Master of Philosophy in Applied Epidemiology Thesis

Health Protection in New South Wales

A thesis submitted for the degree of Master of Philosophy at the Australian National University

Dr Katherine Todd, MBBS, MPH

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NCEPH Supervisor

Associate Professor Martyn Kirk

Dr Kerri Viney

Field Supervisor

Dr Jeremy McAnulty

Australian National University

NSW | Health

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Declaration

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 2017 as part of the degree of Masters of Philosophy in Applied Epidemiology, Australian National University.

Signed: 

Date: 10/11/2017

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Abstract

Health protection involves the prevention and control of threats to health from both communicable diseases and the environment. I conducted a variety of projects across the breadth of Health Protection within NSW Health between March 2016 and October 2017 to fulfil the requirements of the Masters of Philosophy in Applied Epidemiology (MAE).

My first placement was within the Enteric and Zoonotic Diseases division of the Communicable Disease Branch. A large outbreak of *Salmonella* Saintpaul occurred in Australia between December 2015 and June 2016 with a total of 547 confirmed and probable cases notified. When I commenced in March 2016 this outbreak had been underway since December 2015 with no clear vehicle of infection identified. I conducted a case-control study including 72 confirmed cases and 144 controls from SA and NSW which identified that Mung bean sprout consumption was reported by 40.6% (28/69) of cases and 4.3% (6/140) of controls (OR 14.6, 95% CI 5.9-39.4). This outbreak led to a recall of mung bean sprouts from an implicated sprouter in South Australia and public messaging about the safe preparation and consumption of bean sprouts.

In July 2016 six states and territories of Australia were affected by a large outbreak of *Salmonella* Hvittingfoss with 144 confirmed and suspected cases notified. I led a coordinated multi-jurisdictional investigation to identify the source of infection and control the outbreak, including conducting a case-control study. The epidemiological, microbiological and environmental investigation implicated consumption of rockmelon (OR 7.2, 95%CI 1.87-27.93) from a single producer as a significant risk for infection. The producer initiated a voluntary recall of the product.

My second placement was in the Environmental Health Branch of Health Protection. I completed a review of the epidemiology of notifications in NSW to provide a snapshot of elevated blood lead levels in NSW and to inform an evaluation of the NSW elevated blood lead surveillance system. There were 9,486 notifications of elevated blood lead from 1997–2016, with an average annual notification rate of 6.9 per 100,000. I analysed notification data for by age, sex, geographic area, exposure and occupation and compared notification rates over time and between geographic regions. I identified several limitations with the dataset that made it difficult to analyse notification rates, particularly by risk and exposure history and by blood lead level, and made recommendations to improve the data collection system. I also collected qualitative data about the function of the blood lead surveillance system by conducting face-to-face interviews with key stakeholders throughout NSW. Key areas for improvement in the system included changes to the way data is entered into the surveillance system, greater guidance for public health units on following up notifications, a review of the information collected on exposure, and guidance regarding liaising with occupational health regulatory agencies to ensure follow-up of occupational notifications.

Through completing these projects, I made valuable contributions to protecting the health of NSW residents.

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Chapter 1 – Introduction

During the MAE I travelled the breadth of the state of New South Wales, from Broken Hill to Sydney, Parramatta to Newcastle, as well as across borders to liaise with our interstate colleagues in Queensland, South Australia and Victoria. I was fortunate to experience a variety of epidemiological projects covering general public health, environmental health, and enteric and zoonotic diseases.

My primary placement was within Health Protection NSW. Health protection involves the prevention and control of threats to health from both communicable diseases and the environment. There are two main branches within Health Protection NSW. Communicable Diseases Branch (CDB) has five main divisions which cover immunisation, respiratory and vector-borne disease, blood borne viruses and sexually transmitted infections, enteric and zoonotic diseases, and tuberculosis. The Environmental Health Branch (EHB) is divided into general environmental health, health policy and risk assessment, Aboriginal environmental health, and the water unit. Each branch has a director who reports to the executive Director of Health Protection.

In addition to the central Health Protection, within NSW there are 15 Local Health Districts (LHD) served by one or more public health units (PHUs), each headed by a PHU Director. These public health units collectively are known as the Public Health network. The PHUs have responsibility for the day-to-day activities of health protection in their district related to communicable diseases, environmental health and immunisation, including following up individual notifications of disease, managing localised outbreaks, and providing community information. The PHU Directors meet with the Directors of Health Protection regularly as members of the Health Protection Leadership Team, including monthly via teleconference and quarterly face-to-face in North Sydney. These meetings are held to discuss current public health issues across the state of NSW. In addition, both branches of Health Protection NSW hold annual workshops on topical issues within their respective fields to which PHU staff from across the state attend, to ensure continuing education and build capacity within the Public Health network.

I conducted a variety of projects between March 2016 and October 2017 to fulfil the requirements of the Masters of Philosophy in Applied Epidemiology (MAE), and participated in the daily life of Health Protection NSW, which included responding to critical incidents, completing education activities and acting as surge staff when needed.

My first placement was within the Enteric and Zoonotic Diseases division of the Communicable Disease Branch, working on the response to a large outbreak of *Salmonella* Saintpaul that had been

ongoing in Australia since December 2015; when I commenced in March 2016 this outbreak continued with no clear vehicle of infection identified. I conducted a case-control study including cases and controls from SA and NSW which identified an association between mung bean sprout consumption and illness. This outbreak led to a recall of mung bean sprouts from an implicated sprouter in South Australia and public messaging about the safe preparation and consumption of bean sprouts.

In July 2016 six states and territories of Australia were affected by a large outbreak of *Salmonella* Hvittingfoss with 143 confirmed and suspected cases notified. I coordinated a large multi-jurisdictional investigation to identify the source of infection and control the outbreak, including conducting a case-control study. The epidemiological, microbiological and environmental investigation implicated consumption of rockmelon from a single producer as a significant risk for infection, and the producer initiated a voluntary recall of the product.

My second placement was in the Environmental Health Branch of Health Protection. I completed a review of the epidemiology of notifications in NSW to provide a snapshot of elevated blood lead levels in NSW and to inform an evaluation of the NSW elevated blood lead surveillance system. I analysed notification data for by age, sex, geographic area, exposure and occupation and compared notification rates over time and between geographic regions, and identified a number of limitations with the dataset that made it difficult to analyse notification rates, particularly by risk and exposure history and by blood lead level, and made recommendations to improve the data collection system. I also collected qualitative data about the function of the blood lead surveillance system by conducting face-to-face interviews with key stakeholders throughout NSW. Key areas for improvement in the system included changes to the way data is entered into the surveillance system, greater guidance for public health units on following up notifications, a review of the information collected on exposure, and guidance regarding liaising with occupational health regulatory agencies to ensure follow-up of occupational notifications.

In addition, I participated in activities of Health Protection NSW as they arose. This included responding to a notification by the Health Care Complaints Commission to NSW Health of an individual with no medical qualifications who was performing cosmetic surgery procedures in her home. The response team identified a risk that clients who had procedures performed by this person could have been exposed to blood borne viruses and other pathogens. I developed a fact sheet (Appendix 1) written for the general public outlining the problem, how it was identified, what risk this posed, and what people should do if they visited these premises. I also arranged for this to be translated in simplified and traditional Chinese. These documents were published on the NSW Health website.

I also contributed to the Health Protection NSW report. This report highlights the major health outcomes and achievements related to Health Protection NSW's activities on an annual basis. Within this report is a segment titled "Epi Corner" which provides a small vignette on an epidemiological concept, together with some short questions for readers to test their knowledge and understanding of the concept. I authored the 2016 Epi Corner on the topic of case-controls and case-case studies, and the 2017 Epi Corner on confidence intervals and p-values. These are included in Appendix 2.

I presented twice at the NSW Health Bug Breakfast seminar series. Bug Breakfast is a series of hour-long breakfast seminars on communicable disease that have been delivered since 1990, and are made available to the entirety of the NSW public health network by attendance in person or via webinar. Typically, a trainee or other employee or NSW Health will identify a key topic, present an overview of the topic, and invite two experts to also deliver presentations around the topic. On the topic of *Salmonella* in October 2017 I was invited by the convenor to present on the *Salmonella* Hvittingfoss outbreak I investigated in July-August 2016 (discussed further in Chapter 3). In April 2017, I convened the session on *Campylobacter*, including giving an introductory presentation and inviting Craig Shadbolt and Martyn Kirk to speak. The flyer and *Campylobacter* presentation slides are included in Appendix 3.

Whilst working in Communicable Disease Branch, I was the trainee representative on the committee organising the 2016 Communicable Disease workshop. I developed several activities including a quiz on public health topics to engage the attendees and an exercise using chocolates to explore the concept of whole genome sequencing (Appendix 4). I also organised prizes, participated as a facilitator of a small group, and conducted the final evaluation of the workshop including production of a written document analysing participant responses and outlining what worked well, what didn't work well and suggestions for improvement for future workshops.

Finally, whilst working in Environmental Health Branch I contributed to the investigation of community complaints regarding a Cruise Ship Terminal located in White Bay NSW. This included completing data analyses of air quality readings in the area and comparing these to other locations in Sydney, and looking at these trends over time. I prepared a report that was provided to the Environmental Health Expert Advisory Committee for consideration, and used this as the basis for my Lesson from the Field (LFF) on Risk Communication (outlined further in Chapter 6).

Masters of Philosophy (Applied Epidemiology) requirements:

I completed the following requirements for the qualification of Master of Philosophy (Applied Epidemiology):

Field projects

Public health data analysis	The epidemiology of elevated blood lead levels in NSW, 1997–2016 (Chapter 4)
Public health surveillance system establishment and evaluation	An evaluation of the NSW elevated blood lead surveillance system (Chapter 5)
Field investigation of a public health problem	Investigation of a multijurisdictional *Salmonella* Hvittingfoss outbreak (Chapter 3)
Epidemiological study	Investigation of a multijurisdictional *Salmonella* Saintpaul outbreak (Chapter 2)

Additional requirements

Requirement	
Literature review	A literature review was completed for each of the field projects listed above
Report to a non-scientific audience	NSW Health "Infection control breaches in cosmetic procedures: Frequently Asked Questions (FAQs)". Published online 6 July 2016 at http://www.health.nsw.gov.au/Infectious/alerts/Pages/cosmetic-procedures.aspx
Publications	Draft paper being prepared for publication: Todd KM, Beazley R, Furlong C, Kenny B, Shadbolt C, Centofanti A, Schobben X, McAnulty J, Kirk M, Sheppeard V, Polkinghorne B, Gregory J, Easton M, Stafford R, Koehler A, Sintchenko V, Howard P, Wang Q, Da Silva AG, Williamson D, and Hope K. **A multi-state outbreak of Salmonella Hvittingfoss associated with melons in Australia.** Intended for submission to *Epidemiology and Infection*
	Draft paper being prepared for publication: Todd KM, Scalley B, Kirk M and McAnulty J. **The epidemiology of lead poisoning notifications in New South Wales, Australia, 1997-2016.** Intended for submission to *Public Health Research and Practice*.
Oral presentation	Todd KM, Miller M, Hope K. **A large multi-state outbreak of Salmonella Saintpaul: the hazards of stealth ingredients.** Presented at the NSW Gerry Murphy Prize – Australian Faculty of Public Health Medicine (AFPHM), Sydney, Australia - 19th October 2016
	Todd KM, Beazley R, Furlong C, Kenny B, Shadbolt C, Centofanti A, Schobben X, Polkinghorne B, Gregory J, Easton M, Stafford R, Koehler A, Sintchenko V, Howard P, Wang Q, Williamson D, and Hope K. **A multi-state outbreak of Salmonella Hvittingfoss associated with melons in Australia, 2016**. Paper presented at the 2017 Communicable Disease Control Conference, Melbourne, Australia, 26-28th June 2017
	Todd KM, Scalley B, Kirk M and McAnulty J. **The epidemiology of lead poisoning notifications in New South Wales, Australia, 2011-2016.** Paper presented at the 9th TEPHINET Global Scientific Conference, Chiang Mai, Thailand, 7-11th August 2017
	Todd KM, Scalley B, Kirk M and McAnulty J. **The epidemiology of lead poisoning notifications in New South Wales, Australia, 1997-2016.** Paper presented at the 29th Conference of the International Society for Environmental Epidemiology, Sydney, Australia, 24-28th September 2017
Poster presentations	Todd KM, Beazley R, Furlong C, Kenny B, Shadbolt C, Centofanti A, Schobben X, Polkinghorne B, Gregory J, Easton M, Stafford R, Koehler A, Sintchenko V, Howard P, Wang Q, Williamson D, and Hope K. **A multi-state outbreak of Salmonella Hvittingfoss associated with melons in Australia, 2016**. Oral poster presented at the 9th TEPHINET Global Scientific Conference, Chiang Mai, Thailand, 7-11th August 2017

Teaching

Activity	
Teaching first year cohort	Tier S, Collins J, Todd K. **Outbreaks: What I Wish I Knew.** Presented at MAE courseblock March 2017
Bug Breakfast presentations	Todd K. **Salmonellosis**. Presented at the NSW Health Bug Breakfast seminar session, 7 October 2016 Todd K. **Campylobacter**. Presented at the NSW Health Bug Breakfast, 7 April 2017.
Lesson from the field	Todd K. **Lesson from the Field: Risk communication.** Conducted via teleconference, 20 July 2017
Clinical Associate Lecturer, Integrated Population Medicine Program, University of Sydney Medical School	Tutorial 2 – **Social determinants of health** (11 March 2016) Tutorial 3 – **Costs of care, resource management and low-value care** (1 March 2016) Tutorial 4 – **Person-centred management** (22 April 2016) Tutorial 5 – **Global health** (2 June 2017) Tutorial 6 – **Advocacy** (7 July 2017)

Appendix 1 - Fact Sheet regarding infection control breaches

Infection control breaches in cosmetic procedures

6 July 2016

Frequently Asked Questions

What has caused this issue?

Following a recent complaint to the Health Care Complaints Commission (HCCC), NSW Health has become aware that Ms Pu Liu, also known as Mabel Liu, has been performing cosmetic procedures from premises situated at 14/239 Great North Road, Five Dock. Ms Liu is not a medical practitioner registered in Australia.

Inspection of the residential unit in Five Dock found evidence of poor infection control.

There is a risk that clients who have had cosmetic procedures performed at this address may have been exposed to blood-borne viruses such as hepatitis B, hepatitis C and HIV. There is also a risk of skin and soft tissue infections and poor cosmetic results.

Injectable drugs not approved for use in Australia were also found on the premises, raising concerns about the safety and effectiveness of these medicines.

The HCCC has issued an order prohibiting Ms Mabel Liu from:

1. Providing any cosmetic surgical and medical procedures, including any cosmetic surgery that involves cutting beneath the skin and any cosmetic medical procedure that involves piercing the skin
2. Possessing any Schedule 4 drugs for cosmetic use including botulinum toxin (Botox) and hyaluronic acid injection preparations (dermal fillers).

NSW Health recommends that clients who have had procedures performed by Ms Liu at this address should seek the advice of a GP and be tested for blood-borne viruses (hepatitis, B, hepatitis C and HIV.)

How was this identified?

A client who had a poor outcome from a cosmetic surgical procedure performed by Ms Liu at the Five Dock premises made a formal complaint to the Health Care Complaints Commission.

What did the investigations show?

The inspection of the premises in Five Dock found evidence that surgical and other procedures were being performed at the premises; drugs for injection that are not registered for use in Australia; and a general environment not suitably fitted out for the performance of surgical procedures.

What infection control problems were identified?

There was evidence of a lack of hygiene, possible re-use of medications and equipment between patients, and a lack of effective cleaning and sterilisation. Sharing items that should be sterile between patients can allow infection to spread from one person to another.

What procedures are classified as “at risk”?

Based on the very poor level of infection control measures found at the premises, there is a concern that any procedure in which the skin was cut or penetrated such as surgery, stitching or injection undertaken at the Five Dock unit could pose a risk of infection. This could be an acute skin or soft tissue bacterial infection, or a blood-borne virus.

Are there any physical symptoms if people have been infected?

There are two main risks of infection: an acute skin or soft tissue bacterial infection caused by unclean hands and instruments (non-sterile technique), and; infection caused by blood-borne viruses.

People experiencing acute skin or soft tissue bacterial infections might experience:

1. Increased pain at the site of the procedure
2. The site may be red, hot, swollen and painful
3. There may be pus or the wound may smell; stitches may come apart
4. Tiredness, sickness or a fever (temperature above 37.5°C)
5. Becoming very unwell (“septic”) and needing antibiotics urgently.

People will experience these symptoms in the first few days after a procedure. If you feel unwell or experience any of the above after having a cosmetic procedure done, you should seek health advice from your GP.

People exposed to a blood-borne virus might experience:

1. No symptoms for months or years afterwards
2. A mild illness when first infected
3. Uncommonly, people present with acute hepatitis when first infected with hepatitis B or hepatitis C, which causes liver problems and may lead to hospitalisation.

Infections with these viruses can be detected by a blood test.

Can you describe the testing process?

Testing for blood borne viruses is straightforward – all that is required is for you to attend your GP and ask to be tested. Your GP can order a blood test to check if you have hepatitis B, hepatitis C or HIV. We suggest you take this fact sheet with you when you visit your GP.

When will results be available?

Results for hepatitis B, hepatitis C and HIV testing are usually available within a few days of testing.

Where will testing take place?

Blood tests can be arranged by your GP, and can usually be collected at local pathology collection centres.

Do patients have to pay to see their doctor and have their blood test done?

Patients should follow their usual practice when visiting their doctor and get the blood tests through the usual Medicare processes.

What do patients do if they have a positive test result?

You should talk to your doctor about your results.

What does it mean if I have a positive test result?

A positive result means that you have been infected with a blood borne virus sometime in the past. For hepatitis B and C, you may have cleared the virus by yourself, or you may have a long-term (chronic) infection. Your doctor will tell you whether or not your infection is active now. HIV infection is a lifelong infection. There are effective treatments for these infections, so it is important to know whether you are infected or not, so that you can be assessed and receive treatment if needed.

There are many ways in which people can get infected with HIV and hepatitis B and C viruses. If you have been recently infected with one of these viruses, your doctor should notify the local Public Health Unit and work with the local Public Health Unit to investigate possible sources of your infection.

