added to improve the detection of inappropriate opioid requests or injudicious prescribing?</td>
<td>open</td>
</tr>
<tr>
<td>How could DAPIS be expanded or modified to improve its ability to detect opioid misuse or injudicious prescribing?</td>
<td>open</td>
</tr>
<tr>
<td>Do you think that DAPIS is too sensitive? (i.e. Significant time taken to review patient files for which no action is taken) Explain your answer</td>
<td>Yes</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>open</td>
</tr>
<tr>
<td>Please estimate how often (the proportion) of patients you review information in DAPIS that results in any change to the information on that patient, the dose or quantity of drugs they are prescribed, or a request being denied?</td>
<td>Number</td>
</tr>
<tr>
<td>Which opioid medications do you observe as the most commonly used inappropriately or prescribed injudiciously?</td>
<td>open</td>
</tr>
<tr>
<td>Do you think your time could be used more efficiently or effectively? If so, how?</td>
<td>open</td>
</tr>
<tr>
<td>Acceptability</td>
<td></td>
</tr>
<tr>
<td>What do you like about DAPIS?</td>
<td>open</td>
</tr>
<tr>
<td>What do you dislike (e.g. find frustrating or inefficient) about DAPIS?</td>
<td>open</td>
</tr>
<tr>
<td>Do you encounter difficulties in contacting prescribers or pharmacists in relation to particular clients you are concerned about?</td>
<td>Yes</td>
</tr>
<tr>
<td>Can you describe these?</td>
<td>open</td>
</tr>
<tr>
<td>Are there particular prescribers that you have concerns about their opioid prescribing practices? E.g. commonly encounter injudicious opioid prescriptions from is the issue more widespread?</td>
<td>Yes</td>
</tr>
<tr>
<td>Are you satisfied with the current communication between users and operators of DAPIS? Could these be improved in any way?</td>
<td>Yes</td>
</tr>
<tr>
<td>Usefulness</td>
<td></td>
</tr>
<tr>
<td>Do you think DAPIS results in a reduction in injudicious opioid prescribing or opioid misuse?</td>
<td>Yes</td>
</tr>
<tr>
<td>If yes, how?</td>
<td>open</td>
</tr>
</tbody>
</table>
Do you think DAPIS should be expanded to include other drugs e.g. all benzodiazepines?

If yes, which drugs?

Do you think DAPIS should be expanded in any other ways?

What do you see as the main positive impacts of DAPIS?

Have you observed or can you think of any negative impacts of DAPIS?

What do you see as the main barriers to healthcare practitioners using DAPIS?

- Do you have suggestions as to how these could be improved?

Do you have any additional suggestions for how DAPIS could be improved?

Would you like to see the data collected in DAPIS (e.g. on regional and temporal variations in opioid prescribing) regularly reported?

- Should this be for staff within DHHS or as a public report?
- If yes, which data do you think should be reported on?

Do you support a national real-time prescription monitoring system?

What advice or suggestions do you have for the national RT-PMP based on your experience with DAPIS?

What other suggestions do you have as to how money should be invested to reduce opioid-related harms in Australia? (E.g. training and education)

---

### Appendix 8: Semi-structured interview questions for GPs

<table>
<thead>
<tr>
<th>Question</th>
<th>Response format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
</tr>
<tr>
<td>How long have you been working in your profession (include time as a GP registrar or pharmacist intern)?</td>
<td>Number of years</td>
</tr>
<tr>
<td>For GPs how many sessions a week do you work as a GP?</td>
<td>number</td>
</tr>
<tr>
<td>How many patients do you typically see each hour?</td>
<td>number</td>
</tr>
<tr>
<td>Which suburb do you work in the majority of the time?</td>
<td>suburb</td>
</tr>
<tr>
<td>Approximately how often do you prescribe opioids for patients?</td>
<td>Daily</td>
</tr>
<tr>
<td>When did you first register with DORA? (please estimate if you are unsure)</td>
<td>year</td>
</tr>
<tr>
<td>How often do you access DORA as a proportion of all S8 prescription requests?</td>
<td>0-25%</td>
</tr>
<tr>
<td>Have you used DORA for non-S8 prescription or dispensing events e.g. benzodiazepines or tramadol</td>
<td>Yes</td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>How often do you use DORA for the following types of patients?</td>
<td>Never</td>
</tr>
<tr>
<td>New</td>
<td>Never</td>
</tr>
<tr>
<td>Patients of other GPs in the practice</td>
<td>Never</td>
</tr>
<tr>
<td>Regular patients</td>
<td>Never</td>
</tr>
<tr>
<td>In what situation or for what reasons do you usually access DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Simplicity</td>
<td>less than 10 seconds</td>
</tr>
<tr>
<td>How long does it usually take you to access DORA for an individual patient?</td>
<td>open</td>
</tr>
<tr>
<td>Do you find DORA simple and easy to use?</td>
<td>open</td>
</tr>
<tr>
<td>Do you have any suggestions for how DORA could be simplified? (e.g. provide an alert within medical software with a direct link)</td>
<td>open</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>yes</td>
</tr>
<tr>
<td>Has DORA provided information that resulted in you changing your management or prescribing behaviour?</td>
<td>yes</td>
</tr>
<tr>
<td>If so, how? e.g. changes in treatment</td>
<td>open</td>
</tr>
<tr>
<td>Have you been able to detect inappropriate opioid requests or opioid misuse through information provided by DORA?</td>
<td>yes</td>
</tr>
<tr>
<td>If yes, please explain how</td>
<td>open</td>
</tr>
<tr>
<td>Does DORA make you more confident in your ability to identify potential doctor shopping or potentially inappropriate S8 requests?</td>
<td>(Yes</td>
</tr>
<tr>
<td>Why is this?</td>
<td>open</td>
</tr>
<tr>
<td>Does DORA make you more confident in your ability to supply S8 and other drugs of high abuse potential in a safe manner?</td>
<td>Yes</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>0-25</td>
</tr>
<tr>
<td>For regular users of DORA, can you estimate what per centage of the time accessing individual patients on DORA has resulted in you detecting early or inappropriate prescriptions for medications?</td>
<td>open</td>
</tr>
<tr>
<td>What are the most common drugs of misuse potential you have encountered inappropriate requests for?</td>
<td>open</td>
</tr>
<tr>
<td>Acceptability</td>
<td>open</td>
</tr>
<tr>
<td>What do you like about DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Are there any reasons that you don’t use DORA as often as you could?</td>
<td>open</td>
</tr>
<tr>
<td>What is your opinion on pharmacists contacting you in relation to patients they are concerned about?</td>
<td>open</td>
</tr>
<tr>
<td>What is your opinion on the Department of Health and Human Services Pharmaceutical Services Branch (PSB) supporting opioid prescribing for patients based on their risk of opioid misuse?</td>
<td>open</td>
</tr>
<tr>
<td>What do you see as the strengths of the role of PSB in supporting opioid prescribing in Tasmania?</td>
<td>open</td>
</tr>
<tr>
<td>Question</td>
<td>Response Options</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>What do you see as the weaknesses or issues with PSB supporting opioid prescribing in Tasmania?</td>
<td>open</td>
</tr>
<tr>
<td>What is your opinion on staff at PSB contacting you in relation to patients S8 regimen safety and efficacy concerns detected through DORA?</td>
<td>open</td>
</tr>
<tr>
<td><strong>Usefulness</strong></td>
<td></td>
</tr>
<tr>
<td>Do you think DORA results in a reduction in injudicious opioid prescribing? If yes, how?</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you think DORA results in a reduction in prescription opioid related harms? If yes, how?</td>
<td>Yes</td>
</tr>
<tr>
<td>Are you satisfied with the information provided in DORA to guide your decision making?</td>
<td>Yes</td>
</tr>
<tr>
<td>What do you see as the main benefits to having DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Have you observed or can you think of any negative impacts of DORA?</td>
<td>open</td>
</tr>
<tr>
<td>What do you see as the main barriers to using DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Do you feel you have enough time to access DORA?</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you have suggestions as to how these could be improved?</td>
<td>open</td>
</tr>
<tr>
<td>Would you like to see DORA expanded to include other drugs?</td>
<td></td>
</tr>
<tr>
<td>- all benzodiazepines?</td>
<td>Yes</td>
</tr>
<tr>
<td>- S4 opioids e.g. tramadol, panadeine forte, digesic?</td>
<td>Yes</td>
</tr>
<tr>
<td>- Zolpidem and zopiclone</td>
<td>Yes</td>
</tr>
<tr>
<td>- Tricyclic antidepressants</td>
<td>Yes</td>
</tr>
<tr>
<td>- Gabapentinoids (gabapentin, pregabalin [Lyrica])</td>
<td>Yes</td>
</tr>
<tr>
<td>- Atypical antipsychotics</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there any additional information that you would like included in DORA?</td>
<td></td>
</tr>
<tr>
<td>Would you support DORA being expanded to require GPs to review information on DORA prior to prescribing S8 drugs</td>
<td></td>
</tr>
<tr>
<td>- At the point of requesting an Authority to Prescribe</td>
<td>Yes</td>
</tr>
<tr>
<td>- For all patients attending the practice for the first time</td>
<td>Yes</td>
</tr>
<tr>
<td>- For all patients seeing a GP for the first time?</td>
<td>Yes</td>
</tr>
<tr>
<td>- For every S8 request</td>
<td>Yes</td>
</tr>
<tr>
<td>- At a specific time-interval e.g. Every 6 months</td>
<td>Yes</td>
</tr>
<tr>
<td>- Under other circumstances</td>
<td>open</td>
</tr>
<tr>
<td>Do you support a national real-time prescription monitoring system?</td>
<td>Yes</td>
</tr>
<tr>
<td>What advice or suggestions do you have for the national RT-PMP based on your experience with DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Do you have any additional comments or suggestions for how DORA could be improved?</td>
<td>open</td>
</tr>
<tr>
<td>How should money be invested in Australia to reduce opioid-related harms</td>
<td>open</td>
</tr>
<tr>
<td>How many patients have you started on opioids for chronic non-cancer pain in the last 12 months?</td>
<td>number</td>
</tr>
<tr>
<td>How many patients with chronic non-cancer pain have you ceased opioids for in the last 12 months?</td>
<td>number</td>
</tr>
</tbody>
</table>