For more information on infection with blood borne viruses please refer to the Hepatitis B, Hepatitis C or HIV factsheets.

How many patients are at risk?

Due to the poor record keeping practices at the Five Dock premises, it is not clear how many clients may be at risk.

Are there services like this being provided by other people?

There may be other unregistered practitioners operating in NSW who perform cosmetic procedures and/or surgeries in unregulated, unlicensed premises including homes and hotels. These may also pose a health risk

How can I protect myself?

If you are considering cosmetic surgical and medical procedures you should undertake careful research and make sure the person doing the procedure is qualified to do so. Members of the public can search the Australian Health Practitioner Regulation Agency's register to check that a health practitioner is registered.

If you have had a procedure with a poor outcome or have concerns about a practitioner or location you can inform the HCCC on 1800 043 159. This phone line operates from 9am to 5pm on weekdays and can provide advice on how to make a complaint. Information about how to make a complaint can also be accessed by following the link on the HCCC's website.

Further information on how to protect yourself and how to make a complaint can also be accessed by following the link to the public warning made by the HCCC on 30 June 2016.

Where can I get further information?

Contact your local Public Health Unit on 1300 066 055.

有關 Mabel LIU 女士所做的外科整容手術程序的問答

收到最近向醫療保健投訴委員會（HCCC）的一份投訴以後，新州衛生廳 獲知 PU LIU 女士，又名 Mabel LIU 女士，在 14/239 Great North Road, Five Dock 地址做整容。劉女士不是在澳大利亞註冊的醫生。

檢查在 Five Dock 的住所發現證據顯示該住所缺乏防範感染措施。

那些曾在該地址進行美容手術的客戶可能已經感染血源性病毒例如乙型和丙型肝炎病毒和艾滋病毒。皮膚和軟組織可能也受到感染以及美容效果不佳。

在該處所也發現澳大利亞不允許使用的注射藥物，這些藥物的安全性和有效性令人擔憂。

HCCC 發出命令，禁止 Mabel LIU 女士：

a. 提供任何整容手術和醫療程序，包括任何涉及切割皮膚整容手術，任何涉及刺入皮膚穿孔的 美容醫療程序。

b. 擁有任何附表 4 美容用藥，包括肉毒桿菌毒素（肉毒桿菌）和透明質酸注射製劑（真皮填充物）。

新州衛生廳建議，曾在該地址接受劉女士手術程序的客戶應該諮詢家庭醫生並做血液傳播病毒 （乙型和丙型肝炎病毒和艾滋病毒）的檢測。

如何發現了這一情況？

一位在 Five Dock 地址接受 LIU 女士整容手術結果不佳的客戶向醫療保健投訴委員會提出正式投訴。

調查結果發現什麼問題？

檢查 Five Dock 處所有證據顯示該處所用於手術和其他醫療程序; 注射藥物未經註冊未經允許在澳大利亞使用;和整體環境裝修不宜做外科手術。

發現哪些預防感染措施問題？

有證據顯示衛生較差、有可能患者和患者之間重複使用藥物和設備，以及缺乏有效的清洗和消毒。病人共用應該是用完後要消毒的物品會造成感染從人與人之間傳播。

什麼程序被列為"有危險"？

因為在處所內發現的預防感染措施非常差，任何在 Five Dock 處所進行的皮膚切割或穿孔醫療程序如手術，縫合或註射都可能造成感染。感染可能會是一種急性皮膚或軟組織的細菌感染，或血源性病毒感染。

如果被感染是否有任何身體不適症狀？

感染主要有兩類：由於不干淨的手和儀器（ 非無菌技術）引起的急性皮膚或軟組織細菌感染；和由血液傳播的病毒引起的感染。

受急性皮膚或軟組織細菌感染的人可能會感到：

1.在手術部位疼痛加劇

2.該部位可能出現紅、熱、腫及疼痛

3.可能出現膿血或傷口異味;針口可能會裂開。

4.疲勞、生病或發燒（高於 37.5℃度）

5.變得非常不適（"潰瘍"）並迫切需要抗生素。

某些人在手術程序後頭幾天會出現以上症狀。如果你在做完美容手術後感到不適或出現上述情況，你應該去看您的家庭醫生。

受到血源性病毒影響的人可能會：

1. 之後數月或數年無症狀

2. 感染初期會輕微發病

3.剛感染乙型肝炎或丙型肝炎，少數人會得急性肝炎，這會導致肝臟出現問題，並可能需要住院治療。

這些病毒的感染可以通過血液測試來檢測。

你是否能描述一下測試過程？

血液傳播的病毒測試很簡單 – 你只需諮詢您的家庭醫生，並提出要求檢測。您的家庭醫生可以安排驗血，檢測你是否有乙型肝炎，丙型肝炎或艾滋病。我們建議，當您去看你的家庭醫生時帶上這份資料。

什麼時候有結果？

乙型肝炎，丙型肝炎和艾滋病毒檢測，通常在檢測幾天后會有結果。

去哪裡檢測呢？

血液測試可以通過你的家庭醫生安排，並且通常可以在當地的病理檢測中心檢測。

病人看醫生和驗血需要付費嗎？

患者去看自己的醫生時應該按照他們的慣例，並通過常規的 Medicare 程序做血液檢查。

如果檢測結果是陽性的，病人該怎麼辦？

你應該跟你的醫生討論檢驗結果。

如果我的測試結果是陽性,這意味著什麼？

陽性結果意味著你曾經感染血液傳播病毒。對於乙型和丙型肝炎，你也許已經自行清除了病毒，或者你也可能受到長期性的（慢性）感染。你的醫生將會告訴你你受到的感染是否依然是活性。艾滋病毒感染是一種終身感染。對這些感染都有有效的治療方法. 所以, 首先要搞清楚你是否受到感染. 這樣你就可以接受評估和做相應的治療。

感人艾滋病毒, 乙型和丙型肝炎病毒的渠道有多種。如果你最近受到其中一種這些病毒的感染，你的醫生應該通知當地的公共衛生部門，並與當地的公共衛生部門一起調查你感染的可能來源。

有關血液傳播病毒感染的詳細信息，請參閱：
http://www.health.nsw.gov.au/Infectious/factsheets/Pages/default.aspx

有多少病人可能受到影響？

由於位於 Five Dock 的住所缺乏保存記錄，目前尚不清楚有多少客戶可能受到影響。

有沒有其他的人也在提供同類服務？

在新南威爾士州, 可能有其他未註冊的從業人員, 在未受監管和無牌照的場所, 包括住宅和酒店, 從事美容程序和/或手術 。這些都可能對健康構成威脅。

我該如何保護自己？

如果你在考慮做整容手術和醫療程序，你應該做仔細的研究，並確保操作該程序的人員符合資格。市民可以通過下列網址, 搜索澳大利亞衛生執業者監管機構的註冊記錄，查證某個衛生從業者是否登記註冊：https://www.ahpra.gov.au/。

如果你做了美容醫療程序而結果不佳, 或對某個從業人員或場所有疑問, 你可以聯繫衛生保健投訴委員會, 電話: 1800 043 159. 星期一到星期五, 上午 9 點到下午 5 點.工作人員可以就有關如何進行投訴提供建議。 如何進行投訴的信息也可以通過訪問下列 HCCC 網站上的鏈接獲得: http://www.hccc.nsw.gov.au

有關如何保護自己，如何進行投訴的更多信息, 也可以從 2016 年 6 月 30 日起通過下面的鏈接獲得: public warning made by the HCCC

我可以從那裡獲得更多的信息？

聯繫你當地的公共健康結構, 電話: 1300 066 055.

Appendix 2 - Epi Corner

Health Protection Report – Epi corner

Epi Corner 1 – September 2016

Case-control studies

Case control studies have traditionally been frequently used to determine exposures in outbreaks. Their benefits include that they can be carried out rapidly, usually do not require as large a sample size as cohort studies, and are generally less expensive. They allow for multiple exposures to be studied, and for a rare event, they are often the only practical way to test a hypothesis.

However, case-control studies have their limitations; one of the major limitations is their potential for bias, particularly recall and selection bias. In cases of an acute illness like gastroenteritis, patients may search for a cause for their illness, and so be more likely to report an exposure (for example, eating takeaway chicken) than controls; this is a form of recall bias.

It can also be difficult to define an appropriate control group, and methods to select controls also have the ability to introduce selection bias. Traditional sources of controls in case-control studies include:

- Population controls – these are people randomly selected from the general population, for example by random-digit dialling by telephone, or knocking on every third door in a neighbourhood. These control selection methods can be very time-consuming and expensive
- Friend controls – the case is asked to nominate a friend to serve as their control
- Physician nominated controls – this involves asking the patients' GP to select a similar patient from their records to act as a control

In traditional case-control studies, a significant bias can arise because controls are selected randomly, whereas cases that are notified to public health authorities have undergone a process of self-selection. This arises because not all people who suffer from a disease will present to their GP for testing, and not all tests recommended by GPs will be carried out. For every case of salmonella reported in surveillance systems in Australia, it is estimated that there could be between 3 and 12 cases occurring in the community who do not present to GPs and/or undertake faecal testing. This process can be affected by factors such as occupation, social status, health seeking behaviours; and these factors can also be related to differences in possible exposures, for example diet.

Therefore, in this population, the notified cases do not represent a truly random sample of cases.

Case-case studies and their advantages

As we have discussed, the difference in exposure histories seen in a traditional case-control studies between cases and controls may not be due to true differences in exposure, but to biases involved in the how cases are selected (via surveillance system notifications) vs. controls (which are randomly selected).

An alternative is the case-case study. Case-case studies draw on pre-existing surveillance systems and use notifications of different diseases, or of different serotypes of the same disease, as proxy controls. An example of the use of case-case studies is in the setting of salmonellosis. In Australia,

S*almonella* strains are subtyped in the reference laboratory by serotyping, allowing further characterisation of salmonellosis as caused by *Salmonella* Typhimurium, *Salmonella* Enteriditis, *Salmonella* Virchow, etc. This subtyping allows for the identification of outbreaks of less common *Salmonella* serovars.

The data collected on cases via routine surveillance mechanisms can be used in the place of controls to compare exposure histories between different groups of cases. For example, in an ongoing outbreak of one particular *Salmonella* strain – e.g. *Salmonella* Hvittingfoss – information on exposures for these cases, as collected using standard questionnaires, can be compared against exposure data from other recent interviewed cases of *Salmonella* Typhimurium as controls.

This method is time and cost efficient, as it removes the difficulties of identifying community controls for the outbreak and draws on pre-existing surveillance systems. It also helps eliminate the recall and selection biases associated with traditional case-control studies

Benefits of case-case studies:

1. All cases came through the same selection process, therefore biases that may be introduced by differences in health-seeking behaviours etc. between cases and randomly-selected controls is minimised
2. It reduces differences in recall between cases and controls, as both cases and "controls" in this method have suffered from a recent gastrointestinal disease, and will have had the same consideration given to potential exposures

Disadvantages of case-case studies

1. Problems can arise with validity – in the case-case study, each "control" will have one exposure which differs systematically from that of the cases – the exposure which led to their own infection. For example, if using *Salmonella* Typhimurium cases as controls, there may be higher rates of consumption of chicken in the control group compared to the case group. The bias whereby all of the cases form the previous outbreak may differ from the general population in some important aspect could be circumvented by mixing cases from several different serotypes in the pool of controls
2. In small populations, it can be difficult to source a large enough group of controls
3. If using historical cases as controls, there is the problem that dietary habits can change over time – therefore "controls" should not be more than a few years old at most
4. There can be seasonal variation in eating habits, particularly around fresh produce and salads, which may lead to systematic differences between cases and control groups if the control group cases occurred at a different time of year.

Questions

We have discussed recall bias and selection bias. What are some other types of biases that can arise in epidemiological studies?

Bias in epidemiology occurs when errors affect comparison groups differently. Bias is usually categorised into three broad types:

1. Selection bias: errors in the selection of populations for study

2. Information bias: errors in the collection, analysis and interpretation of data
3. Confounding

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Epi corner 2 – October 2017

Confidence intervals and p-values

When we get a result from an epidemiological study, the result can be due to three things:

1. **Chance (also known as random error)**
2. Bias or error
3. Confounding

The impact of chance on the results of a study is usually expressed as **p-values** and **confidence intervals**. The impact of chance on results is mostly determined by the sample size of the study.

P-values

The p-value (or probability value) represents the probability that the association shown in a research study could have occurred by chance alone, if there was no actual relationship between the exposure and outcome.

The size of the p-value helps you understand the possible impact of chance on the result. A statistically significant p-value is traditionally set at less than or equal to 0.05 – this number means that if you repeated the same study 20 times, the probability that the observed result could occur due to chance alone is 5 out of 100 (or 1 in 20). Similarly, a p value of 0.001 means that the probability of the result being due to chance is 1 in 1000. The smaller the p-value, the less likely the results are due to chance.

P-values can be very useful because their method of calculation includes a lot of information, including the sample size, the sampling variation, and difference from expectation, all in one convenient number. Many modern statistical software packages such as SPSS or SAS will calculate the p-value automatically for many different types of statistical test. However, the p value can often be misused. The p value is heavily influenced by sample size – the bigger the population the more likely you are to find a significant result of some kind, even if the statistically significant result is clinically meaningless.

Confidence intervals

Confidence intervals provide an indication of the precision of the result obtained from the study. The confidence interval expresses the concept that the result achieved from the study is probably not 100% accurate, and that the real answer lies somewhere within a given range – the confidence interval is the range within which the true answer is likely to lie.

Traditionally confidence intervals of 95% are used. A 95% confidence interval means that if we repeated the same study many times, then we would include the true result in our interval 95% of the time.

Confidence intervals are influenced by sample size; a small sample will typically give a wide confidence interval whilst a large sample will give a narrower confidence interval. A narrow confidence interval indicates that our result is quite precise.

Question

An outbreak of Salmonella *Dural occurred in a large town. To identify risk factors for infection, the public health unit conducted a case-control study with 13 cases and 25 controls frequency-matched for age and sex. Telephone interviews were conducted using a standardized questionnaire. Raw dragonfruit consumption was the only exposure significantly associated with illness (OR, 26.7; 95% CI, 5.4-101.5; P = .003).*

1. What is the confidence interval?
2. What is the p-value?
3. Write a sentence interpreting these two results
4. What do you think of the size of the confidence interval? What could you do to change the size of the confidence interval?

Answer

1. The confidence interval is between 5.4 and 101.5
2. The p-value is 0.003
3. The odds ratio was 26.7. If we repeated the same experiment 100 times, 95% of the time the odds ratio would lie between 5.4 and 101.5. The probability of this result occurring due to chance is 3 in 1000.
4. The confidence interval is very wide (between 5.4 and 101.5). This is because there was a very small sample size of only 13 cases and 25 controls. If we increased the number of cases and controls in our study (increasing the sample size), this would result in a narrower confidence interval (i.e. a more **precise** estimate)

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Appendix 3 - WGS teaching exercise for 2016 CDB workshop

WGS teaching exercise – chocolates

Introduction to the exercise

There is no wrong answer – this is about understanding some of the basics of trees and what they are showing.

This exercise is about looking at what characteristics are shared. This can be ingredients, preference, brand etc., but whatever participants choose, it should be clear what criteria they are using.

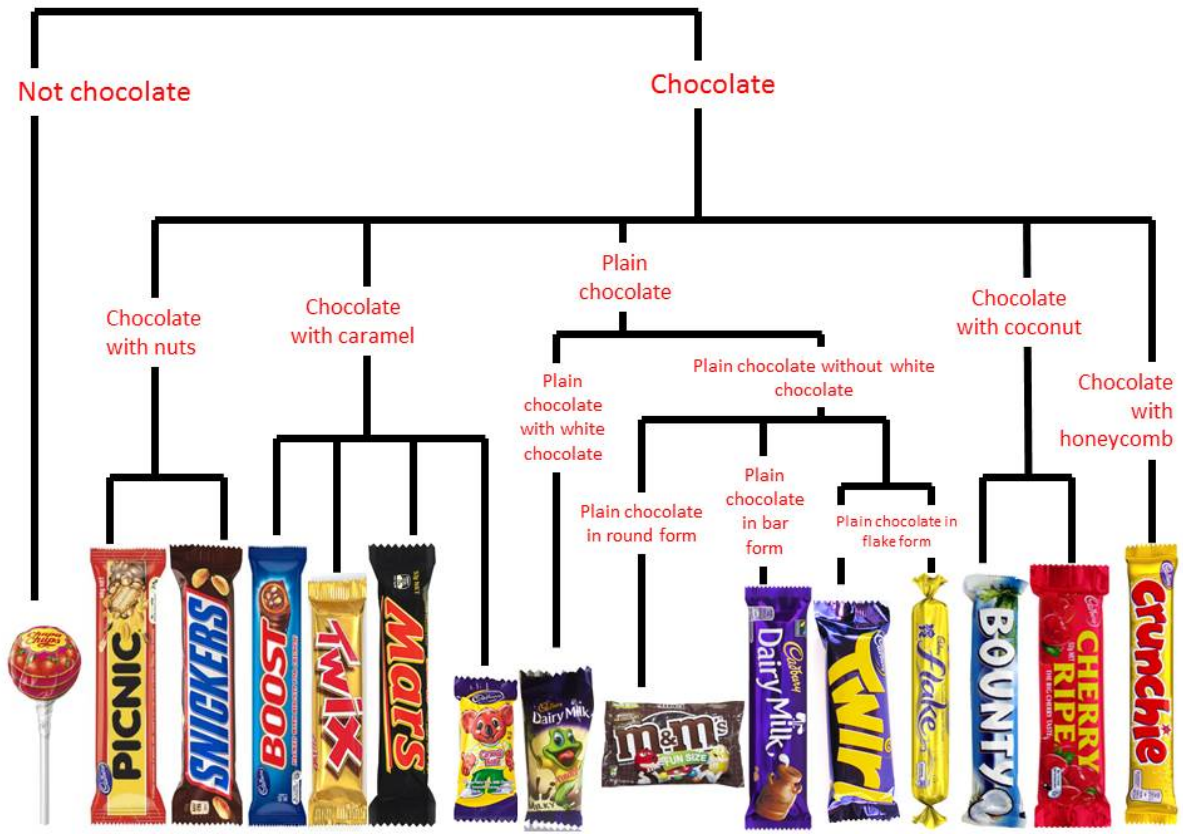
- Let participants know that trees haven't always been drawn from genetics – they can be drawn from physical traits, behaviour, and fossil record.
- Make sure that all the taxa (chocolates) are at terminal nodes – nothing can be within the tree
- Discuss how the tree would look different if you chose different criteria.