**Appendix 9: Semi-structured interview questions for pharmacists**
<table>
<thead>
<tr>
<th>Question</th>
<th>Response format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>&lt;25</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
</tr>
<tr>
<td>How long have you been working in your profession (include time as a pharmacist intern)?</td>
<td>years</td>
</tr>
<tr>
<td>what FTE do you work as a community pharmacist?</td>
<td>number</td>
</tr>
<tr>
<td>How many prescriptions do you dispense per day on average?</td>
<td>number</td>
</tr>
<tr>
<td>Which suburb do you work in the majority of the time?</td>
<td>Suburb</td>
</tr>
<tr>
<td>When did you first register with DORA? (please estimate if you are unsure)</td>
<td>Year</td>
</tr>
<tr>
<td>Approximately how often have you used DORA in the last 6 months?</td>
<td>Number</td>
</tr>
<tr>
<td>How often do you access DORA as a proportion of all S8 prescription requests?</td>
<td>0-25%</td>
</tr>
<tr>
<td>Have you used DORA for non-S8 prescription or dispensing events e.g. benzodiazepines or tramadol</td>
<td>Yes</td>
</tr>
<tr>
<td>In what situation or for what reasons do you usually access DORA?</td>
<td>open</td>
</tr>
<tr>
<td>How often do you use DORA for the following types of patients?</td>
<td></td>
</tr>
<tr>
<td>- New patients to the pharmacy</td>
<td>Never</td>
</tr>
<tr>
<td>- Patients with a history of aberrant opioid-related behaviour</td>
<td>Never</td>
</tr>
<tr>
<td>- Patients receiving high dose opioids</td>
<td>Never</td>
</tr>
<tr>
<td>Simplicity</td>
<td></td>
</tr>
<tr>
<td>How long does it usually take you to access DORA for an individual patient?</td>
<td>less than 10 seconds</td>
</tr>
<tr>
<td>Do you find DORA simple and easy to use?</td>
<td>open</td>
</tr>
<tr>
<td>Do you have any suggestions for how DORA could be simplified? (e.g. provide an alert within medical software with a direct link)</td>
<td>open</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Has DORA provided information that resulted in you changing your management or dispensing?</td>
<td>yes</td>
</tr>
<tr>
<td>If so, how?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you been able to detect unsanctioned opioid use or injudicious opioid prescribing by using DORA?</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you been able to detect opioid misuse through information provided by DORA?</td>
<td>yes</td>
</tr>
<tr>
<td>If yes, please explain</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Does DORA make you more confident in your ability to identify potential doctor shopping or potentially inappropriate S8 requests?</td>
<td>yes</td>
</tr>
<tr>
<td>Why is this?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Does DORA make you more confident in your ability to supply S8 and other drugs of high abuse potential in a safe manner?</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Positive predictive value</strong></td>
<td></td>
</tr>
<tr>
<td>For regular users of DORA, can you estimate what percentage of the time accessing individual patients on DORA has resulted in you detecting early or inappropriate prescriptions for medications?</td>
<td>per centage</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What are the most common drugs of misuse potential you have encountered inappropriate requests for?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acceptability</strong></td>
<td></td>
</tr>
<tr>
<td>What do you like about DORA?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there any reasons that you don’t use DORA as often as you could?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your opinion on PSB supporting opioid prescribing for patients based on their risk of opioid misuse?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What do you see as the strengths of the role of PSB in supporting opioid prescribing in Tasmania?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What do you see as the weaknesses or issues with PSB supporting opioid prescribing in Tasmania?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your opinion on staff at PSB contacting you in relation to patient S8 safety and efficacy concerns detected through DORA?</td>
<td>open</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Usefulness</strong></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Response Options</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Do you think DORA results in a reduction in inappropriate opioid prescribing? If yes, how?</td>
<td>yes</td>
</tr>
<tr>
<td>Do you think DORA results in a reduction in prescription opioid related harms? If yes, how?</td>
<td>yes</td>
</tr>
<tr>
<td>Are you satisfied with the information provided in DORA to guide your decision making?</td>
<td>yes</td>
</tr>
<tr>
<td>What do you see as the main benefits to having DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Have you observed or can you think of any negative impacts of DORA?</td>
<td>open</td>
</tr>
<tr>
<td>What do you see as the main barriers to using DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Do you feel you have enough time to access DORA?</td>
<td>yes</td>
</tr>
<tr>
<td>Do you have suggestions as to how these could be improved?</td>
<td>open</td>
</tr>
<tr>
<td>Would you like to see DORA expanded to include other drugs?</td>
<td>- All benzodiazepines? yes</td>
</tr>
<tr>
<td></td>
<td>- S4 opioids e.g. tramadol, panadeine forte, digesic? yes</td>
</tr>
<tr>
<td></td>
<td>- Zolpidem and zopiclone yes</td>
</tr>
<tr>
<td></td>
<td>- Tricyclic antidepressants yes</td>
</tr>
<tr>
<td></td>
<td>- Gabapentinoids (gabapentin, pregabalin [Lyrica]) yes</td>
</tr>
<tr>
<td></td>
<td>- Atypical antipsychotics yes</td>
</tr>
<tr>
<td>Is there any additional information that you would like included in DORA?</td>
<td>open</td>
</tr>
<tr>
<td>Would you support DORA being expanded to require pharmacists to review information on DORA prior to dispensing S8 drugs for the following groups:</td>
<td>- For all patients attending the pharmacy for the first time? yes</td>
</tr>
<tr>
<td></td>
<td>- For all patients on high oral morphine equivalent dose? yes</td>
</tr>
<tr>
<td></td>
<td>- For all patients assessed as being at high risk or opioid-related harms yes</td>
</tr>
<tr>
<td></td>
<td>- For all S8 prescription events yes</td>
</tr>
<tr>
<td></td>
<td>- Under other circumstances (e.g. at least every 6 months) yes</td>
</tr>
<tr>
<td></td>
<td>- Do you support a national real-time prescription monitoring system? yes</td>
</tr>
<tr>
<td>What advice or suggestions do you have for the national RTPMS based on your experience with DAPIS?</td>
<td>open</td>
</tr>
<tr>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Do you have any additional comments or suggestions for how DAPIS could be improved?</td>
<td>open</td>
</tr>
<tr>
<td>Do you have any suggestions for how money should be invested to reduce opioid-related harms in Australia? (E.g. training and education)</td>
<td>open</td>
</tr>
</tbody>
</table>
SUMMARY OF TEACHING AND OTHER ACTIVITIES
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Abbreviations