Encourage the table to take photos of completed trees (before eating)

Question:

Create a WGS tree with the following chocolates

Answer:


Not chocolate
Chocolate
Chocolate with nuts
Chocolate with caramel
Plain chocolate
Chocolate with coconut
Chocolate with honeycomb
Plain chocolate with white chocolate
Plain chocolate without white chocolate
Plain chocolate in round form
Plain chocolate in bar form
Plain chocolate in flake form
PICNIC
SNICKERS
BOOST
TWIX
Mars
Dairy Milk
m&m's
Dairy Milk
Twirl
Flake
BOUNTY
CHERRY RIPE
Crunchie

Bug Breakfast Topic: Salmonellosis
7 October 2016
08.15am – 09:30am AEST

Hosting Venue: NSW Ministry of Health
Level 4, 73 Miller Street, North Sydney - Taronga, Tumbalong & Kurraba Rooms





SPEAKERS

- **Leigh McIndoe,** Trainee Public Health Officer, NSW Ministry of Health
- **Dr Katherine Todd,** Master of Applied Epidemiology (MAE) Scholar, Public Health Medicine Registrar
- **Marianne Tegel,** Policy and Regulatory Manager, Woolworths Food Company

Remote Site Participants:

Remote sites click here to register for WebEx

Click here to register In-Person attendance

Albury Base Hospital
WebEx Contact: Tracey Oakman (02) 6080 8916

Bathurst Population Health
WebExContact: Deborah Shaw (02) 6330 5941

Broken Hill Hospital
WebEx Contact: Margie Lesjak (08) 8080 1278

Camperdown
WebEx Contact: Essi Huhtinen (02) 9515 9420

Canberra – Department of Health
WebEx Contact: Leroy Trapani (02) 6289 2732

Coffs Harbour
WebEx Contact: Michele Greenwood (02) 6656 7676

Dubbo - Allan Coates Cancer Centre
WebEx Contact: Therese Channell (02) 6809 8963

Goulburn - Springfield House
WebEx Contact: Lisa Stephenson (02) 4824 1840

Gosford Hospital
WebEx Contact: Kirsty Graham (02) 4320 3382

Gosford PHU
WebEx Contact: Paul Cook (02) 4320 9737

Grafton
WebEx Contact: Helen Lennon (02) 6641 8797

Justice Health
WebEx Contact: Greg Cheguelman (02) 9700 3226

Lismore PH Planning & Performance site
WebEx Contact: Colleen Nosworthy (02) 6588 2750

Liverpool - Refugee Health Service
WebEx Contact: Elaine Ochoa (02) 8778 0770

Newcastle Wallsend
WebEx Contact: Julie Kohlhagen (02) 4924 6477

Parramatta – Cumberland Campus
WebEx Contact: Shopna Bag (02) 9840 3603

Penrith – Nepean Blue Mountains LHD
George Truman (02) 4734 2022

Port Macquarie Community Health Centre
WebEx Contact: Colleen Nosworthy (02) 6588 2750

Randwick Hospital
WebEx Contact: Liz Smedley (02) 9382 8309

Tamworth Office - Hunter New England PHU
WebEx Contact: Peter Massey (02) 6764 8000

Wagga Community Health
WebEx Contact: Tony Burns (02) 6933 9120

Westmead - Children's Hospital
WebEx Contact: Robyn Ivey (02) 9845 3566

Wollongong Hospital - SEALS South Pathology
WebEx Contact: Diane Lovatt (02) 4221 6700

Wyong Hospital
WebEx Contact: Jessica Hagan (02) 4394 8342

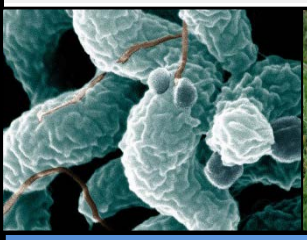
BUG BREAKFAST

Campylobacter

7 April 2017

08.15am – 09:30am AEST

Hosting Venue: NSW Ministry of Health
Level 4, 73 Miller Street, North Sydney - Taronga, Tumbalong & Kurraba Rooms





SPEAKERS

Dr Katherine Todd, Master of Applied Epidemiology (MAE) Scholar, Health Protection NSW and Australian National University

Dr Craig Shadbolt, Food Incident Response & Complaints Manager, NSW Food Authority

Associate Professor Martyn Kirk, National Centre for Epidemiology and Population Health (NCEPH), Australian National University

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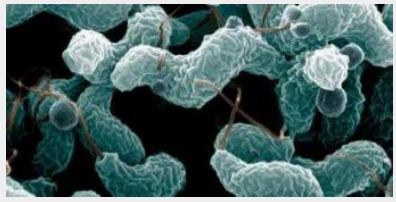
Wyong Hospital
WebEx Contact: Jessica Hagan (02) 4394 8342

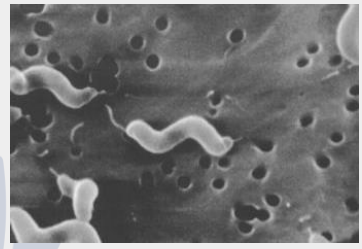
Mona Vale Hospital
WebEx Contact: Jessica Nguyen

Campylobacter



Dr Katherine Todd
Master of Applied Epidemiology (MAE) Scholar
Health Protection, NSW Health
April 2017

Background



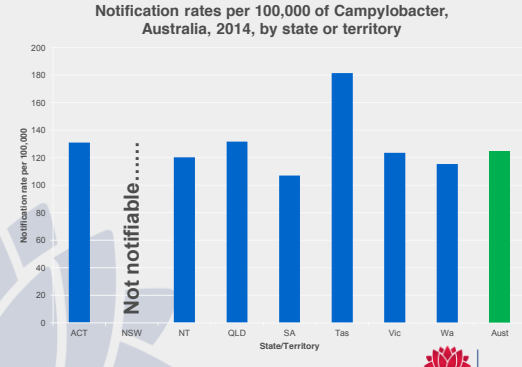
Background

- Spiral, "S" or curved, rod shaped bacteria
- 17 species and 6 subspecies within the genus *Campylobacter*
- *C. jejeni and C. coli* most frequently reported in human disease
- Inhabit the intestinal tract of warm-blooded animals
- Frequently detected in foods derived from these animals

Public Health Importance

Public Health Importance

- Most common bacterial cause of human gastroenteritis in the world
- 96 million foodborne illnesses globally each year
- Leading foodborne illness in children under five years of age
- Infections are generally mild, but can be fatal



Clinical features of *campylobacteriosis*

Clinical features of *campylobacteriosis*

- Onset usually occurs 2-5 days after infection
- Symptoms include:
  - diarrhoea (frequently bloody)
  - Abdominal cramping and pain
  - Fever
- Symptoms typically last 3-6 days
- Rarely, campylobacter can cause invasive disease

Sources and transmission

Sources and transmission

- Undercooked meat, especially chicken
- Unpasteurised milk or drinking water
- Eating cooked food which has been cross-contaminated with *Campylobacter* from raw food
- Handling infected animals
- Person-to-person

Treatment

Treatment

- Usually a self-limited condition
  - Symptomatic/supportive treatment indicated
- Rehydration and correction of electrolyte abnormalities
- Antibiotics only in severe or high-risk cases

Diagnosis

Diagnosis

- Suspect in the setting of severe abdominal pain with diarrhoea
- Detected via stool culture or CIDT
- Speciation and strain typing may be useful epidemiologically
- Further typing is usually performed in specialised reference laboratories

Prevention

Prevention

- Hand washing
- Cooking
- Careful food preparation
  - Cook all raw foods, especially meat
  - Wash raw vegetables
  - Preventing cross-contamination of raw and cooked foods
- Temperature control
- Isolation of unwell children from school or child care
- Preventing unwell food handlers from working

Outbreaks

Outbreaks

'Surprise': Outbreak of *Campylobacter* infection associated with chicken liver pâté at a surprise birthday party, Adelaide, Australia, 2012

Amy Parry,[a] Emily Fearnley[a] and Emma Denehy[a]
Correspondence to Amy Parry (email: amy.parry@health.sa.gov.au)

Outbreaks

Raw milk from Low Sizergh Farm

Notification in NSW

Summary

- *Campylobacter* is an important cause of infectious gastroenteritis
- Presentation ranges from mild self-limiting infection (common) to severe disease and long-term sequelae or death (rare)
- Most commonly contracted from uncooked animal products including poultry, raw milk, and water
- Currently notifiable in all states and territories of Australia except NSW
- Proposed to make *Campylobacter* a notifiable disease in NSW through an amendment to the *Public Health Act (2010)*

Part I:
Communicable Diseases

Enteric and Zoonotic Diseases

“Everybody always knows something,” said Adam, “even if it’s something they don’t know they know.”

Agatha Christie, “Cat Among the Pigeons”, 1959

“You can't eat tomatoes because they're tainted with deadly salmonella! First there was tainted lettuce. Now, tainted tomatoes. Who would have thought that the healthiest part of a B.L.T. would be the bacon?”

David Letterman, “The Late Show”, 2008

“A bag of Bertie Bott's Every Flavour Beans. ‘You want to be careful with those," Ron warned Harry. "When they say every flavour, they mean every flavour - you know, you get all the ordinary ones like chocolate and peppermint and marmalade, but then you can get spinach and liver and tripe. George reckons he had a booger-flavoured one once."

Ron picked up a green bean, looked at it carefully, and bit into a corner.

"Bleaaargh - see? Sprouts.”

J.K. Rowling, “Harry Potter and the Philosopher's Stone”, 1997

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Chapter 2
Epidemiological investigation of a large multi-state outbreak of *Salmonella* Saintpaul: the hazards of stealth ingredients

From NewsCorp Australia article: "SA Health says not to eat raw bean sprouts", April 22nd 2016.

Photo: Stephanie Timotheou

Contents

List of tables

List of figures

Abbreviations used in this chapter

ACT	Australian Capital Territory
ANU	Australian National University
CDB	Communicable Disease Branch
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
GP	General Practitioner
HGQ	Hypothesis-Generating Questionnaire
ICPMR	Institute for Clinical Microbiology and Medical Research
LGA	Local Government Area
MAE	Master of Applied Epidemiology
MDU	Microbiological Diagnostic Unit
NCEPH	National Centre for Epidemiology and Population Health
NSW	New South Wales
NSWFA	New South Wales Food Authority
NT	Northern Territory
OR	Odds Ratio
SA	South Australia
STM	*Salmonella* Typhimurium
WGS	Whole genome Sequencing

Prologue

My role

My first eight months of the MAE were spent within the Enteric and Zoonotic Diseases division of the Communicable Disease Branch, Health Protection NSW. When I commenced in March 2016 the outbreak described in this chapter had been ongoing since December 2015, with no signs of abating and no clear source identified. NSW had the most cases at the outset of the outbreak, and was thus leading the outbreak response.

The NSW, SA and ACT OzFoodNet epidemiologists collaborated with public health unit staff and public health officers within their jurisdictions to interview cases of *Salmonella* Saintpaul using the 7-day National *Salmonella* Hypothesis-Generating Questionnaire (HGQ). Information on food purchase locations ascertained on these interviews were passed on to regulatory agencies in NSW and SA who conducted traceback, sampling of fresh produce, and liaison with industry about fresh produce supply patterns. Laboratory staff at the Institute for Clinical Microbiology and Medical Research (ICPMR) in NSW and the Microbiological Diagnostic Unit (MDU) in Victoria conducted whole genome sequencing (WGS) of case isolates to identify the extent of the outbreak and confirm which jurisdictions were affected. In addition, the epidemiologists from SA, NSW and ACT developed a case-control study protocol to attempt to identify the food vehicle involved in the outbreak via an analytical study.

During my first week, the case-control study protocol was finalised and I was appointed to co-ordinate the NSW arm of the study with the assistance of Kirsty and Megge Miller, the SA OzFoodNet Epidemiologist. As the outbreak gained momentum in SA and simultaneously waned in NSW, my role changed to include responsibility for data entry and analysis for both states, as resources in SA were significantly stretched by the extremely large number of cases occurring. At this point I understood the important role of the MAE in providing a surge staff in the case of acute public health emergencies.

My role included participating in teleconferences and providing input into the final design of the questionnaire and protocol for the case-control study. I also conducted a number of interviews and was responsible for selecting and allocating cases and controls for interview in NSW, which included frequency matching by age group and local government area (LGA). I designed and built an Epi-info™ database based on the questionnaire, and used this to enter and analyse the data. I was responsible for conducting daily data analyses at the height of the outbreak (April 2016). On a typical day, I would enter newly-interviewed cases and controls into the database until 1pm, when I would stop

and conduct an analysis of the data to prepare and disseminate a report to SA by 4pm; this was done to enable urgent public health action to be taken on the strength of association that was emerging between bean sprouts and infection. I was custodian of all NSW data relating to the outbreak, including maintaining the line list, and provided updates on case numbers for situation reports.

I provided input into the final outbreak report and presented on the outbreak for my public health physician colleagues at the Australian Faculty of Public Health Medicine (AFPHM) presentation night in Sydney in October 2016, and at the National Centre for Epidemiology & Population Health (NCEPH) ANU seminar series as a field report in Canberra in March 2017. I also presented a report on this outbreak to Infectious Disease medical registrars at a continuing education evening in Sydney in November 2017. I provided input into the abstract and presentation that Megge Miller presented at the CDC conference in June 2017, and I will be a co-author on a paper currently being written about this outbreak.

In this chapter, I report the findings of the case-control study that the investigation team conducted during the outbreak to identify the likely vehicle of infection, and place this in the context of the overall epidemiology of the outbreak. Whilst not the focus of this report, I acknowledge all the hard work that went into the environmental and laboratory investigations during this outbreak, which were essential in identifying the source of the outbreak and implementing control measures. The public health actions arising from the investigation of this outbreak are illustrated in the media reports in Appendix 5.

Lessons learned

This was my first experience of working in a multidisciplinary outbreak team that was dispersed across multiple geographic locations. I gained an appreciation of the value of large teams (including access to expertise and human resources from other states, as well as the professional satisfaction in collaborating effectively), as well as the challenges involved in coordinating a multijurisdictional and multidisciplinary response. Coordinating activities included managing competing priorities, resource limitations, the difficulties of communication in large teleconferences, over the phone and by email and even the simple challenge of coordinating a teleconference across different time zones.

As my first project, I also experienced the challenges of learning and doing simultaneously—time pressures were so intense that I often had little time to ask or learn how to do new ways of doing things. As an example, I was initially calculating 2x2 tables one by one for each food exposure variable because I hadn't yet learned how to automatically generate tables in Epi-info™ or Stata.

However, I found this process an excellent learning tool because I gained an understanding of the fundamentals very quickly, and then subsequently appreciated shortcuts when I did discover them.

I also learned about different analytical study designs in case-control studies and the different biases that can arise through the way cases are selected, how questions are asked, and how controls are selected. Based on this experience I wrote a segment for "Epi Corner" in the NSW Health Protection newsletter, included in Appendix 2 in Chapter 1.

Public health implications

This was one of the largest *Salmonella* common-source outbreaks recorded in Australia. More than 500 people tested positive for *S.* Saintpaul and it is likely that hundreds more became ill but did not present for testing. Cases occurred across four states and territories of Australia and were implicated in several point-source outbreaks in the Northern Territory as well as the wider outbreak.

This outbreak reinforced the potential for contamination of bean sprouts with *Salmonella* and other enteric bacteria. Sprouts are a known high-risk food that has been associated with multiple large and serious outbreaks over recent years, frequently occurring across large geographical areas and often very challenging to investigate. Sprouts are often described as a "stealth foods", which are garnish-type foods that are often poorly identified and recalled by case patients as something they have eaten. The "stealth" nature of sprouts was reflected in the overall low frequency of recalled sprout consumption identified in this outbreak (41% among case-control study participants and 30% overall) reflected findings of other sprout-associated outbreaks both in Australia and internationally[1-11]

Although not discussed further in this chapter, the environmental investigation of this outbreak combined with the epidemiological and microbiological investigation led to the recall of bean sprouts from an implicated sprout producer in South Australia, as well as the closing down of the sprouting facility for a period whilst it was improved to meet regulatory standards. The sprouter in South Australia was unable to be linked with the NSW cases based on supply patterns and it was hypothesised that contaminated seeds supplied to both states rather than the sprouted beans themselves were the cause of the outbreak, although this was unable to be proved. Routine surveillance and on-going monitoring were maintained after the outbreak to detect any new increase in case numbers.

Abstract

Background

Previous outbreaks of *Salmonella* Saintpaul in Australia have been associated with the consumption of contaminated drinking water and fresh produce. In December 2015, a large outbreak of *S.* Saintpaul occurred in Australia with a total of 376 confirmed and probable cases occurring in NSW, SA, ACT, and later the NT over a six-month period. An extensive epidemiological investigation initially failed to identify a clear source of exposure, however consumption of fresh produce items including onions, bean sprouts, limes, chilli, fresh salad mix, were suspected. We conducted a multijurisdictional case-control study to identify the vehicle of infection.

Method

For the purposes of the case control study, we defined a case as isolation of the outbreak strain of *S.* Saintpaul on whole genome sequencing (WGS) from a faecal specimen in an individual resident in ACT, SA or NSW and with acute gastroenteritis with onset between 16 March and 17 April 2016. We identified cases via routine laboratory notifications.

We compared cases with controls. Controls were selected from routinely notified cases of *S.* Typhimurium and *Campylobacter* with onset dates within 40 days of cases' onsets. Controls were frequency matched to cases by age and geographic location of residence. We interviewed both groups about exposures in their incubation period using a tailored questionnaire. We compared characteristics and carried out univariate and multivariate analysis to identify significant associations between consumption patterns and infection.