NCEPH: National Centre for Epidemiology and Population Health
H7N9: Avian influenza A(H7N9)
PSP: Paralytic Shellfish Poisoning
PST: Paralytic Shellfish Toxin
TSQAP: Tasmanian Shellfish Quality Assurance Program
UTAS: University of Tasmania
WHO: World Health Organization
WPRO: Western Pacific Regional Office
1. Teaching activities

Background

All MAE Scholars are required to complete two teaching requirements: preparation and delivery of a lesson from the field and a teaching session for first year MAE Scholars. The lesson from the field is a case-based study developed based on a challenge encountered during the MAE.

My role

For the MAE teaching requirements, I participated in teaching of first years during their outbreak investigation short course by assisting with teaching a case study of an outbreak of arboviral infection in Nhulunbuy, Northern Territory. I also prepared a teaching session for the first year MAE Scholars with colleagues from my MAE cohort. Our session was called epi-cranium and we prepared a range of epidemiology-related trivia questions based on the game Cranium.

For my lesson from the field, I delivered a teaching session for the other MAE Scholars on rapid risk assessment of acute events of potential public health concern based on the World Health Organization guidelines. I prepared an interactive activity that involved a scenario of several cases of a new strain of highly pathogenic avian influenza A(H9N2) in Australia. In the scenario each of the participants were allocated roles and then worked in small groups to perform the hazard assessment, exposure assessment and context assessment. We then applied the risk characterisation and risk assessment tool as a group. The full lesson schedule is provided in Appendices.

Appendix 10.

In addition to the MAE teaching requirements, I was also asked to deliver several lectures and workshops during my period as a MAE Scholar. I presented two lectures for the University of Tasmania; the first to Master of Public Health students on Communicable Disease Epidemiology; and the second to medical students on population health in Tasmania. The slides from the lectures are in Appendix 11 and Appendix 12.
I also co-convened two workshops for general practice registrars and one workshop for general practice supervisors. The registrar workshops, which are compulsory for general practice registrars, were on research and evidence-based medicine and population health medicine. The supervisor workshop was on critical appraisal and evidence-based practice. The workshops involved a combination of didactic teaching, small group exercises and interactive scenarios.

**Lessons learned**

My lesson from the field ran smoothly and was well received. Allocating roles to my colleagues ensured that everyone participated, and I received positive feedback after the lesson. I did not request formal feedback which may have been useful to identify any areas for improvement and to determine whether the learning objectives had been met.

I have found that teaching helps to consolidate existing knowledge highlights any gaps in knowledge or deficiencies in understanding a topic. I find it challenging to engage medical students and clinicians in public health and epidemiology who are focused on clinical medicine. One of the best approaches I have learnt to use are clinical scenarios that incorporate the concepts that I want to teach, such as risks and benefits of screening for prostate cancer or evidence-based treatment of otitis media. The MAE teaching sessions taught me to think carefully about the objectives of each session prior to its delivery and to ensure the concepts are made as simple as possible.

**Acknowledgements**

Thanks to Martyn Kirk, MAE Convenor during my course blocks, for his high standards and friendly approach, which I have tried to emulate, and Patrick O’Sullivan at General Practice Training Tasmania who makes teaching fun.
2. Field Epidemiology Fellowship at WHO

Background

From March to May 2017 I completed an eight-week Field Epidemiology Fellowship at the World Health Organisation (WHO) Western Pacific Regional Office (WPRO). My fellowship coincided with the peak of the fifth epidemic wave of avian influenza A(H7N9). In February/March 2017, up to 50 cases of avian influenza A(H7N9) were reported weekly from the China Focal Point to WHO WPRO. More cases were notified in the fifth epidemic of 2016/2017 than all the previous years combined. At the time there was also discussion over the emergence of human cases of highly pathogenic H7N9, which causes severe disease in poultry, and had only previously been identified in poultry. An additional cause for concerns was the geographical spread of H7N9 into provinces that had previously been unaffected, such as Tibet.

We performed weekly risk assessment of the risk of sustained human-to-human transmission of H7N9. The WHO risk assessment process incorporates both the likelihood of spread and the consequences to human health if such transmission were to occur. By regularly reviewing the risk assessment, WHO was able to provide a consistent message via regular updates that the risk of sustained human to human was low. Among the many human and animal public health implications of H7N9, the cultural considerations regarding poultry livestock, transportation, slaughtering and hygiene practices were all debated broadly at the WPRO headquarters.

My role

I was allocated the role of contact point within my team for avian influenza which meant I was responsible for responding to cases of avian influenza, preparing weekly surveillance reports on avian influenza and delivering regular presentations to members within my unit on the descriptive epidemiology of new cases. Each Friday afternoon we received an email documenting the previous weeks confirmed cases of avian influenza A(H7N9) from the China Focal Point. We then had to translate the information into English, rapidly assess the number of new cases, perform descriptive epidemiology and prepare a draft update of the Disease Outbreak News, which is published on the WHO
website. The draft would then be checked and cleared by senior members of our team and sent to the WHO headquarters in Geneva prior to its public release.

In addition to the daily and weekly responsibilities related to avian influenza and other surveillance activities, my major project as a Field Epidemiology Fellow was to perform a targeted review of the literature and assess the evidence in support of control measures for avian influenza. This work was presented at the end of my Fellowship at WPRO and was subsequently selected as a late breaker abstract for presentation at the TEPHINET international conference in Chiang Mai in August 2017. The slides from the TEPHINET presentation are in Appendix 13.

**Lessons learned**

When I arrived at WPRO I had very little knowledge of avian influenza or the International Health Regulations. My role as the contact point for avian influenza within my team required a crash course in the disease (and Chinese geography). Because the information is publicly released and of global significance, I learnt several lessons during this process. Firstly, I developed my ability to write clearly and succinctly, ensuring the information couldn’t be misinterpreted. I also learnt to choose the wording carefully for two primary reasons, so that it contained no implied or actual criticism of the international management of avian influenza and to maintain a calm message regarding the risk of human to human transmission of avian influenza. Finally, I learnt to carefully check for errors or omissions prior to forwarding to other members of my team because the information becomes publicly available and any errors may result in misinterpretations and require significant work to undo.

By participating in the daily meetings where we shared information with senior staff members, I gained skills in rapidly preparing information for presentation and experience in presenting information to an audience of ten to 30 team members.

**Acknowledgements**

I am especially grateful to Babatunde Olowokure who was an inspiring team leader. I would also like to thank the other Field Epidemiology Fellows, technical officers and medical officers that I worked with during my placement.
WHO Western Pacific Regional Office in Manila
3. Paralytic shellfish poisoning

**Background**

Paralytic shellfish poisoning is a rare but potentially fatal disease that occurs after eating seafood containing paralytic shellfish toxins. Several species of algae in Tasmania, Victoria, South Australia and New South Wales can produce paralytic shellfish toxins during harmful algal blooms. Wild shellfish are not monitored for PST in Tasmania and therefore consumption of wild shellfish during harmful algal blooms can lead to paralytic shellfish poisoning.