Results

The case-control study included 72 confirmed cases and 144 controls from SA and NSW. No association was identified between illness and consumption of tomatoes, raw cucumbers, potatoes, broccoli, limes, black pepper, milk, chicken or eggs prepared at home. Consumption of beansprouts was reported by 40.6% (28/69) of cases and 9.7% (14/144) of controls (unadjusted OR 6.3, 95% CI 3.0-13.2), with consumption of mung bean sprouts specifically reported by 40.6% (28/69) of cases and 4.3% (6/140) of controls (unadjusted OR 14.6, 95% CI 5.9-39.4).

Conclusion

S. Saintpaul infection was strongly associated with consumption of mung bean sprouts. Sprouts are a known high-risk food for bacterial contamination due to unique aspects of their production, and have been the source of many past outbreaks of *Salmonella.* It is imperative that sprout producers adhere to stringent hygiene process during production to minimise the risks of contamination.

Introduction

Salmonella enterica is a common cause of outbreaks of acute gastroenteritis and is usually transmitted by contaminated food. *Salmonella* affects people of all ages, but rates are particularly high in young children. *Salmonella* infections may be particularly severe in the elderly, immunosuppressed and in pregnant women[12]. Symptoms usually last 3-7 days and include diarrhoea, fever, headache, abdominal pain and myalgia. Asymptomatic infection may also occur, and approximately 1% of infected adults and 5% of infected children aged under 5 will excrete *Salmonella* for greater than a year[12, 13].

Common sources of *Salmonella* infection include undercooked poultry or raw or undercooked eggs; as well as via cross-contamination to other foods that may not be cooked before eating via contact with contaminated food, food surfaces or utensils. Raw produce is also increasingly recognised as a vehicle for transmission of infection[14]. Australia has seen an increase in gastroenteritis outbreaks associated with fresh fruit and vegetables over recent years, as have other developed countries[15]. Fresh produce associated outbreaks can pose challenges due to their ability to be widely and quickly distributed geographically, including crossing state and international borders[15, 16].

S. Saintpaul accounted for 4.5% of national annual salmonellosis notifications in 2015 (unpublished data). Queensland is traditionally the jurisdiction with the highest proportion of *S.* Saintpaul cases in Australia. In 2011, Queensland accounted for 53.0% (215/406) of all cases of *S.* Saintpaul notified in Australia[17]. Known reservoirs of *S.* Saintpaul include reptiles, amphibians, wallabies and kangaroos, and in Australia it has been detected in a variety of environmental samples[18, 19]. Foodborne outbreaks with this *Salmonella* serotype in Australia have previously been associated with the consumption of contaminated water and rockmelon, and an overseas outbreak implicated bean sprout seeds produced in Australia[1, 19, 20]. Internationally, *S*. Saintpaul outbreaks have been attributed to the consumption of jalapeno peppers, bean sprouts, cucumbers, paprika and mangoes [20-22].

During December 2015, an increase in *Salmonella* Saintpaul (S. Saintpaul) notifications was detected through routine surveillance in New South Wales (NSW), South Australia (SA) and the Australian Capital Territory (ACT). In April 2016, a substantial increase in notifications of *S.* Saintpaul in the Northern Territory (NT) was identified and they were retrospectively and prospectively added to the outbreak investigation.

Methods

Study objectives

A coordinated epidemiological investigation was launched in December 2015 order to:

1. Determine whether the increase in notifications across multiple jurisdictions were linked
2. Identify the source of the illness
3. Control the source of the outbreak

The epidemiological investigation had three main phases: a hypothesis-generation phase to identify a possible source from food histories of cases; a hypothesis-testing phase involving a case-control study using SA and NSW cases; and a post case-case study period of monitoring to assess if there was an ongoing risk to public health.

Hypothesis generation

A confirmed outbreak case was initially defined as:

> Any resident of NSW, SA or ACT with laboratory-confirmed S Saintpaul infection with specimen collection on or after 1 December 2015 to date.

As the outbreak continued and following an expert advisory committee recommendation, whole genome sequencing (WGS) was included in the case definition from February 2016 onwards. Cases that had occurred previously were retroactively sequenced. Cases who otherwise met the case definition but did not have isolates sent for WGS were classified as probable cases.

Cases from NSW, SA and ACT were interviewed within their jurisdictions by public health staff using the OzFoodNet national *Salmonella* hypothesis-generating and trawling questionnaire. This questionnaire asks what people ate in the 7 days before they become unwell and consists of an open-ended food history as well as specific yes/no questions for over 200 individual food items. These interviews suggested a fresh produce item, possibly onions, might be the source of infection. The results from the hypothesis-generating questionnaires conducted between December 2015 and March 2016 were compared with consumption frequency rates obtained from the Victorian food consumption database. This is a database of food histories from well people living in Victoria, and was used to provide some indication of what “normal” consumption patterns might be. The analysis was seasonally adjusted to cover the same time period as cases were reported (the summer months of 2015-2016). We generated odds ratios using these as estimated background rates to identify foods that appeared to be consumed more frequently among cases than among the wider population.

Case-control study

In March 2016, a multi-jurisdictional frequency-matched case-control study was initiated to test the hypothesis that *Salmonella* Saintpaul infection was associated with the consumption of fresh produce items. Food items were selected for inclusion based on data collected in the hypothesis-generating phase of the investigation. Although fresh produce (particularly onions) emerged as a possible vehicle there was no obvious suspect food identified; thus, the following items were included in the development of a targeted questionnaire:

- Foods with an elevated odds ratio where the p-value was <0.05 when compared with consumption rates among the Victorian community participants
- Foods where the frequency of consumptions was >60% amongst cases interviewed during the hypothesis-generating phase of the investigation

Case definition

We defined a case for the purposes of the case-control study as:

Isolation **of the outbreak strain on WGS** of *S.* Saintpaul from a faecal specimen in an individual who:

1. Experienced acute onset of gastroenteritis* since with onset between 16 March and 17 April 2016, AND
2. Was resident in or visited ACT, NSW or SA within 7 days prior to illness onset

   **Gastroenteritis was defined as diarrhoea consisting of three or more loose bowel motions in a 24 hours period*

Cases were **excluded** from the study if they:

- Were found to have a different sequence to the outbreak on whole genome sequencing as determined by the reference laboratory
- Could not be reached after 6 attempts to contact them, spread over 3 days
- Were unable to recall the date that their diarrhoea began (onset date)
- Were unable to answer questions (e.g. dementia) or need an interpreter
- Were not interviewed within 40 days of collection of a faecal specimen
- Had an enteric pathogen other than *S*. Saintpaul isolated in or detected in their stool specimen
- had another member of the household who had an onset of diarrhoea in the 2 weeks prior to the onset of diarrhoea in the laboratory-confirmed case selected for the study

- Returned from travelling overseas within the 7 days prior to onset of their illness or to another state other than NSW, SA and ACT
- Resided in an institution, such as an aged care facility.

The protocol and questionnaire from the study are included in the appendix (Appendix 3 and 4).

Recruitment of cases and controls

Cases were identified through routine passive notifications to jurisdiction based surveillance systems. Controls were selected from notifications of *S.* Typhimurium in NSW and/or *Campylobacter* in SA. *S.* We selected *S.* Typhimurium and *Campylobacter* controls since these pathogens are typically associated with chicken and egg consumption rather than fresh produce. Controls were selected from the same broad age groups as cases (aged <15 years, 15-40 years and 40+ years) and from the same local government area (LGA). If a control was unable to be found in the LGA as a case, a control was selected from an LGA that had previously reported cases of *S.* Saintpaul. Using red onions as the hypothesis, 51 cases and 102 controls was the target sample size in total to detect an odds ratio of 3.0 assuming 17% consumption rates of red onions among controls (as identified in the Victorian community database).

Cases and controls were asked whether they had consumed ham, bacon, salami, carrots, tomatoes, onions, bean sprouts, raw cucumbers, salad mixes, chili, potatoes, broccoli, limes, peaches, bananas, pepper, milk, eggs or prepared raw chicken at home in the 7 days prior to diarrhoea onset. A 7-day incubation period was selected given longer incubation periods identified in previous outbreaks[28] and the potential for missing an exposure with low inoculum if a shorter incubation period was used. Cases were excluded if there was no diarrhoea or no clear onset date. For fruit and vegetable items, further information including sub-types (e.g. Roma or cherry tomatoes) was asked. For each food item consumed, we collected data on time and place of purchase in NSW, although not in SA.

During the period of the case-control study there were no cases in ACT. Both NSW and SA interviewed the cases and controls resident within their borders, and de-identified responses were entered into a single Epi-info™ database for analysis.

Statistical analysis

Statistical analyses were initially conducted using Epi-info™ version 7, and confirmed using Stata version 14.1. Case and control demographic details were compared using Pearson's χ^2 test. We used univariate analysis to calculate crude odds ratios with 95% confidence intervals for all exposures. We constructed a maximum-likelihood logistic regression model using sequential backward elimination for all variables significantly associated with illness in the univariate analysis (p-value <0.05), and

including age group and sex. For items that were statistically significant we included the parent category in the model rather than the sub-category (e.g. “carrots” was used instead of “raw carrots”) with the exception of bean sprouts, where mung bean sprouts was used as the variable. Stratified analysis was carried out on the variables of red onions, eggs eaten outside the home and mung bean sprouts using Mantel-Haenszel weighted odds ratio to further investigate the relationship between significant variables and examine for potential confounding or effect modification.

Ethics

As this was considered an investigation of public health importance, clearance from a Human Research Ethics Committee (HREC) was not required to be obtained. Participation in the study was voluntary and verbal consent was obtained. Retention of information regarding cases and controls is maintained in accordance with relevant privacy legislation.

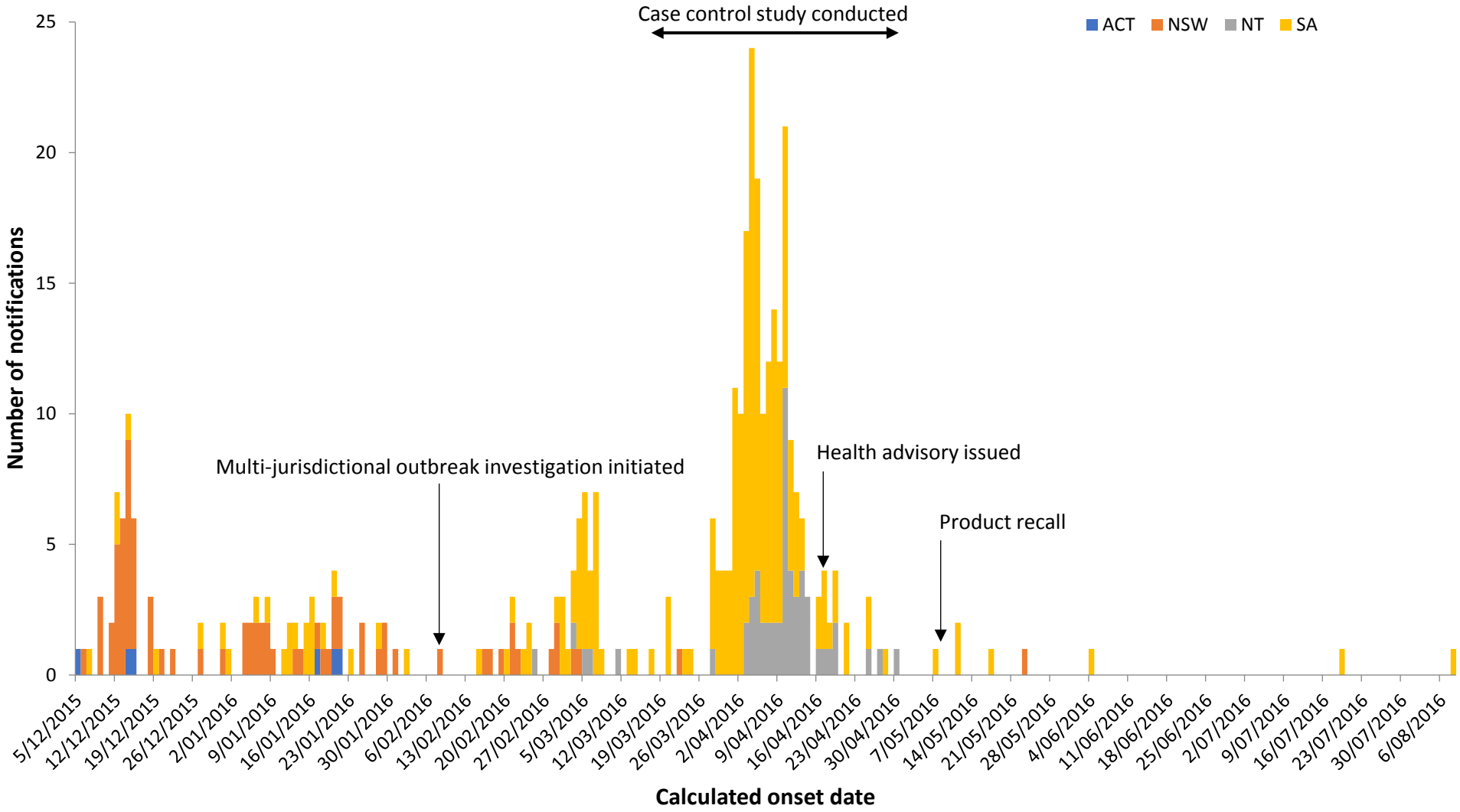
Results

Between 1 December 2015 and 31 August 2016, there were 376 confirmed or probable outbreak cases notified across Australia, including 237 from South Australia, 77 from NSW, 56 from the Northern Territory and 6 from the ACT (Figure 1). Of these 376 cases, 239 were confirmed and 137 were probable cases. Females accounted for 59.6% of confirmed and probable cases. Cases ranged from 0-95 years with a median age of 32 years; 28% of cases were aged between 25 and 34 years of age.

Hypothesisgeneration

The food items that were reported consumed most frequently included carrots (88%), milk (86%), onions (81%), tomatoes (81%), potatoes (79%), black pepper (74%) and cucumber (72%). When compared with community consumption rates among Victorian participants in a community survey conducted in 2015, red onion, beansprouts, brown onions, limes, chili, bacon, salad mix and peaches were all consumed at rates higher than expected ($p<0.05$). However, no clear hypothesis was identified prior to the commencement of the case-control study.

Figure 1 - Notifications of *Salmonella* Saintpaul by calculated onset date for ACT, NSW, NT and SA, Australia, 1 December 2015 to 31 August 2016



Calculated onset date was based on the recalled onset date for cases who were interviewed, or the specimen collection date for cases who were not interviewed

Case-control study

The case-control study was conducted between 10 March and 24 May 2016. 72 consecutive cases with the outbreak strain and 144 frequency-matched controls with onsets within 40 days of the case were recruited. There was a higher proportion of females in the case group (61.1%) compared to the control group (52.1%); however, this difference was not statistically significant.

Table 1 – Characteristics of cases and controls recruited into the *Salmonella* Saintpaul study, Australia, 10 March – 24 May 2016

Characteristic	Cases		Controls		*P* value
	N	%	N	%	
Age (years)					
< 15	8	11.1	14	9.7	0.95
15-40	34	47.2	69	47.9	
40+	30	41.7	61	12.4	
Jurisdiction					
NSW	10	13.9	20	13.9	-
SA	62	86.1	124	86.1	
Sex					
Female	44	61.1	75	52.1	0.21
Male	28	38.9	69	47.9	
Total	**72**		**144**		

Univariate analysis

In univariate analysis, cases were significantly more likely to have reported consuming bean sprouts (OR 6.3, 95% CI 3.0-13.2) and particularly mung bean sprouts (OR 15.2, 95% CI 5.9-39.4) during the 7-day exposure period compared with controls. Other significant exposures associated with an elevated odds ratio among cases included carrots, chili, salami, red onions, ham, four leaf salad mix and eggs eaten outside the home (Table 2). The full univariate analysis results for all exposures are included in Appendix 1.

Table 2 – Food items with elevated odds of exposure among cases of *Salmonella* Saintpaul infection: case-control study, Australia, 10 March- 24 May 2016

Exposure name	Cases		Controls		OR	95% CI	p-value
Bean sprouts	28/69	40.6%	14/144	9.7%	6.3	3.0 - 13.2	<0.001
Mung bean sprouts	28/69	40.6%	6/140	4.3%	15.2	5.9 - 39.4	<0.001
Bagged carrots	33/71	46.5%	35/134	26.1%	2.5	1.3 - 4.5	0.003
Eggs away from home	20/67	29.8%	21/140	15.0%	2.4	1.2 - 4.8	0.012
Other carrots	7/59	11.9%	4/136	2.9%	4.4	1.2 - 15.8	0.020
Other chili	15/66	22.7%	14/134	10.4%	2.5	1.1 - 5.6	0.020
Chili	29/71	40.8%	35/138	25.4%	2.0	1.1 - 3.7	0.021
Other salami	8/69	11.6%	4/140	2.9%	4.5	1.3 - 15.4	0.022
Raw carrots	43/72	59.7%	61/140	43.6%	1.9	1.1 - 3.4	0.026
Red onions	21/69	30.4%	23/134	17.2%	2.1	1.1 - 4.2	0.030
Ham	34/68	50.0%	47/136	34.6%	1.9	1.0 - 3.4	0.034
Other ham	8/58	13.8%	7/136	5.1%	2.9	1.0 - 8.6	0.039
Dried chili	7/68	10.3%	4/136	2.9%	3.8	1.1 - 13.4	0.045
Four-leaf salad mix	14/68	20.6%	14/135	10.4%	2.2	1.0 - 5.0	0.046

** OR – odds ratio; CI – confidence interval*
** "Other" indicated not otherwise specified in the questionnaire – e.g. "other carrots" could include carrots that were not purchased bagged or loose, but consumed in some other form e.g. in a purchased salad*

Multivariate regression

The final model included ham, salami, carrots, red onions, mung bean sprouts, four leaf salad, chili, and eggs eaten away from home, adjusted for age and sex as matching variables. Consumption of mung bean sprouts (OR 18.4, 95% CI 5.36-63.25), red onions (OR 3.4, 95%CI 1.26-8.96) and eggs eaten outside the home (OR 2.8, 95% CI 1.10-7.24) were the only items that remained significantly associated with infection in the final model. The full model is shown in Appendix 2.

Stratified analysis

A stratified analysis was done on the key exposure categories of bean sprouts, red onions and eggs outside the home to further explore the association between mung bean sprouts, red onion and eggs outside the home that was seen in the multivariate analysis (Table 3). When looking at only those cases and controls who consumed any bean sprouts, no exposure was statistically significantly associated with infection. Among those cases and controls who did NOT consume any bean sprouts, red onions (OR 2.36, 95%CI 1.03-5.41) and eggs away from home (OR 2.47, 95% CI 1.08-5.66) were associated with infection. The Mantel-Haenszel weighted odds ratio for mung beans (stratified by red onion) was 16.5 and for mung beans (stratified by eggs) was 16.6.

Table 3 – Stratified analysis of selected food items consumed by cases and controls

Exposure name	Cases		Controls		OR	95% CI	p-value
DID consume MUNG bean sprouts							
Red onions	9/27	33.3%	1/5	20.0%	2.00	0.19-20.61	1.000
Eggs away from home	5/25	20.0%	1/5	20.0%	1.00	0.09-11.03	1.000
DID NOT consume MUNG bean sprouts							
Red onions	**12/39**	**30.8%**	**20/126**	**15.9%**	**2.36**	**1.03-5.41**	**0.034**
Eggs away from home	**12/39**	**30.8%**	**20/131**	**15.3%**	**2.47**	**1.08-5.66**	**0.030**
DID consume eggs outside the home							
Mung bean sprouts	5/17	29.4%	1/21	4.8%	8.33	0.87-80.12	0.071
Red onions	6/19	31.6%	2/19	10.5%	3.92	0.68-22.71	0.232
DID NOT consume eggs outside the home							
Mung bean sprouts	**20/47**	**42.6%**	**4/115**	**3.5%**	**20.56**	**6.49-65.11**	**<0.001**
Red onions	14/46	30.4%	20/112	17.9%	2.01	0.91-4.45	0.081
DID consume red onion							
Mung bean sprouts	**9/21**	**42.9%**	**1/21**	**4.8%**	**15.00**	**1.68-133.56**	**0.009**
eggs away from home	6/20	30.0%	2/22	9.1%	4.29	0.75-24.42	0.122
DID NOT consume red onion							
Mung bean sprouts	**18/45**	**40.0%**	**4/110**	**3.6%**	**17.67**	**5.52-56.52**	**<0.001**
Eggs away from home	13/45	28.9%	17/109	15.6%	2.20	0.96-5.02	0.058

** OR – odds ratio; CI – confidence interval*

Discussion

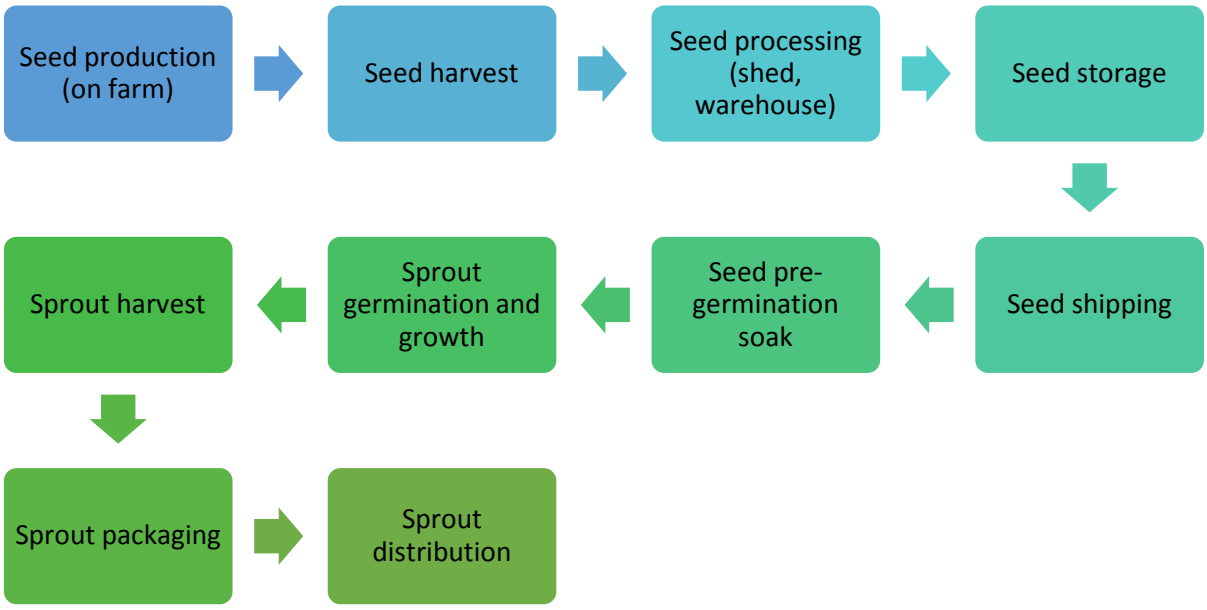
This was the largest documented *Salmonella* outbreak associated with bean sprouts in Australia. It affected multiple states and territories and continued for over 6 months due to the challenges in identifying the source of infection. This outbreak once more highlighted the well-recognised risks associated with consumption of sprouts, in this case mung bean sprouts, as well as the difficulties involved in investigating sprout-associated outbreaks.

Seed sprouts have been associated with over 50 foodborne outbreaks around the world over the past three decades[1-3, 5, 7-11, 23, 24]. A variety of sprout varieties have been implicated in previous outbreaks, most commonly alfalfa, but also mung bean, radish, fenugreek and clover sprouts; these outbreaks have included multiple serotypes of *Salmonella* enterica as well as pathogenic *E. coli*[9, 25]. Two of the largest and most serious foodborne outbreaks documented in the literature were due to enterohaemorrhagic *E. coli* contaminated bean sprouts: an outbreak in Europe, the US and Canada affecting 4321 people in 16 countries with 50 deaths attributed to contaminated fenugreek sprouts, and an outbreak primarily among Japanese schoolchildren attributed to white radish sprouts in 1996 resulted in 9,451 cases and 12 deaths[26, 27].

Mung bean sprout-associated outbreaks are less common than alfalfa sprout-associated outbreaks. Possible reasons for few outbreaks being associated with mung bean sprouts include the fact that mung bean sprouts are often cooked (for example, in Asian dishes), and that consumption of mung bean sprouts may not be easily recalled by patients. They may also not be inquired about during an investigation[28].

Sprout consumption has been increasing globally due to their widespread availability, high nutritional content and perceived health benefit; however, consumer awareness of the risks associated with sprout consumption is frequently low[24, 29]. Sprouts remain a high-risk food for several reasons. Pathogens can be internalised within the seed and reside inside sprout tissues, meaning that surface sanitation and washing in the absence of cooking is insufficient to render the sprout safe for consumption[25, 30]. The germination and sprouting process, involving soaking in water and being placed in warm and humid conditions, provides optimal conditions for bacterial growth[29]. Contamination of sprouts can occur at any stage of the production process including during seed production, storage and distribution, sprout germination and growth, or during sprout harvest, packaging and distribution (Figure 2).

Figure 2 - Simplified sprout production process[31, 32]



A review by the US Centers for Disease Control and Prevention found that in most outbreaks caused by sprout products, the seeds used for sprouting were suspected to be the primary source of contamination[5, 33]. This is a cause for concern as seeds remain viable for years, so they may be transported long distances and stored for some time prior to sprouting[9]. *Salmonella* has been

demonstrated to remain viable on alfalfa seeds in dark storage for two years[34]. Australian-produced sprout seed has frequently been a source of sprout-associated outbreaks overseas[1, 2, 35]. In a US study into sprout-associated outbreaks occurring in the US between 1998-2010, among 13 outbreaks caused by imported seeds Australia was the most frequently identified source of imported seeds for *Salmonella* outbreaks (responsible for outbreaks of Salmonella Kottbus, Bovismorbificans, and Oranienburg) and was source of all identified STEC-associated outbreaks[9].

Compared with other foodborne-disease outbreaks, sprout-associated outbreaks tend to be larger and more likely to involve multiple geographical regions (whether states or countries) [9]. A US study found sprouts were responsible for eight percent of multistate foodborne disease outbreaks in the USA, the fourth most common vehicle after fruits, vegetable row crops and beef[36]. In this *S* Saintpaul outbreak, cases were widely dispersed with clusters of cases occurring in December 2015 and March 2016 followed by a large peak in April 2016. Although the source of cases in South Australia and Northern Territory was traced to a sprouter in Adelaide, this did not account for the cases in NSW or the ACT, as the implicated producer did not supply to either of these states. However, the cases were known to be part of the same outbreak due to the use of WGS in confirming outbreak cases. In this outbreak, the temporal and geographic clustering of cases suggested that a contaminated seed batch as the source of the outbreak (although this was not proved based on environmental testing), and this is further supported by the literature demonstrating seeds as the primary source for most outbreaks. The explosive nature of the outbreak in South Australia was possibly due to poor practices in the sprouting facility that allowed amplification of the outbreak.

In our outbreak, cases were predominantly adult women, which has been noted in several previous sprout-related outbreaks[2-4, 7, 23, 37]. This suggests that in an outbreak in which there is no clear source and which primarily women and middle-aged adults are affected, a fresh produce source and specifically sprouts should be suspected. It is possible that women have different eating habits to men and are more likely to eat salad-type items. Additionally, in this outbreak as in previous sprout-related outbreaks, more than half of cases did not recall eating sprouts. Sprouts are often used as garnish or side dishes, or are served mixed with other food items in dishes such as Asian rolls, which makes them difficult to remember by patients and renders them classical “stealth” vehicles[10, 38]

The case-case study design was used in this outbreak as a convenient way of recruiting controls. Case-case studies are not frequently used, although this is changing. In Australia in 2016 they were utilised for three multi-jurisdictional *Salmonella* outbreaks, with the source successfully identified in all three. The case-case study design offers two key advantages over traditional control selection: it provides a convenient control source in a setting in which developments of new technologies have

rendered traditional control selection methods obsolete (e.g. single digit changes to phone numbers); it also helped reduce bias and improve response to the questionnaire from controls[16].

Study limitations

The case-controls study conducted during this outbreak had several limitations. One was an emerging lack of appropriate controls to match with the *S* Saintpaul cases, particularly in South Australia where the outbreak became so explosive that there were insufficient *S.* Typhimurium controls available requiring recruitment of *Campylobacter* controls instead. This may have introduced selection bias, particularly if the *Campylobacter* controls were different from the *S.* Typhimurium controls. This would be an important consideration in future outbreaks. However, the use of these as controls also had the benefit of reducing recall bias, as both cases and controls had a clear date of onset of illness, and a similar probability of recalling what they had eaten in the week prior.

Cases and controls were also interviewed by different interviewers in different states. This could have led to differences in the way the questionnaire was administered and the degree of probing, leading to the potential for information ascertainment to be systematically different between states. In addition, once the hypothesis of bean sprouts became clear there was the potential for interviewers to ask more probing questions about bean sprouts than other exposures, potentially overestimating the association between bean sprouts and infection. We attempt to adjust for this by having a clear and prescriptive protocol, and by providing an initial orientation to the questionnaire with all interviewers.

We initially included in the questionnaire all foods where the frequency of consumptions was >60%. In hindsight, given the investigation eventually identified the “stealth” food of sprouts with a consumption rate of only 40%, in the absence of microbiological or environmental evidence of the source of infection this could have implied that the true vehicle was not something that had been enquired about on the questionnaire that was also a “stealth” food (for example other garnish such as coriander).

Conclusion

In this outbreak, *S.* Saintpaul infection was strongly associated with consumption of mung bean sprouts. Bean sprouts are a known high-risk food, given they are not typically cooked before consumption and are grown in an environment that provide optimal conditions for bacterial growth. To prevent future outbreaks, it is essential that sprout producers adhere to stringent hygiene process during production to minimise the risks of contamination. Given the inability of the production process to completely eliminate the risk of contamination, consumers should also be educated about the potential risks of consuming bean sprouts to enable them to make an informed choice. Bean sprout-associated outbreaks and those caused by "stealth" foods remain challenging to investigate, and case-case studies can be invaluable epidemiological tool in identify potential suspect food items.

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Appendices

Appendix 1 – full univariate analysis

Table 4 – Association between all food items included in the questionnaire and *Salmonella* Saintpaul infection: case-control study, Australia 24 March – 10 May 2016

Exposure name	Cases		Controls		OR	95% CI	p-value
	N	%	N	%			
Ham	34/68	50.0%	47/136	34.6%	1.89	1.05-3.42	0.034
- Pre-packaged	7/64	10.9%	9/136	6.6%	1.73	0.61-4.88	0.294
- Deli ham	22/65	33.8%	31/136	2.8%	1.73	0.90-3.32	0.096
- Other	8/58	13.8%	7/136	5.1%	2.95	1.02-8.56	0.039
Bacon	33/70	47.1%	50/135	37.0%	1.52	0.84-2.72	0.162
- Pre-packaged	11/64	17.2%	19/137	13.9%	1.29	0.57-2.90	0.538
- Deli bacon	13/65	20.0%	22/135	16.3%	1.28	0.60-2.75	0.519
- Other	9/66	13.6%	13/129	10.1%	1.41	0.57-3.49	0.457
Salami	16/71	22.5%	19/142	13.4%	1.88	0.90-3.94	0.089
- Pre-packaged	3/70	4.3%	5/141	3.5%	1.22	0.28-5.25	1.000
- Deli salami	6/69	8.7%	11/141	7.8%	1.13	0.40-3.18	0.823
- Other	8/69	11.6%	4/140	2.9%	4.46	1.29-15.37	0.022
Raw carrots	43/72	59.7%	61/140	43.6%	1.92	1.08-3.42	0.026
- Bagged	33/71	46.5%	35/134	26.1%	2.46	1.34-4.50	0.003
- Loose	7/70	10.0%	10/134	7.5%	1.38	0.50-3.79	0.534
- Pre-made salad or sandwich	10/71	14.1%	16/138	11.6%	1.25	0.54-2.92	0.605
- Other	7/59	11.9%	4/136	2.9%	4.44	1.25-15.81	0.020
Tomatoes	49/72	62.1%	89/143	62.2%	1.29	0.71-2.35	0.401
- Truss	24/68	35.3%	33/135	24.4%	1.69	0.89-3.18	0.104
- Roma	5/67	7.5%	14/136	10.3%	0.70	0.24-2.04	0.515
- Cherry	12/69	17.4%	31/138	22.5%	0.73	0.35-1.52	0.396
- Grape	2/71	2.8%	7/134	5.2%	0.53	0.11-2.60	0.722
- General	14/70	20.0%	32/138	23.2%	0.83	0.41-1.68	0.601
- Pre-made salad or sandwich	7/69	10.1%	12/129	9.3%	1.10	0.41-2.94	0.848
- Other	4/56	7.1%	8/119	6.7%	1.07	0.31-3.71	1.000
Raw onions	29/72	40.3%	44/138	31.9%	1.44	0.80-2.60	0.225
- Brown	5/71	7.0%	13/139	9.3%	0.73	0.25-2.15	0.572
- Red	21/69	30.4%	23/134	17.2%	2.11	1.07-4.17	0.030
- White	1/70	1.4%	6/138	4.3%	0.32	0.04-2.70	0.427
- Salad onions	0/70	0.0%	1/139	0.7%	0.00	-	1.000
- Spring onions	8/71	11.3%	9/139	6.5%	1.83	0.68-4.98	0.228
- Pre-made salad or sandwich	7/68	10.3%	6/130	4.6%	2.37	0.76-7.36	0.126
- Other	0/55	0.0%	1/110	0.9%	0.00	-	1.000
Bean sprouts	28/69	40.6%	14/144	9.7%	6.34	3.05-13.18	0.000
- Mung bean sprouts	28/69	40.6%	6/140	4.3%	15.25	5.91-39.38	0.000
- Alfalfa sprouts	2/69	2.9%	2/139	1.4%	2.04	0.28-14.83	0.601
- Pre-made salad or sandwich	2/69	2.9%	2/140	1.4%	2.06	0.28-14.94	0.600
- Other	0/60	0.0%	2/134	1.5%	0.00	-	1.000
Raw cucumbers	47/71	66.2%	80/139	57.5%	1.44	0.80-2.62	0.226