**My role**

Shortly before commencing the MAE, I was involved in responding to an outbreak of four cases of paralytic shellfish poisoning in Tasmania. Upon returning from the first course block at NCEPH, I was selected to prepare a presentation on the outbreak investigation as the Tasmanian Gerry Murphy candidate at the National Conference of the Royal Australian College of Physicians. I subsequently prepared a manuscript which was published in *Communicable Diseases Intelligence* in September 2018 (Appendix 14). I have included it in this chapter because the report was prepared and submitted for publication during the MAE.

**Lessons learned**

The outbreak of paralytic shellfish poisoning in Tasmania gave me an opportunity to work with external government organisations, namely the Tasmanian Shellfish Quality Assurance Program (TSQAP). I learnt a lot about the management of environmental health hazards and the Tasmanian shellfish program during this outbreak and the work that followed and the competing interests of the shellfish industry in Tasmania. An ongoing concern for shellfish farms is that negative publicity may affect commercial shellfish sales and Tasmania’s reputation for high-quality shellfish. I also learnt that the risks of contaminated shellfish are difficult to quantify and the funding limitations on testing of wild shellfish limit the ability to resolve the uncertainties.
Acknowledgements

I would like to thank my co-authors, Mark Veitch and Katrina Wilson, and all the staff who assisted in the management of the PSP outbreak.
Appendices

Appendix 10: Lesson from the Field: Rapid Risk Assessment of Acute Events of Potential Public Health Concern

Learning objectives:

- To gain an understanding of the aims and objectives of assessing the risk of an acute public health event
- To become familiar with the steps in performing a rapid risk assessment of acute events of potential public health concern by participating in a scenario with colleagues
- To become familiar with the resources available in performing rapid risk assessment of acute events of public health concern

Pre-lesson questionnaire

Survey Monkey questionnaire:

1) What do you understand by the term risk assessment?
2) What are the steps involved in a risk assessment?
3) How do you think risk assessment could potentially be used in infectious diseases?
4) Which infectious diseases do you think pose the greatest threat to Australia?

Pre-lesson reading:

- Annexe 2 of the World Health Organization International Health Regulations (2005), Third Edition
- World Health Organization Emergency Response Framework

The lesson

Part 1: Background information

Aims of risk assessment:

- Assess the risk of an acute public health event
- To document the summarised information of a RRA of acute events of potential public health concern at one particular point in time (may be repeated as event develops)
- To inform and support decision making of senior management regarding acute events of potential public health concern
- To identify and initiate WHO response mechanisms to
  - Reduce the impact of the event on human health
  - Reduce negative social and economic consequences
- To share WHO Rapid Risk assessment with key stakeholders and partners

Objectives of rapid risk assessment

- To assess the risk posed by an acute public health event to negatively impact human health
- To categorize the risk as low, moderate, high or very high, using the Hazard, Exposure and Context approach
- To agree on specific actions to be taken by WHO based on the outcome of the risk assessment
- To identify communications/ information products to be shared, and to which stakeholders

Performing a rapid risk assessment using the WHO template

- The rapid risk assessment is conducted in a short meeting (maximum 1 hour); the person leading the risk assessment may pre-fill information on page 2 of the template (supporting information) before the meeting takes place, to have a basis for discussion.
- By the end of the meeting, the risk assessment template should be filled in as per consensus of the team conducting the risk assessment.
- The completed risk assessment should be shared with all members of the team

Rapid risk assessment process

For further details see the WHO rapid risk assessment guidelines p14
### Exposure assessment

<table>
<thead>
<tr>
<th>Definition</th>
<th>Information required to evaluate exposure includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost certain</td>
<td>Is expected to occur in most circumstances (e.g. probability of 95% or more)</td>
</tr>
<tr>
<td>Highly likely</td>
<td>Will probably occur in most circumstances (e.g. a probability of between 70% and 94%)</td>
</tr>
<tr>
<td>Likely</td>
<td>Will occur some of the time (e.g. a probability of between 30% and 69%)</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Could occur some of the time (e.g. a probability of between 5% and 29%)</td>
</tr>
<tr>
<td>Very unlikely</td>
<td>Could occur under exceptional circumstances (e.g. a probability of less than 5%)</td>
</tr>
</tbody>
</table>

### Process

- Mode of transmission (e.g. human-to-human: droplet spread, sexual transmission; animal-to-human; occupational risk);
- Information related to the vector (e.g. distribution, density, infectivity) and/or animal hosts (density, prevalence, existing control programmes);
- Incubation period (known or suspected);
- Estimation of the potential for transmission (e.g. R0 basic reproduction number);
- Immune status of the exposed population; and
- Dose of exposure (e.g. amount of ingested/absorbed/inhaled heavy metals, salmonella bacteria, radionuclides) and duration of exposure.

### Context assessment

<table>
<thead>
<tr>
<th>Definition</th>
<th>Context assessment is an evaluation of the environment in which the event is taking place. This may include the physical environment such as climate, vegetation, land use (e.g. farming, industry) and water systems and sources, as well as the health of the population (e.g. nutritional status, disease burden and previous outbreaks), infrastructure (e.g. transport links, health-care and public health infrastructure), cultural practices and beliefs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Context assessment should consider all factors that can affect the risk of the event. These factors may be social, ethical, technical, scientific, economic, environmental and political. They will include the surveillance system’s capacity to detect cases, health-seeking behaviour of the individual groups, the prevalence of malnutrition, environmental conditions favouring the multiplication of vectors and the presence of animal hosts. For instance:</td>
</tr>
<tr>
<td></td>
<td>For measles, the risk of expansion of an outbreak after the detection of the event will depend upon factors including the immunization coverage of the population; the capacity to quickly organize a mass vaccination campaign if the coverage is too low; the local conditions of hygiene; the access to health care; the capacity to detect and isolate cases; and population behaviour.</td>
</tr>
<tr>
<td></td>
<td>For an event such as contamination of a river by a chemical agent, the risk of human intoxication will depend on factors such as local practices about water use; season (cold or hot, rainy or dry); river flow; capacity to broadcast messages of prevention; and acceptability of control measures.</td>
</tr>
<tr>
<td>Level</td>
<td>Definition</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| Severe   | - Severe impact for a large population or at-risk group  
           - Severe disruption to normal activities and services  
           - A large number of additional control measures will be needed and most of these require significant resources to implement  
           - Serious increase in costs for authorities and stakeholders |
| Major    | - Major impact for a small population or at-risk group  
           - Major disruption to normal activities and services  
           - A large number of additional control measures will be needed and some of these require significant resources to implement  
           - Significant increase in costs for authorities and stakeholders |
| Moderate | - Moderate impact as a large population or at-risk group is affected  
           - Moderate disruption to normal activities and services  
           - Some additional control measures will be needed and some of these require moderate resources to implement  
           - Moderate increase in costs for authorities and stakeholders |
| Minor    | - Minor impact for a small population or at-risk group  
           - Limited disruption to normal activities and services  
           - A small number of additional control measures will be needed that require minimal resources  
           - Some increase in costs for authorities and stakeholders. |
| Minimal  | - Limited impact on the affected population  
           - Little disruption to normal activities and services  
           - Routine responses are adequate and there is no need to implement additional control measures  
           - Few extra costs for authorities and stakeholders |
Part 2: The scenario

July 2018: Following three deaths from MERS in Australia during 2017, the Federal Health Minister announced a suite of changes to the management of infectious diseases in Australia. He outlined a plan which included establishing a national CDC. The national CDC will be responsible for carrying out rapid risk assessment of acute public health threats. The two purposes of rapid risk assessment have been listed as:

- To develop priorities in planning the management of potential infectious disease epidemics or pandemics affecting Australia
- To establish a formal method for managing emerging infectious diseases in Australia

Due to immense political pressure, the National Incident Room in Canberra has been converted into the CDC and a number of staff have been contracted to start work with just two weeks notice. You are among the new staff who has just been recruited.