- Lebanese	15/68	22.1%	29/137	21.2%	1.05	0.52-2.13	0.884
- Continental/ telegraph	30/68	44.1%	53/133	39.8%	1.19	0.66-2.15	0.561
- Pre-made salad or sandwich	8/66	12.12%	14/134	10.4%	1.18	0.47-2.98	0.722
- Other	4/59	6.8%	2/123	1.6%	4.40	0.78-24.75	0.088
Salad							#N/A
- Crunchy salad mix	6/70	8.6%	7/140	5.0%	1.78	0.58-5.52	0.311
- Baby spinach	12/68	17.6%	25/137	18.2%	0.96	0.45-2.05	0.916
- Rocket	4/70	5.7%	14/139	10.1%	0.54	0.17-1.71	0.434
- Greek/Mediterranean salad mix	3/71	4.2%	4/139	2.9%	1.49	0.32-6.84	0.691
- Coleslaw/dry slaw	6/71	8.4%	12/137	8.8%	0.96	0.35-2.68	0.940
- Four-leaf salad mix	14/68	20.6%	14/135	10.4%	2.24	1.00-5.02	0.046
- Any other lettuce mix	6/71	8.4%	12/143	8.4%	1.01	0.36-2.81	0.988
- Any other pre-packaged salad	9/68	13.2%	11/140	7.9%	1.79	0.70-4.55	0.217
Chili	29/71	40.8%	35/138	25.4%	2.03	1.11-3.74	0.021
- Fresh	11/69	15.9%	21/134	15.7%	1.02	0.46-2.26	0.960
- Dried	7/68	10.3%	4/136	2.9%	3.79	1.07-13.42	0.045
- Other	15/66	22.7%	14/134	10.4%	2.52	1.13-5.60	0.020
Potatoes	50/71	70.4%	116/142	81.7%	0.53	0.27-1.04	0.062
- Red	6/66	9.1%	17/130	13.1%	0.66	0.25-1.77	0.413
- White	37/66	56.1%	93/138	67.4%	0.62	0.34-1.13	0.115
- Other	11/59	18.6%	25/119	21.0%	0.86	0.39-1.90	0.712
Broccoli	43/71	60.6%	79/142	55.6%	1.22	0.69-2.19	0.493
- Fresh	36/69	52.2%	61/138	44.2%	1.38	0.77-2.46	0.279
- Frozen	4/69	5.8%	11/137	8.0%	0.70	0.22-2.30	0.778
- Broccolini	6/69	8.7%	13/137	9.5%	0.91	0.33-2.50	0.853
- Other	1/62	1.6%	2/123	1.6%	0.99	0.09-11.16	1.000
Limes	14/72	19.4%	16/143	11.2%	1.92	0.88-4.19	0.099
- Bagged	3/70	4.3%	2/136	1.5%	3.00	0.49-18.39	0.339
- Loose	10/70	14.3%	10/141	7.1%	2.18	0.86-5.52	0.093
- Other	3/67	4.5%	4/136	2.9%	1.55	0.34-7.12	0.687
Peaches	14/72	19.4%	18/144	12.5%	1.69	0.79-3.63	0.176
- Yellow	7/69	10.1%	13/143	9.1%	1.13	0.43-2.97	0.806
- White	6/69	8.7%	4/142	2.8%	3.29	0.90-12.05	0.083
- Other	4/65	6.1%	4/140	2.9%	2.23	0.54-9.21	0.267
Bananas	36/71	50.7%	95/142	66.9%	0.51	0.28-0.91	0.022
- Regular/Cavendish	35/70	50.0%	93/142	65.5%	0.53	0.29-0.94	0.030
- Other	0/50	0.0%	4/105	3.8%	0.00	-	0.306
Black pepper	42/71	59.1%	95/143	66.4%	0.73	0.41-1.32	0.296
- Whole	34/69	49.3%	68/136	50.0%	0.97	0.54-1.73	0.922
- Ground	9/68	13.2%	30/134	22.4%	0.53	0.24-1.19	0.119
- Other	0/60	0.0%	1/123	0.8%	0.00	-	1.000
Milk	60/72	83.3%	127/144	88.2%	0.67	0.30-1.49	0.323
- Full cream	33/67	49.2%	69/136	50.7%	0.94	0.52-1.69	0.843
- Skim	24/64	37.5%	43/134	32.1%	1.27	0.68-2.37	0.452
- Other	14/59	23.7%	28/130	21.5%	1.13	0.55-2.35	0.737
Chicken purchased raw and prepared at home	46/72	63.9%	94/140	67.1%	0.87	0.48-1.57	0.636
- Whole chicken	8/67	11.9%	10/138	7.2%	1.74	0.65-4.62	0.265
- Chicken pieces	42/70	60.0%	82/136	60.3%	0.99	0.55-1.78	0.967

- Other	2/60	3.3%	13/131	9.9%	0.31	0.07-1.43	0.152
Eggs at home	54/72	75.0%	98/142	69.0%	1.35	0.71-2.56	0.362
- Free range	39/68	57.3%	69/133	51.9%	1.25	0.69-2.25	0.462
- Barn laid	4/66	6.1%	3/121	2.5%	2.54	0.55-11.70	0.245
- Caged eggs	4/64	6.2%	14/123	11.4%	0.52	0.16-1.65	0.307
- Other	10/59	16.9%	11/115	9.6%	1.93	0.77-4.85	0.157
Eggs away from home	20/67	29.8%	21/140	15.0%	2.41	1.20-4.85	0.012
Cafés, restaurants, bars	43/69	62.3%	73/141	51.8%	1.54	0.86-2.77	0.149
Bakeries	14/67	20.9%	23/140	16.4%	1.34	0.64-2.81	0.433
Takeaways including service stations, fast food outlets	38/68	55.9%	66/141	46.8%	1.44	0.80-2.58	0.219
Social gatherings	14/68	20.6%	20/140	14.3%	1.56	0.73-3.31	0.249

Appendix 2: Multivariate analysis: logistic regression model

Figure 3 – Logistic regression, selected food items, age and sex: case-control study, Australia 24 March – 10 May 2016

```
Logistic regression                               Number of obs     =        166
                                                  LR chi2(10)       =      50.33
                                                  Prob > chi2       =     0.0000
Log likelihood = -80.264971                       Pseudo R2         =     0.2387
```

casecontrol	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	.9921084	.0103516	-0.76	0.448	.9720257	1.012606
sex	1.244882	.5177123	0.53	0.598	.5509815	2.812675
ham	1.52062	.6675458	0.95	0.340	.6432008	3.594964
salami1	.7302877	.4353851	-0.53	0.598	.226998	2.349448
carrots	1.006498	.4207958	0.02	0.988	.4435508	2.283929
red_onions1	3.363949	1.681056	2.43	0.015	1.263226	8.958139
mungbeansp~1	18.40955	11.59275	4.63	0.000	5.35833	63.24946
fourleafsa~x	1.536215	.8503383	0.78	0.438	.5191445	4.54586
chili	1.375228	.613367	0.71	0.475	.5737587	3.29625
eggs_away_~e	2.81813	1.35684	2.15	0.031	1.096818	7.240814
_cons	.1720197	.0992263	-3.05	0.002	.0555365	.5328164

Appendix 3 - *Salmonella* Saintpaul Case Control Study Protocol

Study protocol for *Salmonella* Saintpaul Case-Case Study

Draft Number: 4

Date of Draft: 08/03/2016

Prepared by: Kirsty Hope

Study leader: Kirsty Hope

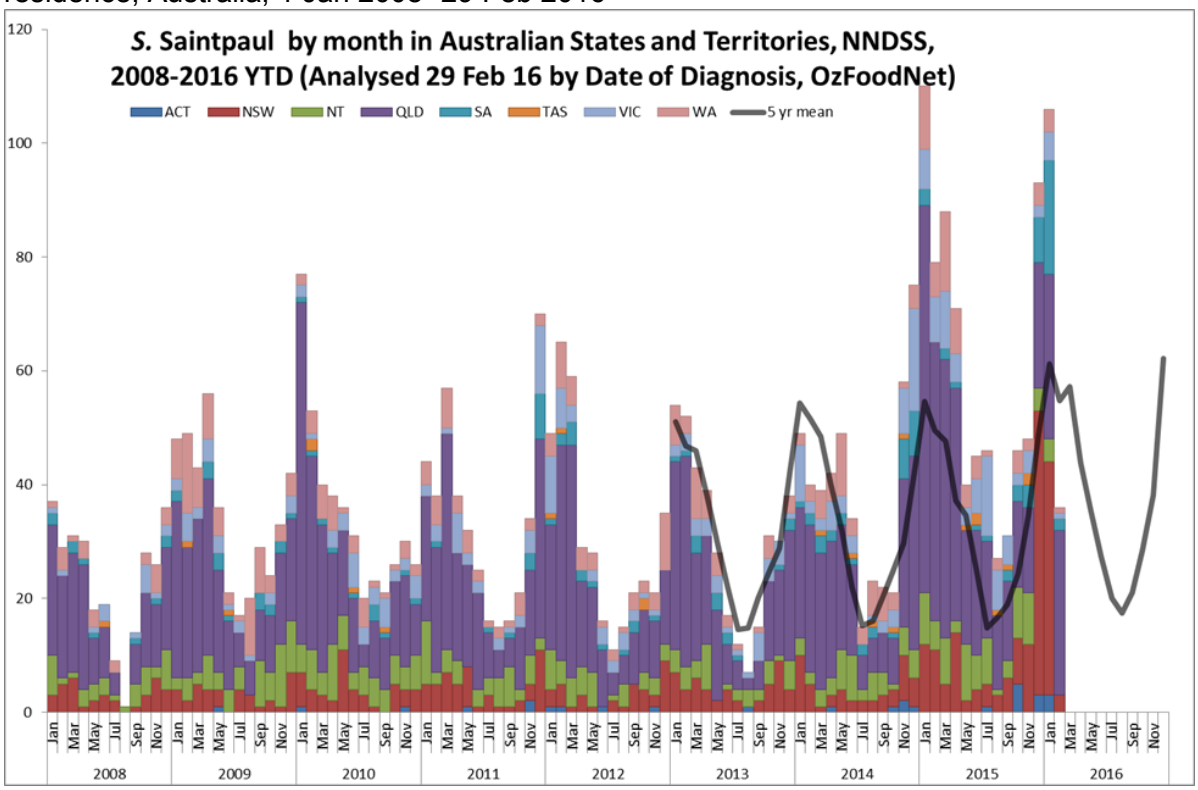
OzFoodNet Epidemiologists: Kirsty Hope (NSW), Brett Archer (NSW), James Flint (HNE), Laura Ford (ACT), Megge Miller (SA)

Background

During December 2015, a notable increase in *Salmonella* Saintpaul (*S.* Saintpaul) notifications was detected through routine surveillance in NSW, SA and ACT. As at 3 March 2016, a total of 146 notifications for S.Saintpaul have been received across the three jurisdictions since 1 December 2015.

S. Saintpaul is a relatively uncommon *Salmonella* serotype in Australia, accounting for 3.3% of national annual salmonellosis notifications in 2011. Queensland is traditionally the jurisdiction with the highest proportion of S.Saintpaul cases in Australia. NSW have seen a large increase in S.Saintpaul notifications peaking in week 52 of 2015 and SA have observed a peak in their notifications in week 3 of 2016 (Figure 1).

Figure 1: *Salmonella* Saintpaul notifications by month of diagnosis date and jurisdiction of residence, Australia, 1 Jan 2008- 29 Feb 2016



Foodborne outbreaks with this *Salmonella* serotype in Australia have previously been associated with the consumption of rockmelon and bean sprouts. Internationally, *S.* Saintpaul outbreaks have been attributed to the consumption of jalapeno peppers, bean sprouts, cucumbers, paprika and mangoes (Appendix 1).

Study Rationale

Cases of *Salmonella* Saintpaul continue to occur in NSW, SA and ACT above expected levels. Hypothesis generating interviews indicate onions (amongst other vegetables) may be the source of these infections. It is important to determine if there is an association between onion consumption and illness in order to prevent illness and inform future food safety measures.

Study Hypotheses

This study is designed to test the hypothesis that there is no association between *S.* Saintpaul and the following foods, using data collected in the hypothesis generating phase of this investigation

- Foods with an elevated odds ratio where the p value was <0.05
- Foods where the frequency of consumption was >60%

Methods

The study design is a case-case study, with investigators recruiting two cases of *Salmonella* Typhimurium (STM) for every case of *Salmonella* Saintpaul.

Case Definition

A case is a person who has:

- Isolation of the outbreak sequence of *Salmonella* Saintpaul in an individual who:
  (a) experienced acute onset of gastroenteritis since 1 Dec 2015*, AND
  (b) was resident in or visited ACT, NSW or SA within 7 days prior to illness onset.

Questionnaire

The case-case questionnaire contains questions on eligibility, consent and demographics, and structured questions on a limited range of fresh and frozen fruit and vegetables. Most questions will be designated as Yes/No/Unknown.

Case Eligibility

Investigators will recruit cases reported under State legislation. Cases will be **excluded** from the study if:

- If they are found to have a different sequence to the outbreak.
- Cases cannot be reached after 6 attempts to contact them, spread over 3 days.
- Unable to recall the date that their diarrhoea began (onset date).
- They are unable to answer questions (eg Dementia) or need an interpreter
- They are not interviewed within 40 days of collection of a faecal specimen.
- Another enteric pathogen other than *S*. Saintpaul was isolated in or detected in their stool specimen.
- If there has been another member of the household who has had an onset of diarrhoea in the 2 weeks prior to the onset of diarrhoea in the laboratory-confirmed case selected for the study.
- They have returned from travelling overseas within the 7 days prior to onset of their illness or to another state other than NSW, SA and ACT.
- They reside in an institution, such as an aged care facility.

Enrolment of cases

- As there is a delay in obtaining the whole genome sequencing (WGS) results, *Salmonella* Saintpaul cases will be enrolled into the study and interviewed. The case will later be excluded if they have a sequence different to the outbreak sequence.
- As per standard surveillance guidelines, consent to contact the patient or the patient's parent or guardian for a child aged less than 18 years, will be sought from the referring medical practitioner in NSW and ACT or during the process of medical notification in SA.
- Cases will then be contacted, verbal consent obtained and questions asked to determine eligibility. If eligible, interviewers will administer the study questionnaire.
- It will be at the parent's or guardian's discretion as to whether a child aged between 15 and 17 years is interviewed directly. Information from a child aged less than 15 years will be obtained from the parent

or guardian who is most familiar with their dietary and behavioural lifestyle.

- Cases will be interviewed by telephone by trained public health staff as soon as possible after notification using a structured national case-case questionnaire regarding their illness and food consumed in 5 days prior to their onset of illness.
- Cases will continue to be enrolled until a decision is made by the investigation team to cease or the required sample size is reached.

Control Selection

Investigators will select cases of STM (herein after referred to as "controls"), from a list provided by the OzFoodNet (OFN) Epidemiologist. Controls will be frequency matched by age group (<15 years, 15-40, 40+) and geographic location to the cases (LGA). If controls cannot be found within the same LGA then they can be selected from an LGA within the state that has previously had cases.

Controls should have a specimen collection date within four weeks of the case. When more than two controls are available the ones with the closest onset date to the case should be tried first.

Two controls will be interviewed per case. If interviewers are unsuccessful in speaking with a potential control after 6 attempts to contact them over 3 days, they should move onto the next potential control.

Bias associated with control group

	STM controls	**Comments**
Selection bias	Cases and control-cases both identified through the same surveillance system	
Recall bias	Reduced due to both groups experiencing some symptoms.	
Information bias		
Representative	Selections of controls based on factors related to exposure – may not represent true exposure prevalence of larger population.	Results will only be generalizable to STM control-cases, not the general population.

	STM controls	Comments
Interpretation of Odds ratio	Measure of effect should be interpreted cautiously with regards to what group is being used as the comparison group	
Identification of new or unique risk factors	Risk factors may be underestimated or not identified because present in both groups, but useful to generate hypotheses for other studies If analysis is done often, it may detect changes in risk factors not otherwise found	NEPSS data from MDU and SA Pathology data have indicated there have been no recent STM isolates from fresh produce. If the source is chicken or eggs, we will be unlikely to detect this with the study design as MDU and SA Pathology data indicate there have been recent isolations of *Salmonella* Saintpaul in chicken meat and from chicken layer litter environment.
System requirements		
Recruitment	Cases and control-cases already in the routine surveillance system.	
Cost	Minimal cost, as the cases and control-cases are already in the routine surveillance system.	
Timeframes	Can be done quickly in an outbreak	

Control eligibility

A control will be excluded from the investigation if:

- They have already been interviewed as part of an outbreak investigation

- Controls cannot be reached after 6 attempts to contact them over 3 days.
- Unable to recall the date that their diarrhoea began (onset date).
- They are unable to answer questions (eg dementia) or need an interpreter.
- They are not interviewed within 40 days of collection of a faecal specimen.
- Another enteric pathogen other than *S*. Typhimurium was isolated in or detected in their stool specimen.
- If there has been another member of the household who has had an onset of diarrhoea in the 2 weeks prior to the onset of diarrhoea in the laboratory-confirmed control-case selected for the study.
- They have returned from travelling overseas or interstate (other than NSW, ACT, SA) within the 7 days prior to the onset of their diarrhoea.
- They reside in an institution, such as an aged care facility.

Case and control interviews

Interviewers will follow specific introductions and prompts in the questionnaire. Cases and controls will be interviewed about their exposures to various foods in the seven days prior to onset of their illness. The exposure period includes the seven whole days prior to the onset of illness, along with the part day when the illness began. To assist with case and control recall, all interviewers should recommend to interviewees to have a calendar in front of them.

Interviewers should make 6 attempts to contact both cases and controls for interview. At least 3 attempts should be made within normal business hours and 3 attempts outside business hours. If a person cannot be contacted an SMS can be sent if able or a message left on their phone. The outcomes of case and control interviews should be recorded for quality control assessment.

Interviewers should not give details of specific hypotheses under study. Any request for information regarding *Salmonella* infection and potential sources should be given at the end of the interview. Interviewers may offer to send out standard public health information about *Salmonella* prepared by their local health department.

As this is an outbreak investigation, results of the study may not be available publicly and their information can be accessed through a FOI process.

If study subjects request information on the conduct of this study interviewers should indicate that it is an outbreak investigation of

Salmonella being conducted under the relevant jurisdictional public health legislation.

Sample size

Estimated sample sizes are based on the following assumptions:

- Prevalence of eating onions 55%, brown onions 39%, red onions 17%. among healthy community controls (obtained from Victorian Food Frequency study)
- To detect an odds ratio of 2 to 4
- α=0.05,
- β=80%, and
- Study design is unmatched

Table 1: Numbers of cases and controls required to observe a statistically significant odds ratio of either 2 to 4 based on different fresh produce and their prevalence.

			No. of cases								
OR			**2.00**			**3.00**			**4.00**		
Ratio cases:controls			**1:1**	**1:2**	**1:3**	**1:1**	**1:2**	**1:3**	**1:1**	**1:2**	**1:3**
Food	**Variable ID**	**Prevalence**									
Fruit_PawPaw	VAR420	2%	1221	875	758	412	288	246	231	159	134
Fruit_Exotic	VAR429	2%	1221	875	758	412	288	246	231	159	134
Veg_Beansprout_Any	VAR327	6%	438	316	274	151	107	92	87	61	52
Veg_Capsicum_Other_Any	VAR207	6%	438	316	274	151	107	92	87	61	52
Veg_Onion_Brown_Raw	VAR233	7%	382	276	240	133	94	81	76	54	46
Fruit_Limes	VAR401	8%	341	246	214	119	85	73	69	48	41
Veg_Onion_Red_Raw	VAR239	10%	283	205	179	100	71	62	58	41	35
Veg_Chilli_Any	VAR213	15%	208	151	132	75	54	47	45	32	28
Veg_Onion_Red_Any	VAR236	17%	191	139	122	70	51	44	42	30	26
DeliMeat_Bacon_Any	VAR118	31%	140	104	91	55	41	36	35	26	23
Veg_Saladmix_Any	VAR330	31%	140	104	91	55	41	36	35	26	23
Veg_Mush_Any	VAR359	37%	134	100	88	54	40	36	35	26	23
Veg_Onion_Brown_Any	VAR230	39%	133	99	88	54	40	36	35	26	23
Veg_Onion	VAR229	55%	143	108	97	62	47	42	42	32	29

If using any onions as the hypothesis: it has a frequency consumption of 55%, therefore for an OR of 3 and 1:2 control ratio we would need 47 cases and 94 controls. If we use the hypothesis of red onions, which has a frequency of consumption of 17%, an OR of 3 and a 1:2 control ratio we would need 51 cases and 102 controls.