Staff meeting 0800 August 3, 2018

- Julie: You are a recently graduate MAE scholar and have been recruited to lead the risk assessment development planning, implementation and evaluation committee of the national CDC when the pandemic strikes.
- Mica: You are a spatial scientist and mathematician and recently submitted your PhD in modelling influenza transmission, evolution and environmental adaptation.
- Siobhan: You are an ex-tv personality who now works as a freelance health journalist. You have recently started working at the national CDC as a health communication expert.
- Rose: You are a recently graduated MAE scholar and have been recruited as an epidemiologist at NT Health communicable disease headquarters and as the NT national CDC rep. You are the only person in the team who has experience in risk
assessment for infectious diseases and you are the lead epidemiologist on the risk assessment core committee.

- Katherine: You were the chair of CDNA during the H1N1 pandemic in Australia and also have a PhD in influenza epidemiology. You have extensive experience in infection prevention and control and detailed knowledge of influenza pathophysiology and epidemiology. You have been invited to be the lead influenza expert on the risk assessment committee.

- Brigitta: You are a researcher from ANU who has been recruited part-time by the CDC to build cross-organisational relationships and partnerships. You are focused on enhancing the connections and team-based approaches to problem solving and relationships.

- Sam: You have been seconded from ACT Health to work at CDC but haven’t been allocated to a section yet.

- Jonathan: You are the lead policy advisor at the CDC and a previous EHO.

- Aly: You are the Indigenous Health advisor at the CDC with clinical experience working in the NT as a remote area nurse.

The scenario:

- 0800 CDC morning meeting

- Confidential information from the National Incident Room has just arrived that four cases of suspected highly pathogenic avian influenza A(H9N2) have been detected in two different locations in Australia. Two cases have been detected in siblings aged 7 and 9 in the Royal Prince Alfred hospital in Sydney and both are reported to have died. The family members of the cases, including two other siblings and their parents, are also reported to have developed symptoms of influenza overnight. The family have just returned from Ulaanbaatar and the mother is pregnant.

- The other two cases have been reported in Jabiru in the Northern Territory among a school group of children from Mongolia who are on an exchange with their sister city. At least one of the children has died and the other is in a critical condition, having just been evacuated by helicopter to the Royal Darwin hospital.

The plan:

- Nominate a person to lead the risk assessment

- The lead can then allocate roles to the team working in pairs or groups of three. Use the WHO risk assessment guidelines as a guide.

  - Group 1: Hazard assessment
  - Group 2: Exposure assessment
  - Group 3: Context assessment
- Take 30 minutes to research your topic based on the WHO Rapid Risk Assessment guidelines and develop a short power point presentation to be shared with the group.

30 minutes later group reconvene

- Short powerpoint presentations delivered by the groups
- Groups then work together facilitated by myself to perform the risk assessment

Selected sections from the WHO Rapid Risk Assessment template:

### Overall risk (based on information available at time of assessment)

<table>
<thead>
<tr>
<th></th>
<th>Very high</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Risk question*  
*Identified at the beginning of meeting, specific to the event

<table>
<thead>
<tr>
<th>Risk question*</th>
<th>Assessment</th>
<th>Likelihood*</th>
<th>Consequences**</th>
<th>Risk***</th>
<th>Confidence*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk for impact on human health?</td>
<td>National</td>
<td>Likely</td>
<td>Minor</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Regional</td>
<td>Likely</td>
<td>Minor</td>
<td>Moderate</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of event spreading and/or increasing cases?</td>
<td>National</td>
<td>Likely</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>Likely</td>
<td>Mild to mod</td>
<td>Mod to high</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>Very unlikely</td>
<td>Minimal</td>
<td>Low</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of insufficient control capacities with available resources?</td>
<td>National</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Low-mod</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>Very unlikely</td>
<td>Minimal</td>
<td>Low</td>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Choose from Almost certain, High likely, Likely, Unlikely, Very unlikely OR insufficient information available

**Choose from Severe, Major, Moderate, Minor, Minimal OR insufficient information available

***Choose from Very high, High, Moderate, Low according to the risk matrix combining likelihood and consequences

*Choose High or Low
Appendix 11: Copy of the slides used for the lecture to University of Tasmania Master of Public Health students on Communicable Disease Epidemiology
**Define and Count Cases**

Case Definitions:
- Probable Case: a person who had diarrhoea and/or vomiting with onset after 30 March 2013 who has reported eating ammonium sulphate.
- Confirmed case: a Probable Case with a stool specimen in which norovirus has been identified.

**Line List**

<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Sex</th>
<th>Symptoms</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>M</td>
<td>Diarrhoea</td>
<td>Healthy</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>F</td>
<td>Vomiting</td>
<td>Healthy</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>M</td>
<td>Diarrhoea</td>
<td>Severe</td>
</tr>
</tbody>
</table>

**Descriptive Epidemiology**

- 138 cases
- Age: median 32 years, range 0-84
- Sex distribution: 56% male
- Incubation period: median 29 hours, range 2-68
- Illness duration: median 48 hours, range 24-168 hours
- 1 case hospitalised

**Descriptive Epidemiology: Time**

- Illness onset distribution
- Median: 48 hours
- Range: 24-168 hours

**Is it an Outbreak?**

- Determine the incidence of cases
- Confirm the diagnosis
- Admit and count cases
- Describe the epidemiology, time, space, and person
- Formulate related cases
- Conduct and test hypotheses
- Compare to previous outbreaks
- Plan a more systematic study
- Prepare a paper report
- Execute control and prevention activities
WHO IS AT RISK?
- What are the symptoms?
- Have they been contracted?
- Have they been isolated?
- What is the typical age range?
- What is the typical duration?
- Environmental factors:
  - Soil
  - Water
  - Food
  - Other sources
- Additional factors:
  - Smoking
  - Alcohol
  - Other habits

IS IT AN OUTBREAK?
1. Determine the presence of an outbreak.
2. Confirm the diagnosis.
3. Define and count cases.
4. Examine epidemiology: time, place, and person.
5. Determine who is at risk.
6. Develop and test hypotheses.
7. Conduct hypothesis with facts.
8. Plan a recovery strategy.
9. Prepare a written report.
10. Execute control and prevention activities.

DEVELOP AND TEST HYPOTHESIS (ANALYTICAL EPIDEMIOLOGY)
- Hypothesis: oysters consumed at Napa Bay Oyster Farm were contaminated with norovirus.
- Observational studies among consumers.
- Null hypothesis: consumption of Napa Bay oyster farm did not result in illness.
- Consider current information.
- Conduct an analytical study.
- Conduct case control.
- Consider new hypotheses.

CASE CONTROL
- Study design by groups.
- Case-Control Study.
-天津
- Osaka
- Case-Control Study
- New York
- 100 cases

CONSORT
- Study design by groups.
- Case-Control Study.
- New York
- 100 cases

ANALYTICAL EPIDEMIOLOGY
- 2 groups identified: all diners interviewed.
- Retrospective cohort design.
- Risk ratio:
  - Who ate oysters: 17/20 = 0.85
  - Who didn’t eat oysters: 1/10 = 0.1
- Relative risk: 8.5 (95% confidence interval 1.3-55).
- Mortality rate:
  - n = 12
  - 12/12
  - Mortality rate: 100%
1. Determine the existence of an outbreak.
2. Confirm the diagnosis.
3. Define and count cases.
4. Descriptive epidemiology: time, place, and person.
5. Determine who is at risk.
6. Develop and test hypotheses.
7. Compare hypotheses with facts.
8. Plan a more systematic study.
9. Prepare a written report.
10. Execute control and prevention activities.

**COMPARE HYPOTHESIS WITH FACTS**
- Is it biologically plausible?
- Do the findings make sense?
- Are the epidemiological findings valid?
- Study power, chance, bias, confounding, effect modification.
- Do the epidemiological findings fit with environmental investigations?

**PLAN A MORE SYSTEMATIC STUDY**
- After field investigation is complete.
- Consider more thorough study to answer gaps in information e.g., vaccine efficacy, serosurvey, longer-term follow-up.
- Not needed for smaller outbreaks e.g., gastro.

**PREPARE A WRITTEN REPORT**
- Internal report and debate.
- Have there been other similar outbreaks?
- Report for consumers and industry.
- Health department bulletin or peer-reviewed journal e.g., Communicable Diseases Intelligence.
- Share lessons learned and public health importance.
CONTROL AND PREVENTION

OUTBREAK RESPONSE

PARALYTIC SHELLFISH POISONING OUTBREAK 2015

DESCRIPTIVE EPIDEMIOLOGY

- Algal bloom east coast Tas from July 2015
- Public Health Alert Friday 3rd October 2015
- Initial two cases notified Friday 3rd October

- Outbreak team established
- Case definitions: probable and confirmed
- Active case finding
- Temporary signs erected
- Communication to public
- Telephone interviews with cases
- Tourism information

- 2 - 12 October
- 5 suspected cases notified
- 4 confirmed, no probable
- 3M (75%) males, median age 59 years
- Median number of mussels consumed: 14 (6-35)
- Median time exposure - symptoms: 1.25 hours (30 minutes to 12 hours)
Appendix 12: Copy of the slides used for the population health and epidemiology in Tasmania lecture

Topics

- Snapshot of Tasmania’s population
- What the data tells us
- Why it’s important for you

The Population: Australia

Health indicators for Australia and OECD average, 2013

<table>
<thead>
<tr>
<th>Indicator</th>
<th>OECD average</th>
<th>Australia</th>
<th>OECD average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy at birth (male)</td>
<td>77.0</td>
<td>80.8</td>
<td>79.8</td>
</tr>
<tr>
<td>Life expectancy at birth (female)</td>
<td>83.1</td>
<td>84.3</td>
<td>87.3</td>
</tr>
<tr>
<td>Average years living with disability (years)</td>
<td>11.0</td>
<td>13.3</td>
<td>12.0</td>
</tr>
<tr>
<td>Cancer mortality rate per 100,000</td>
<td>26.0</td>
<td>19.7</td>
<td>23.5</td>
</tr>
<tr>
<td>Teenage suicide rate per 100,000</td>
<td>12.0</td>
<td>15.5</td>
<td>13.0</td>
</tr>
<tr>
<td>Infant mortality rate per 100 live births</td>
<td>5.0</td>
<td>5.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Low birthweight births</td>
<td>6.0</td>
<td>6.2</td>
<td>5.4</td>
</tr>
<tr>
<td>Heavy smoking (current smokers aged 15 years+)</td>
<td>19.6</td>
<td>12.6</td>
<td>17.7</td>
</tr>
<tr>
<td>Alcohol consumption (litres per person aged 15 and over)</td>
<td>8.0</td>
<td>5.3</td>
<td>7.4</td>
</tr>
<tr>
<td>Deaths aged 15 and over, combined external and internal deaths</td>
<td>20.0</td>
<td>20.3</td>
<td>19.0</td>
</tr>
<tr>
<td>Diabetes mortality among adults (males)</td>
<td>2.0</td>
<td>3.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Diabetes mortality among adults (females)</td>
<td>2.0</td>
<td>3.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

The oldest jurisdiction in Australia

Median age of population at 30 June

An ageing population

We have the highest % of the population with a self-reported disability, 2009

We are more likely than other Australians to report our health as poor

We have the lowest average household income

Australia’s life expectancy

Life expectancy at birth by sex, Australia, 1890-2014
<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause</th>
<th>Age-standardised mortality rate (Tasmania)</th>
<th>Age-standardised mortality rate (Australia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Malignant neoplasms (C00-C97)</td>
<td>135.1</td>
<td>153.1</td>
</tr>
<tr>
<td>2</td>
<td>Ischaemic heart disease (I20-I25)</td>
<td>131.1</td>
<td>87.4</td>
</tr>
<tr>
<td>3</td>
<td>Cardiovascular disease (I00-I09)</td>
<td>47.3</td>
<td>41.5</td>
</tr>
<tr>
<td>4</td>
<td>Other forms of heart disease (I26-I50)</td>
<td>39.8</td>
<td>29.3</td>
</tr>
<tr>
<td>5</td>
<td>Diabetes, including type 1 and type 2</td>
<td>9.4</td>
<td>3.9</td>
</tr>
<tr>
<td>6</td>
<td>Chronic lower respiratory disease (J40-J47)</td>
<td>3.4</td>
<td>5.3</td>
</tr>
</tbody>
</table>

**CANCER CARDIOVASCULAR DISEASE**

**Cancer**

Cancers

![Cancer Map](image)

**Cancer rates**

![Graph of Cancer Rates](image)

**CANCER DIAGNOSES – MALES, 2005-09**

- Prostate: 31.2%
- Colorectal: 13.1%
- Lung: 9.5%
- Melanoma of skin: 6.4%
- All lymphomas: 4.0%

1. % of all new cases
2. Discounted at 2005-09 annual average + 79.3 cases per (2000)

Source: AIHW, My Healthy Communities, National overview.
CANCER DIAGNOSES – FEMALES, 2005-09

<table>
<thead>
<tr>
<th>Disease</th>
<th>% of all new cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>35.8%</td>
</tr>
<tr>
<td>Colorectal</td>
<td>16.8%</td>
</tr>
<tr>
<td>Melanoma of skin</td>
<td>9.8%</td>
</tr>
<tr>
<td>Lung</td>
<td>9.4%</td>
</tr>
<tr>
<td>All lymphomas</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

Note: 1. There were 137,770 new cases diagnosed in 2005-09; average 49,496 cases per year.

CARDIOVASCULAR DISEASE

Hypertension by State/Territory

High cholesterol by State/Territory

Heart attacks (STEMI) by state/territory

HOSPITAL SEPARATIONS, IHD, TAS, 2007-11

Source: Heart Foundation Australian Heart Maps

Source: Heart Foundation Australian Heart Maps

Source: Heart Foundation Australian Heart Maps

Source: Australian Institute of Health and Welfare
AND AN INCREASING NUMBER OF CHILDREN (AGE 5-17), 2011/12
(WAS 18% 10 YEARS AGO)

Overweight and obesity:
Tasmania v's Australia

Source: ABS National Health Survey: First results, 2014-15

SO IN A NUTSHELL.....

WE ARE:
- OLD
- FAT
- SICK
- POOR

WHAT CAN WE DO ABOUT IT?

Keep people out of hospital?

Manage people with chronic conditions better?

KEEPING PEOPLE OUT OF HOSPITAL

ALL-CAUSE HOSPITALISATIONS BY SEX, TAS, 2002-11

Stevens/Paramedics, Queensland, Tasmania.
Appendix 13: Copy of the slides presented at the TEPHINET international conference

Human infection with avian influenza A(H7N9): Descriptive epidemiology and preliminary review of the literature
Laura Edwards^{1,2} and Stephanie Williams^{1}

{Australian National University, Canberra, Australia
Department of Health and Human Services, Tasmania, Australia

Introduction
- Field Epidemiology Fellow at World Health Organisation Western Pacific Regional Office March – May 2017
- Weekly analysis of avian influenza A(H7N9) notifications for WHO risk assessment

Overview
- Avian influenza A(H7N9)
  - Characteristics
  - Epidemiology
- Public health control measures
  - Current evidence
  - Evidence gaps

Is elimination of human infection with avian influenza A(H7N9) possible?