Public health follow-up

As part of this study, interviewers may identify cases that work in occupations with a higher likelihood of transmitting *Salmonella* to other people, such as health care workers, child-care workers or food handlers. If cases work in these occupations they should be advised not to work until symptoms resolve in line with recommendations contained in jurisdictional protocols.

Interviewers may also identify cases that are part of a potential point source outbreak where other people are either confirmed or not confirmed as infected with *Salmonella*. The source of outbreaks identified from case interviews should be followed up separately and may form part of a separate investigation. Cases that are identified as part of recognised outbreaks should be brought to the attention of the OFN epidemiologist.

Data Entry & Analysis

Interviewers will collect data on cases and controls on paper forms and update the case information and case notes on the relevant jurisdictional database at the end of the interview. For analytical purposes, the food exposure data will be entered into an excel spreadsheet as designated by the lead jurisdiction, by a person assigned to data entry. Analysis will be done by the lead jurisdiction.

The lead jurisdiction will analyse exposure histories between cases and controls to generate odds ratios with 95% confidence intervals using an unmatched analysis.

Interim analysis will be required during the conduct of the study to examine potential associations requiring public health action. This will be done at 25 cases. The investigation team will review the data and decide on next steps.

The lead jurisdiction will conduct a final univariate and multivariate analysis once the investigation is complete, which will take into account:

- age and sex difference between cases and controls.

Ethical considerations

Participation in the study will be voluntary and verbal consent will be obtained. As this is considered an investigation of public health importance, clearance from a Human Research Ethics Committee will not be obtained. Retention of information regarding cases and controls is maintained in accordance with relevant privacy legislation.

Study outcomes

The main objective of this study is to identify food-based risk factors for infection with *Salmonella* Saintpaul. Summary results of this study will be communicated to the public health network, CDNA and food safety enforcement agencies. Depending on the results, the investigation team will prepare a final report and a manuscript for publication.

Appendix 4 - *Salmonella* Saintpaul Case Control Study Questionnaire

Salmonella Saintpaul

CASE-CONTROL STUDY

☐ **Case** (*Salmonella* Saintpaul) ☐ **Control** (*Salmonella* Typhimurium)

Name: _____

Notification ID: _____

Contact number: _____

Age: _____

Sex: Male (1) [ ] Female (0) [ ]

Local Government Area of residence: _____

Attempts to contact case

Date	Time	Interviewer	Outcome

1. INTRODUCTION

If case is under 15 years of age you will need to speak to parent or guardian.

If case is aged 15 -17 years you will need to obtain parent or guardian consent prior to interview.

" **Hello, my name is……. I work for the _____ NSW Ministry of Health."**

For adults: **May I please speak with ……<name of case>?"**

For children under 18 years: **May I please speak with the parent or guardian of ……<name of case>?"**

When the case comes to the phone then repeat the introduction and proceed with the explanatory statement.

If the case is unavailable then arrange an alternative time for the interview

We are currently investigating an outbreak of gastroenteritis due to *Salmonella*. As *Salmonella* is a notifiable infectious disease, doctors and laboratories are required to notify the Health Department of all cases diagnosed in NSW. You/ your child has recently been diagnosed with *Salmonella* infection and we would like to ask you some questions about {your / your child's} illness, travel history and foods consumed prior to {your / your child's} illness. The questions should take about 20 minutes. Your participation is voluntary and all responses are totally confidential.

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.

Can you assist us in this investigation by participating?

Verbal consent given for interview	**Yes** ☐	**No** ☐

If declining interview, what is the reason for not participating?

☐ No time ☐ Not interested ☐ Other:_____

For children 15-17 years

Do you give your consent for me to speak directly with ……<name of case>?"

Verbal consent given to interview child 15-17 years	**Yes** ☐	**No** ☐

Interviewer Note:	Please note that for cases under the age of 15 years, (and those 15-17 if parent being interviewed) questions relate to the case, not the person being interviewed unless specified in the body of the questionnaire.

"Because I will be asking about specific dates around the time of your illness, it may be helpful for you to have a calendar or diary in front of you. Do you need a few minutes to get these?"

2. CLINICAL INFORMATION

Interviewer to complete before interview:

Date of specimen collection ☐☐ ☐☐ ☐☐

Day Month Year

1. **On what date did your illness begin?** ☐☐ ☐☐ ☐☐

Day Month Year

(If person is unsure of date then prompt with date of stool specimen)

2. **During this illness, did {you / your child} have any of the following symptoms?**

Symptom	**Yes**	**No**	**DK/NS**	
Diarrhoea				Date of onset: ____/_____/____
Nausea				
Vomiting				
Stomach cramps				
Blood in your stool				
Fever				
Headache				
Muscle/body aches				
Other				
Please specify:				

3. **For how many days did {your / your child's} diarrhoea last? DAYS** ☐☐

☐ ..... Still continuing
☐ ..... No diarrhoea
☐ ..... Don't know/not sure

4. **Did you { your child} present to an emergency department at a hospital for this illness?**

☐ ..... Yes
☐ ..... No, *go to question 7*
☐ ..... Don't know/not sure, *go to question 7*

5. **Were you {was your child} admitted to hospital for this illness?**

☐ ..... Yes
☐ ..... No, go to *go to question 7*
☐ ..... Don't know/not sure, *go to question 7*

6. **If yes, for how many nights were {you / your child} hospitalised?** ☐☐ **NIGHTS**
☐ ..... Don't know/not sure, *go to question 7*

7. **When your symptoms began, were you employed as a health care worker, child-care worker or food preparer/foodhandler?**

☐ ..... Yes, please specify:_____
☐ ..... No
☐ ..... Don't know/not sure

8. **In the 2 weeks <u>before</u> your illness began, did anyone in your <u>household</u> have diarrhoea or a stool test that was positive for *Salmonella*?**

☐ ..... Yes- END INTERVIEW (see below)
☐ ..... No, *go to question 9*
☐ ..... Don't know/not sure, *go to question 9*

If there was someone in the case's household with diarrhoea in the 2 weeks before illness onset – END INTERVIEW
with "Since there was someone else in your household who was unwell with diarrhea before you, we will not be able to include you in our study. It is possible that you may have caught the Salmonella infection from them.
Are there any questions you would like to ask me?
Would you like some information about Salmonella?
Thank you very much for your time and cooperation."

Interviewer note: If the case responds yes to the above questions (7 & 8), you will need to ensure that this is followed up with the relevant public health action.

3. TRAVEL INFORMATION

9. In the 7 <u>days</u> before your diarrhoea began, did {you / your child} travel outside of Australia?

☐ ..... Yes
☐ ..... No, *go to question 12*
☐ ..... Don't know/not sure, *go to question 12*

10. To which country or countries did {you / your child} travel?

_____
_____

☐ ..... Don't know/not sure

11. What date did {you / your child} return to Australia?
_____/_____/_____

☐ ..... Don't know/not sure

If case was overseas for any of the exposure period (<u>7 days prior to onset date</u>) – *End the interview for case control study*. *Please go to question 40 for eating outside of the home.*

Please state "Since you were overseas during the exposure period, we will not be able to include you in our investigation. However, we would still like to know where you ate outside of the home while in SA/NSW/ACT"- *go to question 40.*

12. In the 7 <u>days</u> before your diarrhoea began, did {you / your child} travel interstate or within the state?

☐ ..... Yes
☐ ..... No, *go to question 16*
☐ ..... Don't know/not sure, *go to question 16*

13. Where did you travel to?

_____
_____
_____

☐ ..... Don't know/not sure

14. What was your date of departure?
_____/_____/_____

15. What was your date of return?
_____/_____/_____

If case was not in SA, NSW, or ACT for all the exposure period (entire 7 days prior to onset date) – ***End the interview for case control study****. Please go to question 40 for eating outside of the home.*

Please state: "Since you were overseas during the exposure period, we will not be able to include you in our investigation. However, we would still like to know where you ate outside of the home while in SA/NSW/ACT"- *go to question 40.*

4. FOOD EXPOSURES

Interviewer Note:	Refer to your calendar to determine the interval from the DATE 7 DAYS BEFORE DIARRHOEA BEGAN to the DAY DIARRHOEA BEGAN. Please note that this exposure period means that the person should include the seven whole days prior to onset of illness and the part of the day when their illness began. **PLEASE ENSURE THAT YOU CLARIFY THE DATES WITH THE PERSON BEING INTERVIEWED AND RECORD THE DATES OF INTEREST HERE.**
EXPOSURE PERIOD IS BETWEEN	___/___/_____ (onset date minus 7 days) and ___/___/_____ (onset date)

" For the rest of the questions, I would like to ask you about foods that you/your child may have consumed in the 7 days before [your / your child's] diarrhoea/illness began, and the day that your/your child/s illness began. We are interested in food that you ate inside the home and outside of the home"

16. Did you/your child eat any ham?

☐ **Yes** *If Yes, please fill in Table 1*
☐ **No** *If No, please proceed to Question 17*
☐ **Don't know**…..*If don't know, please prompt with items in Table 1*

Table 1: Did you eat any of the following types of ham? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Ham	Prepackaged					
	Deli section					

	Other, please specify:					

17. Did you/your child eat any bacon?

☐ **Yes** *If Yes, please fill in Table 2*
☐ **No** *If No, please proceed to Question 18*
☐ **Don't know**…..*If don't know, please prompt with items in Table 2*

Table 2: Did you eat any of the following types of bacon? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Bacon	Prepackaged					
	Deli section					
	Other, please specify:					

18. Did you/your child eat any salami?

☐ **Yes** *If Yes, please fill in Table 3*
☐ **No** *If No, please proceed to Question 19*
☐ **Don't know**…..*If don't know, please prompt with items in Table 3*

Table 3: Did you eat any of the following types of salami? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Salami	Prepacked					
	Deli section					

	Other, please specify:					

19. Did you/your child eat any carrots raw, including any carrots that may have been part of a pre-made salad or sandwich?

☐ **Yes** *If Yes, please fill in Table 4*
☐ **No** *If No, please proceed to Question 22*
☐ **Don't know**…..*If don't know, please prompt with items in Table 4*

Table 4: Did you eat any of the following types of carrots raw? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Carrots	Bagged					
	Loose					
	Any raw carrots consumed as part of a pre-made sandwich or salad					
	Other, please specify:					

20. Do you still have any carrots left over from the batch of carrots you ate from in the 7 days before you became unwell?

☐ **Yes**
☐ **No** *If No, please proceed to Question 22*

21. Would we be able to organise someone to come and collect the carrots from your home for testing?

☐ **Yes** *make arrangements for the samples to be collected from the case's home*
☐ **No**

22. Did you/your child eat any tomatoes raw, including any tomatoes that may have been part of a pre-made salad or sandwich?

☐ **Yes** *If Yes, please fill in Table 5*
☐ **No** *If No, please proceed to Question 23*
☐ **Don't know**…..*If don't know, please prompt with items in Table 5*

Table 5: Did you eat any of the following types of tomatoes raw? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Tomatoes	Truss (vine attached) 					Purchased: ☐ *Loose* ☐ *Packaged*
	Roma 					Purchased: ☐ *Loose* ☐ *Packaged*
	Cherry 					Purchased: ☐ *Loose* ☐ *Packaged*
	Grape 					Purchased: ☐ *Loose* ☐ *Packaged*
	General 					Purchased: ☐ *Loose* ☐ *Packaged*
	Any raw tomatoes consumed as part of a pre-made sandwich or salad					

	Other, please specify					

23. Did you/your child eat any onions raw, including any onions that may have been part of a pre-made salad or sandwich?

☐ **Yes** *If Yes, please fill in Table 6*
☐ **No** *If No, please proceed to Question 26*
☐ **Don't know**…..*If don't know, please prompt with items in Table 6*

Table 6: Did you eat any of the following types of onions raw? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Onions	Brown 					Purchased: ☐ *Loose* ☐ *Bagged*
	Red 					Purchased: ☐ *Loose* ☐ *Bagged*
	White 					Purchased: ☐ *Loose* ☐ *Bagged*
	Salad onion 					

	Spring onions 					
	Any raw onions consumed as part of a pre-made sandwich or salad					Please describe type of onion:
	Other, please specify					

24. Do you still have any onions left over from the batch of onions you ate from in the 7 days before you became unwell?

☐ **Yes**
☐ **No** *If No, please proceed to Question 26.*

25. Would we be able to organise someone to come and collect the onions from your home for testing?

☐ **Yes** *make arrangements for the samples to be collected from the case's home*
☐ **No**

26. Did you/your child eat any bean sprouts raw, including any bean sprout that may have been part of a pre-made salad or sandwich?

☐ **Yes** *If Yes, please fill in Table 7*
☐ **No** *If No, please proceed to Question 27*
☐ **Don't know**…..*If don't know, please prompt with items in Table 7*

Table 7: Did you eat any of the following types of bean sprouts raw? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Bean sprouts	Mung bean sprouts 					

	Alfalfa sprouts 					
	Any raw sprouts consumed as part of a pre-made sandwich or salad					
	Other, please describe					

27. Did you/your child eat any cucumbers raw, including any cucumbers that may have been part of a pre-made salad or sandwich?

☐ **Yes** *If Yes, please fill in Table 8*
☐ **No** *If No, please proceed to Question 28*
☐ **Don't know**…..*If don't know, please prompt with items in Table 8*

Table 8: Did you eat any of the following types of cucumbers raw? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Cucumbers	Lebanese 					
	Continental/telegraph 					
	Any raw cucumbers consumed as part of a pre-made sandwich or salad					
	Other, please describe					

28. Did you/your child eat any of the following pre-packaged salads?

*Table 9***:** *Please ask about each option and fill out purchasing and brand details*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Pre-packaged salads	Crunchy salad mix/crunchy vegetable mix					
	Baby spinach					
	Rocket					
	Greek/Mediterranean salad mix					:
	Coleslaw/dryslaw					
	Four leaf salad mix					
	Any other lettuce mix, please describe					
	Any other pre-packaged salads, please describe					

29. Did you/your child eat any chilli?

☐ **Yes** *If Yes, please fill in Table 10*
☐ **No** *If No, please proceed to Question 30*
☐ **Don't know**…..*If don't know, please prompt with items in Table 10*

Table 10: Did you eat any of the following types of chilli? *(Please ask about each option and fill out purchasing and brand details).*

Food item	Yes	No	Don't know	Purchased (store name & suburb)	Brand and type (if unknown, describe packaging e.g. colour)

Chilli	Fresh					Eaten: ☐ *Raw* ☐ *Cooked*
	Dried					Eaten: ☐ *Raw* ☐ *Cooked*
	Other, please specify:					

30. Did you/your child eat any potatoes?

☐ **Yes** *If Yes, please fill in Table 11*
☐ **No** *If No, please proceed to Question 31*
☐ **Don't know**…..*If don't know, please prompt with items in Table 11*

Table 11: Did you eat any of the following types of potatoes? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand and type (if unknown, describe packaging e.g. colour)
Potatoes	Red 					Purchased: ☐ *Loose* ☐ *Bagged*
	White 					Purchased: ☐ *Loose* ☐ *Bagged*
	Other, specify:					Purchased: ☐ *Loose* ☐ *Bagged*

31. Did you/your child eat any broccoli?

☐ **Yes** *If Yes, please fill in Table 12*
☐ **No** *If No, please proceed to Question 32*
☐ **Don't know**…..*If don't know, please prompt with items in Table 12*

Table 12: Did you eat any of the following types of broccoli? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Broccoli	Fresh					Eaten: ☐ *Raw* ☐ *Cooked*
	Frozen					
	Broccolini					Eaten: ☐ *Raw* ☐ *Cooked*
	Other, please specify:					

32. Did you/your child eat any limes?

☐ **Yes** *If Yes, please fill in Table 13*
☐ **No** *If No, please proceed to Question 33*
☐ **Don't know**…..*If don't know, please prompt with items in Table 13*

Table 13: Did you eat any of the following types of limes? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Limes	Bagged					
	Loose					
	Other, please specify:					

33. Did you/your child eat any peaches?

☐ **Yes** *If Yes, please fill in Table 14*
☐ **No** *If No, please proceed to Question 34*
☐ **Don't know**…..*If don't know, please prompt with items in Table 14*

Table 14: Did you eat any of the following types of peaches? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Peaches	Yellow 					Purchased: ☐ *Loose* ☐ *Bagged*
	White 					Purchased: ☐ *Loose* ☐ *Bagged*
	Other, please specify					

34. Did you/your child eat any bananas?

☐ **Yes** *If Yes, please fill in Table 15*
☐ **No** *If No, please proceed to Question 35*
☐ **Don't know**…..*If don't know, please prompt with items in Table 15*

Table 15: Did you eat any of the following types of banana? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Bananas	Regular/Cavendish 					
	Other, please specify					

35. Did you/your child eat any black pepper?

☐ **Yes** *If Yes, please fill in Table 16*
☐ **No** *If No, please proceed Question 36*

☐ **Don't know**…..*If don't know, please prompt with items in Table 16*

Table 16: Did you eat any of the following types of black pepper? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Black pepper	Whole					
	Ground					
	Other, please specify					

36. Did you/your child consume any milk?

☐ **Yes** *If Yes, please fill in Table 17*
☐ **No** *If No, please proceed Question 37*
☐ **Don't know**…..*If don't know, please prompt with items in Table 17*

Table 17: Did you consume any of the following types of milk? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Milk	Full cream					Purchased: ☐ *Fresh* ☐*Long-life (UHT)*
	Skim					Purchased: ☐ *Fresh* ☐*Long-life (UHT)*
	Other, please specify					

37. Did you/your child eat any chicken purchased raw and prepared/cooked at home?

☐ **Yes** *If Yes, please fill in Table 18*
☐ **No** *If No, please proceed to Question 38*
☐ **Don't know**…..*If don't know, please prompt with items in Table 18*

Table 18: Did you eat any of the following types of chicken purchased raw and prepared/cooked at home?