Avian influenza A(H7N9)

Context: China
- Large quantities of domestic waterfowl mixed with other animals and poultry
- Poultry industry:
  - 19.8 million tonnes of meat in 2013
  - 29.1 million tonnes of eggs in 2013
- Live poultry market system:
  - 50% of the poultry industry
  - Less regulation than the integrated system
- More points of contact between poultry, other animals and humans
Characteristics of avian influenza A(H7N9)

- US CDC Influenza Risk Assessment Tool
- WHO Tool for Influenza Pandemic Risk Assessment

Methods
1. Descriptive analysis of epidemiological characteristics
   - Comparison of 3rd epidemic (2016-2017) with previous years
   - Open-source data
2. Structured literature review
   - Scopus and PubMed
   - Terms “avian influenza” and “control”

Results: Location of animal and human cases, waves 3-5
(October 2014 – May 2017)

Results: preliminary literature review
- One systematic review of live poultry market interventions
  (Offeddu et al. 2016)
- Peer-reviewed articles published prior to July 2015 in PubMed,
  Web of Science, Medline and reference lists
- Intervention: pre and post
  - Temporary live poultry market closure
  - Periodic market closure
  - Disinfection and disinfection
  - Date excluding live poultry average
- Outcome: Avian influenza virus detection rates in birds,
  environment or influenza incidence in humans
Impact of live poultry market closure on the short term risk of avian influenza virus *in poultry*

Impact of live poultry market closure on the short term risk of avian influenza virus *in humans*

**Current evidence: Vaccine**
- **Human vaccine:**
  - Several candidate vaccine viruses being developed.
  - Phase I trial 2014: well tolerated, safe and immunogenic.
  - 2 doses (Sunil et al. 2016).
  - Phase II trial approved March 2017.
- **Poultry vaccine:**
  - Recombinant H7 vaccines developed.
  - Chinese Ministry of Agriculture announced a trial in 2 provinces (Guangdong and Guangxi) in June 2017.

**Discussion**
- Case ascertainment: passive and sentinel surveillance.
- Ecological studies: bias and confounding.
- Medium to long-term impact of control measures.
- Social, environmental and economic impacts.
- Coordination with other countries in the Western Pacific Region.
- Future predictions e.g., antigenic shift/drift.

**Conclusion**
- The 5th wave of avian influenza A(H7N9)
  - The biggest season recorded.
  - Broad geographical distribution and more cases in rural settings.
  - Lower case fatality.
- Current evidence supports interventions in live poultry markets such as weekly or biweekly rest days and overnight bans on live poultry.
- Phase I human vaccine trials suggest a vaccine will be safe and immunogenic.
- Elimination of human infection with avian influenza A(H7N9) is theoretically possible but current approaches are insufficient.

**Acknowledgements**
- WHO WPRO
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- Jim O'meara
- Balbina Oliveira
- China CDC
- Welcome to
- MAV (RFP) Supervisors
- Stephanie Williams
- Adam Wedge
Appendix 14: Copy of the article on paralytic shellfish poisoning published in Communicable Diseases Intelligence

An Outbreak of Paralytic Shellfish Poisoning in Tasmania
Laura J Edwards, Katrina Wilson, Mark GK Veitch
An Outbreak of Paralytic Shellfish Poisoning in Tasmania

Laura J Edwards, Katrina Wilson, Mark GK Veitch

Abstract

Paralytic shellfish poisoning (PSP) is a rare illness caused by eating shellfish containing paralytic shellfish toxins (PST). Toxins are produced during harmful algal blooms, which occur most years on the east coast of Tasmania. Contaminated seafood looks and tastes normal and toxins are not destroyed by cooking or freezing. Commercial shellfish farms are monitored for harmful algae and shellfish toxins, but wild shellfish are not and pose a potential public health risk.

A case of PSP was documented in Tasmania in 2011, and we are aware of anecdotal reports of cases in the 1980s and 1990s. We are not aware of cases elsewhere in Australia but harmful algal blooms have been detected in Victoria, South Australia and New South Wales.

Routine monitoring of commercial shellfish in 2015 detected a large bloom of Alexandrium tamarense on the east coast of Tasmania, which can cause PSP. Between 2 and 12 October 2015, four cases of PSP were identified. All were adults who ate wild mussels from the east coast of Tasmania and had onset of numbness or tingling of the face and muscle weakness from 30 minutes to 12 hours later. Two cases were briefly hospitalised, both recovered.

Since the outbreak, permanent signage at locations where shellfish are frequently recreationally foraged has been erected. Additional alerts are released during high risk periods based on surveillance of commercial sites by the Tasmanian Shellfish Quality Assurance Program. Several states in Australia are at risk of cases of PSP. We recommend active surveillance and multi-jurisdictional collaboration to manage this risk.

Summary

This article describes an outbreak of four cases of paralytic shellfish poisoning in Tasmania during a harmful algal bloom of Alexandrium tamarense.

Keywords: Paralytic shellfish poisoning, paralytic shellfish toxin, saxitoxin, harmful algal blooms, Alexandrium tamarense
Introduction

Paralytic shellfish poisoning (PSP) is a rare illness caused by consumption of shellfish contaminated with paralytic shellfish toxins (PST). PST are produced by certain types of algae during harmful algal blooms and bioaccumulate in bivalve filter-feeding shellfish such as oysters, mussels and scallops. Contaminated seafood looks, smells and tastes normal and the toxins are not destroyed by cooling or cooking.

PSP primarily occurs in temperate climates but cases also occur in tropical regions. The global incidence has been reported to be up to 2000 cases each year but surveillance is limited; therefore this may be an underestimate. Case-fatality rates vary considerably; from low, up to 6 to 15 percent in some series. Dose, host factors and access to care affect the risk of death. In Tasmania, one case of PSP was reported in 2013 and we are aware of anecdotal case reports in the 1980s and 1990s. We are not aware of any cases in other states or territories of Australia.

The symptoms of PSP result from toxin-mediated blockage of voltage-gated sodium channels and develop from within a few minutes to several hours after ingestion of contaminated shellfish. Initial symptoms include facial or peripheral paraesthesia progressing to numbness, weakness, loss of coordination, difficulty speaking and double vision. Recovery is expected within hours up to several days but, in severe cases, respiratory failure and death can occur. Treatment is supportive and patients may require mechanical ventilation. Laboratory identification of PST in urine or implicated shellfish can be used to confirm the diagnosis.

Three genera of dinoflagellate algae contain species that are capable of producing PST: Gymnodinium spp, Alexandrium spp and Pyrodinium spp. Two species of PST-producing algae are currently found in Tasmania, Gymnodinium catenatum, which has caused recurrent blooms in the south east Huon and Derwent river region since 1973, and Alexandrium tamarense, which has been detected in low concentration on the east coast of Tasmania since 1987. Harmful algal blooms have also been detected in Victoria, South Australia and New South Wales.

In Tasmania, bivalve shellfish marine farming and commercial wild harvest bivalve shellfish fishing, excluding the commercial scallop industry, are monitored by the Tasmanian Shellfish Quality Assurance Program (TSQAP) under the Tasmanian Biotoxin Management Plan. The Plan outlines the frequency and distribution of biotxin testing in marine farms. The frequency of testing is based on a risk assessment approach with flesh from most harvest areas tested weekly.

Toxin concentrations above the regulatory limit of 0.8mg/kg result in closure of the marine farm until concentrations drop below the limit on two consecutive tests. TSQAP advises a joint government and industry group, the Harmful Algal Bloom Emergency Management Group, of the results of biotxin and algae testing and a list of marine farm and harvest closures. TSQAP monitoring information assists in the management of biotxin risk in susceptible wild fisheries (i.e. scallop, abalone and rock lobster) and enables these industries to enact their own risk management strategies for biotoxins. Other wild shellfish are not routinely monitored for biotoxins.

A permanent Public Health Alert in Tasmania recommends people do not eat recreationally harvested wild shellfish due to the risk of poor water quality in unmonitored areas. During periods of high risk for shellfish poisoning associated with high levels of algae or toxins in marine farms, additional Public Health alerts are issued to warn of the increased risk and distributed using social and traditional media.

This report describes an outbreak of four cases of PSP associated with consumption of wild-harvested mussels from a single location on the east coast of Tasmania during a harmful algal bloom of Alexandrium tamarense in October 2015.
Methods

In July 2015, routine monitoring of marine farms on the east coast of Tasmania detected a bloom of *Alexandrium tamarense* and elevated levels of PST confirmed in accordance with the TSQAP Biotoxin Management Plan, which resulted in closure of commercial marine farms. From July to September 2015, the algal bloom expanded resulting in a Public Health Alert on 2 October 2015 warning against consumption of wild shellfish.

At approximately 11pm on 2 October, an ambulance officer reported two cases of suspected PSP to Public Health Services. Following this, an outbreak team was established led by Public Health Services including the OzFoodNet epidemiologist, Public Health Officers, Surveillance Coordinator, Environmental Health Officers, Media Liaison Officer, TSQAP and the Acting Director of Public Health.

Public Health Officers conducted telephone interviews with all cases using a standard questionnaire for shellfish poisoning. Information was collected on patient demographics, the consumed shellfish, the location from which wild shellfish were gathered and clinical features.

Case definitions for probable and confirmed cases were adapted from previous case definitions developed by Public Health Services. A probable case was defined as a person who had consumed shellfish and developed clinical features of PSP within 12 hours. Clinical features included numbness or paraesthesia around the mouth, face or extremities and at least one of the following: generalised weakness, dizziness or vertigo, slurred or unclear speech, difficulty swallowing, difficulty breathing, paralysis, clumsiness, unsteady walking, or double vision. A confirmed case was defined as the features of a probable case; and one or more of detection of PST in a urine specimen of the case, detection of PST in a sample of consumed shellfish or consumption of shellfish from an area known to be affected by high levels of paralytic shellfish toxin.

Active case finding involved telephone contact with all the state hospital Emergency Departments; alerts to General Practitioners, Emergency Departments, and ambulance officers; and public media releases.

Results

Descriptive epidemiology

Five suspected cases were notified to Public Health Services, two by an ambulance officer, one by an Emergency Department Physician, one by a General Practitioner and one by a member of the public. One reported illness did not meet a case definition and was excluded. All four cases occurred between 2 and 12 October 2015 and were confirmed as having eaten wild mussels that had been gathered from Little Swansport, an area known to be affected by high levels of PST on the east coast of Tasmania. The median number of mussels consumed was 14 (range 6 to 35). The cases were all aged between 51 and 61; three were male. The time from exposure to onset of symptoms was 30, 60 and 90 minutes, and 12 hours.

All the cases reported numbness or tingling and muscle weakness (Table 1). Most also had dizziness, a floating sensation and nausea. One case reported difficulty swallowing or slurred speech.

Table 1: Summary of symptoms of cases

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Number affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paresthesia or numbness</td>
<td>4</td>
</tr>
<tr>
<td>Mouth or Face</td>
<td>4</td>
</tr>
<tr>
<td>Fingers</td>
<td>3</td>
</tr>
<tr>
<td>Arms</td>
<td>0</td>
</tr>
<tr>
<td>Legs</td>
<td>1</td>
</tr>
<tr>
<td>Dizziness</td>
<td>3</td>
</tr>
<tr>
<td>Floating sensation</td>
<td>3</td>
</tr>
<tr>
<td>Nausea</td>
<td>3</td>
</tr>
<tr>
<td>Vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>4</td>
</tr>
<tr>
<td>Arms</td>
<td>3</td>
</tr>
<tr>
<td>Legs</td>
<td>4</td>
</tr>
<tr>
<td>Difficulty with swallowing or slurred speech</td>
<td>4</td>
</tr>
<tr>
<td>Respiratory difficulties</td>
<td>0</td>
</tr>
</tbody>
</table>
Two cases were hospitalised overnight and both recovered uneventfully. No urine samples were collected for PST testing. One case supplied a sample of leftover mussels pickled in vinegar, but these were unsuitable for toxin testing.

Environmental investigations

Environmental sampling at the time of the outbreak revealed harmful algal blooms and elevated levels of PST at multiple locations on the east and south-east coasts of Tasmania. The commercial harvest areas in Little Swanport and Mercury Passage recorded the highest levels of PST (Figure 1). Little Swanport harvest area, adjacent to the location of wild mussels gathered by the cases, was closed due to elevated PST levels from 23 September until 20 November 2015, and Mercury Passage harvest area, approximately 26 kilometres south, was closed from 29 July to 20 November 2015 (Figure 2). A single wild mussel sample collected from the same location as the four cases at Little Swanport on 14 October 2015 had a PST level of 35 mg/kg, more than 40 times the regulatory limit of 0.8 mg/kg (Figure 2).

Outbreak response

Temporary warning signs were erected on 5 and 6 October 2015 at 21 east coast locations including boat launching ramps and popular fishing and swimming spots. Public Health Alerts were promoted on Twitter, through Media Releases and on the Department of Health and Human Services website. Multiple television and radio interviews were held in the first two weeks of October.

Discussion

PSP is a notifiable disease in Tasmania – suspected case of food or water-borne illness – under the Public Health Act 1997. Prior to this outbreak, there were anecdotal accounts of PSP cases occurring in the 1980s and 1990s and one documented case in 2011. Because the disease is rare clinicians and the public have limited awareness of PSP. Mild cases may have not sought medical attention nor been reported. Media campaigns and public signage about various risks from wild foraged shellfish since the 1980s in south-eastern Tasmania have aimed to raise awareness. We are not aware of any cases.

Figure 1: Location of PSP outbreak and two sampling sites with the highest levels of PST recorded, 2015

(Source: GoogleEarth and TSWAP)
of PSP elsewhere in Australia but it is possible that cases of PSP may not have been recognised, reported or documented.

Currently, monitoring for PST is confined to commercial marine farms and fisheries. Difficulties in establishing a monitoring system for foraging in recreational waters include the intensity, extent and costs of monitoring that would be required. Techniques for the rapid testing of shellfish flesh for biotoxins have been developed and integrative monitoring systems are being used internationally to share information on current shellfish toxin levels. Some commercial enterprises in Tasmania are using rapid tests to assist with farm risk management practices, but the kits are not yet internationally validated.

Following the outbreak, Public Health Services developed a fact sheet on PSP and permanent signage which was erected at numerous coastal locations. The signs have been designed to enable additional warnings to be revealed during periods of high risk for shellfish poisoning. Guidelines for public health responses to high levels of PST or cases of PSP, and surveillance protocols, have been developed to ensure a consistent response when the risk of shellfish poisoning is present. There are no Australian laboratories accredited for human testing of urinary PST.

The prevalence of algae that can cause PSP has changed in recent decades. Since the 1970s, *Gymnodinium catenatum* has caused periodic algal blooms in Tasmania. Three genotypes of *A. tamaense* have been identified in Tasmania. Two of these *A. australiense* and *A. pacificum* are known to occur on the east coast. In 2012, a large recall of commercial mussels that had been air freighted to Japan occurred at estimated cost to the shellfish industry of $23 million. Recent evidence suggests that this event may have been caused by a toxigenic genotype of *A. tamaense*, known as *A. fundyense*, which had not previously been detected.

Water temperatures on the east coast of Tasmania in 2015 were approximately four degrees warmer than average due to the El Niño Southern Oscillation, which caused warm cur-
reversing trends travelling south to move closer to the land mass. The contribution of this to the harmful algal blooms is unclear.

Algal blooms are influenced by factors including nutrient levels, turbulence, water temperature, sunlight, water pH and ocean currents. Anthropogenic global warming figures as a key determinant of factors increasing the distribution and frequency of algal blooms in recent decades. Additional factors such as increased awareness and testing may also have contributed.

## Conclusion

Several Australian states and territories are at risk of cases of PSP. Routine monitoring is in place for commercial shellfish in Tasmania but not for most recreationally foraged wild shellfish, so the public need to be aware of the risks associated with their consumption. Awareness may be improved by permanent signage along the east and south-east coast of Tasmania, and by public health alerts during high-risk periods. Clinicians also need to be aware of the need to report suspected cases of PSP to Public Health Units and be encouraged to collect urine specimens or leftover uneaten shellfish for PST testing. We recommend active surveillance across Australia in collaboration with Departments of Primary Industries, researchers and other marine regulatory bodies to manage the social, economic, environmental and health risks associated with harmful algal blooms and shellfish poisoning.

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