(Please ask about each option and fill out purchasing and brand details).

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Chicken	Whole chicken					☐ *Free Range* ☐ *Organic* ☐ *Corn Feed* ☐ General *Other details/description:*
	Chicken pieces (e.g. thigh, wings)					☐ *Free Range* ☐ *Organic* ☐ *Corn Feed* ☐ General ☐ Pre-packaged: Brand:_____ ☐ From deli *Cut of chicken (e.g. thigh, drumstick, wings etc)*
	Other, please specify					

38. Did you/your child eat any eggs at home?

☐ **Yes** *If Yes, please fill in Table 19*
☐ **No** *If No, please proceed to Question 39*
☐ **Don't know**…..*If don't know, please prompt with items in Table 19*

Table 19: Did you eat any of the following types of eggs at home? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Purchased (store name & suburb)	Brand (if unknown, describe packaging e.g. colour)
Eggs	Free range					
	Barn laid					
	Caged eggs					

	Other, please specify					

39. Did you/your child eat any eggs away from home?

☐ **Yes** *If Yes, please specify how the eggs were eaten and where the food was purchased from*

_____

☐ **No**
☐ **Don't know**

LOYALTY CARD

To help us in this investigation, we can use information from loyalty cards to collect more precise information on the specific foods mentioned during the interview.

Do you have a loyalty card such as Flybuys, Woolworth Everyday Rewards, etc? ☐Y ☐N

If yes, we are seeking your consent to trace your card number with the respective supermarket to check the dates of purchases, brand information and expiry dates of the products. We would only follow up on the food items listed during this interview and would not access information about other items you may have purchased. This would be very useful for our investigation.

Do consent to share your loyalty card number so we can collect this more precise information?
☐Y ☐N

Flybuys number:

Woolworth everyday rewards number:

Other, specify _____ number:

Did you consistently use this loyalty card for purchases in the 2-3 weeks prior to your illness? ☐Y ☐N

40. Thinking about food eaten outside of the home, did you eat food from:

Food Premise Type	**Where:** (Name and location of premises)	**When:** (date and time)	**What:** (did you eat)

Cafes, restaurants, bars	☐Y ☐N ☐DK			
Bakeries	☐Y ☐N ☐DK			
Takeaways, including from service stations, fast food outlets, etc.	☐Y ☐N ☐DK			
Social gatherings, such as: festivals weddings parties religious events work conferences?	☐Y ☐N ☐DK			

EDUCATION: Preventing Salmonella and other foodborne diseases

Keep clean

Wash your hands before handling food and often during food preparation.

Wash your hands after going to the toilet, changing the baby or being in contact with animals.

Wash and clean all surfaces and equipment used for food preparation or serving.

Protect kitchen areas and food from insects, pests and other animals.

Separate raw and cooked foods

Separate raw meat, poultry, fish and seafood from other foods.

Use separate equipment and utensils such as knives and cutting boards for handling raw foods.

Store foods in covered containers to avoid contact between raw and cooked foods.

Cook thoroughly

Cook food thoroughly, especially meat, poultry, eggs, fish and seafood. For meat and poultry, make sure juices are clear, not pink.

Bring foods like soups and stews to boiling point.

Reheat cooked food thoroughly. Bring to the boil or heat until too hot to touch. Stir while re-heating.

Keep food at safe temperatures

Do not leave cooked food at room temperature for more than two hours.

Do not store food too long, even in a refrigerator.

Do not thaw frozen food at room temperature.

Food for infants and young children and other people with low immune systems should ideally be freshly prepared and not stored at all after cooking.

Use safe water and foods

Do not use food beyond its expiry date.

Wash fruits and vegetables in safe water, especially if eaten raw.

Hygiene and preventing transmission discussed	☐Y ☐N
Would you like us to send you a fact sheet with information about Salmonella?	☐Y ☐N

CONCLUSION

Thanks for your time today.

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.

The data collected is kept confidential and identifying information will not be disclosed for any other purpose without your consent.

If we have any further questions, could we contact you again?	☐Y ☐N

INTERVIEW COMPLETED BY

Name of Interviewer:

Date of interview: Length of interview:_____minutes

How well did the case recall the information requested? ☐ very well ☐ well ☐ not well ☐ not at all

GENERAL NOTES:

Raw bean sprouts linked to salmonella outbreak in South Australia

Posted Thu 21 Apr 2016, 4:09pm

South Australians are being warned not to eat raw bean sprouts after a significant increase in the number of Salmonella Saintpaul cases, SA Health says.

MAP: SA

SA Health said there had been 108 Salmonella Saintpaul cases reported over the past 11 days.

Since the start of December, SA Health said it had been notified of 233 cases of Salmonella Saintpaul.

Of the 233 cases, 43 people have been hospitalised.

SA Health said there were normally 15 to 20 cases of this particular strain of salmonella in South Australia each year.

Chief public health officer Professor Paddy Phillips said initial investigations held in conjunction with local councils and food suppliers indicated bean sprouts eaten raw may be responsible for the increased number of cases.

"We are advising South Australians to cook all bean sprouts and avoid eating raw bean sprouts," Professor Phillips said.

"We also want to alert food retailers such as restaurants and cafes not to serve raw bean sprouts until further notice."

Salmonella infection may produce symptoms of fever, diarrhoea, loss of appetite, headache, stomach cramps and nausea and vomiting.

Topics: health, diet-and-nutrition, sa, australia

SA Health says not to eat raw bean sprouts after salmonella outbreak

THE Department of Health in SA is warning people not to eat raw bean sprouts following a jump in salmonella cases.

Rebecca Sullivan and Vanessa Brown

APRIL 22, 2016 **3:46PM**

Bean sprouts are usually sold pre-washed and are used in stir fries and salads. *Source:istock*

THE Department of Health in South Australia is warning SA residents not to eat raw bean sprouts following a big jump in the number of reported salmonella cases.

Over the past 11 days there have been 108 salmonella cases reported in South Australia, which normally sees around 15 to 20 cases each year.

Since the start of December, SA Health has been notified of 233 cases of salmonella. Of these 233 cases, 43 people have been hospitalised.

“Our investigations have indicated to us that it is likely that the consumption of raw bean

sprouts is contributing to this increase,” said SA Health’s chief public health officer, Professor Paddy Phillips.

Most pho dishes come topped with bean sprouts and herbs. Picture: Stephanie Timotheou *Source:News Corp Australia*

“As a result we are today advising South Australians to cook all bean sprouts and avoid

eating raw bean sprouts.

“We also want to alert food retailers such as restaurants and cafes not to serve raw

bean sprouts until further notice. We are working closely with the producers, suppliers and handlers of the sprouts and are continuing to investigate.

“Salmonella infection may produce symptoms of fever, diarrhoea, loss of appetite,

headache, stomach cramps and nausea and vomiting,” he said.

Bean sprouts - not to be confused with snow pea sprouts - are commonly used in stir fries, salads and noodle dishes, and are served alongside popular Asian dishes like pho.

According to the Food Safety Information Council, outbreaks of food-borne illness both in Australia and overseas have been associated with eating seed sprouts.

In 2005, a Salmonella outbreak in WA of 125 cases was linked to alfalfa sprouts and a 2006 Salmonella outbreak of 15 cases in Victoria was linked to alfalfa sprouts.

Beansprouts are being blamed for an outbreak of salmonella in South Australia. Picture: iStock. *Source:istock*

To eat bean sprouts, the FSIC recommend safely adhereing to the use by date displayed on seed sprout packaging, follow storage directions and always store seed sprouts at 5ºC or below.

Consumers should avoid cross contamination from other risky foods such as meat or poultry. Washing sprouts has been found to be not very effective as laboratory studies have shown that bacteria can be internalised in the sprouts, making it difficult to wash off and sanitise, and bacteria can be protected in a biofilm on the sprout surface.

People in the four vulnerable demographics, such as young children, people over 70, immune-compromised or pregnant should not eat uncooked sprouts of any kind.

A Woolworths spokesperson said customers shouldn't be concerned about the supply available within their stores.

"Woolworths is not supplied by the producer affected. Customers can purchase this product from our supermarkets with confidence," their statement said.

News.com.au has contacted Coles for comment.

Chapter 3
Multistate outbreak of *Salmonella* Hvittingfoss infections linked to rockmelon, Australia, 2016

Public information notice in supermarket, North Sydney, August 2016

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Contents

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Abbreviations used in this chapter

ACT	Australian Capital Territory
CDC	Centers for Disease Control and Prevention
CDNA	Communicable Diseases Network of Australia
FSANZ	Food Standards Australia and New Zealand
HGQ	Hypothesis Generating Questionnaire
HPNSW	Health Protection, New South Wales
ICPMR	Institute of Chemical Pathology and Microbiological Research
MDU	Microbiological Diagnostic Unit
NSW	New South Wales
NT	Northern Territory
QLD	Queensland
SA	South Australia
USA	United States of Australia
VIC	Victoria
WA	Western Australia
WGS	Whole Genome Sequencing

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Prologue

My role

This multijurisdictional *Salmonella* outbreak occurred only a few weeks after the conclusion of the *Salmonella* Saintpaul outbreak described in Chapter 2. This presented an excellent opportunity for me as a member of the outbreak team to consolidate the knowledge I had gained previously, and take on more responsibility in coordinating the response to this outbreak.

I coordinated the initial NSW response to the outbreak. This involved maintaining the line list, coordinating with public health units (PHUs) to organise interviews, entering and analysing data from hypothesis-generating questionnaires, and preparing reports and situation reports to distribute within NSW, including to the Health Minister. Once it was identified that the outbreak involved multiple jurisdictions, NSW was appointed the lead jurisdiction for the outbreak and I took on the role of lead epidemiologist for the outbreak as a whole.

I collated data from multiple jurisdictions, describing cases by time, place and person and creating frequency tables of potential exposures. I also wrote frequent situation reports for dissemination to the OzFoodNet network. I participated in regular outbreak teleconferences, which included providing an update of the epidemiology succinctly and comprehensively for other members of the outbreak team. I also coordinated the case control study that was conducted in three states (South Australia, NSW and WA), including developing the draft study protocol (appendix 1) and questionnaire (appendix 2) and communicating with epidemiologists in other states to finalise the protocol. I completed the initial and final analysis of the case control study for the outbreak and prepared reports and presentations. I presented at the OzFoodNet debrief for the outbreak in Brisbane in March 2017. I also presented the outbreak at the 2017 Communicable Disease Control conference held in Melbourne, Australia in June 2017 (appendix 3) and presented a poster on this outbreak at the 9th Global TEPHINET Conference in Chiang Mai, Thailand in August 2017.

I was invited to present an outline of the outbreak to a meeting on rockmelon safety convened by the Food Authority for major retailers and horticulture industry representatives. This was very well received and I was subsequently invited to present at the Food Standards Australia and New Zealand (FSANZ)'s third National Food Safety Incident Response Forum in Melbourne in June 2017. This was an extremely fulfilling professional opportunity and I enjoyed the opportunity to communicate the results of the epidemiological investigation to a wider lay audience, and participate in discussions on how to make the rockmelon industry safer.

Lessons learned

Investigating this outbreak so soon after the *Salmonella* Saintpaul outbreak provided an excellent opportunity for me to build on the skills I had learned. I once again appreciated the challenges of running multi-jurisdictional outbreak investigations (MJOIs), including the difficulties in maintaining communication lines and making sure the correct people have the right information at the right time. I also gained a deeper understanding of the complexity of internal and interdisciplinary politics and collaboration. Skills I identified to manage this challenge included communicating upward often and frequently, being open with information, acknowledging the contribution and knowledge of others, and cultivating an environment of trust so that people were willing to collaborate and share information. Overall this outbreak was managed across borders effectively, due to the strong leadership and trust within the OzFoodNet network.

I additionally learned that as an epidemiologist, I was not always able or available to discuss or explain my findings (including their limitations) and that written reports often travelled more widely and to different audiences than was intended. Therefore, it is important that any analysis in written or report form can "speak for itself" – this could include outlining clearly the limitations of any analysis.

Public health implications

This outbreak identified rockmelon from a single farm as the source of the outbreak; subsequently, a voluntary trade-level recall of the affected product was initiated by the farm, stopping the outbreak. As the recall was underway, information sharing between different agencies identified that a shipment of rockmelon from the affected farm was en route to South-East Asia, and the shipment was subsequently halted. It is likely that a wider outbreak, potentially involving other countries, was subsequently avoided by the prompt public health action that was taken.

Following this outbreak, the NSW Food authority initiated an education project with rockmelon farmers in NSW about the importance of food safety measures and how to implement these in their farms. The NSW Food Authority also began a review of the legislation around food safety and horticulture with key stakeholders to identify areas where the regulations can be strengthened, a process that remains underway.

Multijurisdictional outbreak of *Salmonella* Hvittingfoss infection linked to rockmelons, Australia, 2016

Todd KM[1,10], Beazley R[2], Furlong C[1], Shadbolt C[3], Centofanti A[3], Schobben X[4], Polkinghorne B[5], Miller M[4], Gregory J[6], Easton M[6], Stafford R[7], Sintchenko V[8], Wang Q[8], Howard P[8], Williamson D[9], Sheppeard V[1], McAnulty J[1], Kirk M[10], Hope K[1]

[1]Health Protection NSW, Sydney, NSW

[2]Communicable Disease Control Branch, SA Health, Adelaide, SA

[3]NSW Food Authority, Sydney, NSW

[4]Northern Territory Environmental Health Branch, Casuarina, NT

[5]Office of Health Protection, Australian Government Department of Health, Canberra, ACT

[6]Department of Health and Human Services, Melbourne, VIC

[7]Communicable Disease Unit, QLD Health, Brisbane, QLD

[8]Institute for Clinical Microbiology and Research, Westmead, NSW

[9]Microbiological Diagnostic Unit (MDU), Melbourne, VIC

[10]Australian National University, Canberra, ACT

Abstract

In July 2016 six states and territories of Australia were affected by a large outbreak of *Salmonella* Hvittingfoss. A coordinated investigation was initiated to identify the source of infection and control the outbreak. A case was defined as isolation of *S.* Hvittingfoss with the outbreak strain on whole genome sequencing in an individual tested in Australia on or after 14 June 2016. Cases were interviewed using a hypothesis-generating questionnaire and fresh fruit and vegetable consumption frequencies for cases compared with expected community consumption patterns. We conducted a case-control study comparing consumption of melons and other fruits and vegetables by *S.* Hvittingfoss cases with *S.* Typhimurium or *Campylobacter* controls. Food traceback activities were conducted in multiple states and territories, and a selection of case and produce isolates further characterised using whole genome sequencing (WGS). During the outbreak period 144 suspected and confirmed cases of *S.* Hvittingfoss were notified Australia-wide. Almost three-quarters of cases were aged less than 5 years or over 65 years (51% and 22% respectively). Binomial comparison of case consumption patterns with background rates in the community found watermelon and rockmelon were consumed at higher frequency among cases. Univariate analysis of the case-control

study indicated consumption of rockmelon (OR 7.2, 95%CI 1.9-27.9), fresh fruit salad (OR 5.4, 95% CI 1.2-27.1), and strawberries (OR 3.3, 95% CI 1.1-10.7) were significantly associated with increased risk of *S.* Hvittingfoss infection. In multivariate analysis after adjusting for age and sex only rockmelon remained significantly associated with illness (OR 5.7, 95%CI 1.5-21.9). Traceback implicated a single rockmelon grower who initiated a voluntary trade level recall of affected product. A national media alert was issued by government authorities to warn consumers not to consume any rockmelon already purchased. WGS identified two separate strains of *S.* Hvittingfoss amongst outbreak cases. Rockmelon is a known high-risk fresh produce and it is important that the community are educated about safe preparation and handling, particularly those involved in food provision to children and the elderly.

Introduction

It is estimated that 4.1 million (90% credible interval 2.3-6.4 million) Australians suffer from an episode of foodborne gastroenteritis every year[1, 2], at a total cost of $1.25 billion per annum[3]. The bacteria *Salmonella* is a significant contributor to the burden of foodborne disease in Australia, being the second most commonly notified causative agent of diarrheal disease and the most commonly identified pathogen in foodborne outbreaks where the aetiology is identified[1]. The identification of risk factors for *Salmonella* infection provides the opportunity for prevention.

In Australia, contaminated food is estimated to be the source of approximately 72% of salmonellosis cases, with commonly identified sources including egg, poultry meat, pork, beef, dairy, nuts and fresh produce[4]. Australia has seen an increase in gastroenteritis outbreaks associated with fresh fruit and vegetables over recent years, as have other developed countries[5]. Fresh produce associated outbreaks can pose particular challenges due to their ability to be widely and quickly distributed geographically, including crossing state and international borders[5].

Salmonella enterica serovar Hvittingfoss is a relatively uncommon serotype in Australia. It is most common in the state of Queensland, where it averages approximately 78 notifications per year with most notifications occurring in the under 5 age-group (unpublished data). Foodborne outbreaks due to *S.* Hvittingfoss are very uncommon worldwide with the largest published in the literature being associated with the Subway chain of sandwich restaurants in Illinois, USA in 2010[6]. In that outbreak no specific food vehicle was identified but lettuce, tomatoes and olives were associated with increased risk of infection. Previous clusters of *S.* Hvittingfoss infection have occurred in multiple states throughout Australia in 2005, 2006 and 2010 with no clear source identified[7].

In July 2016, routine surveillance detected an increase in notifications of *S.* Hvittingfoss above expected levels in four of Australia's eight jurisdictions – New South Wales (NSW), South Australia (SA), Western Australia (WA) and the Australian Capital Territory (ACT). A coordinated outbreak investigation was launched to identify the source and control the outbreak.

Methods

Outbreak detection and hypothesis generation

We defined a confirmed outbreak case as infection with *S.* Hvittingfoss strain identified as the outbreak strain on whole genome sequencing (WGS) in an individual tested in Australia on or after 14 June 2016. A suspected case was defined as isolation of *S.* Hvittingfoss in an individual tested in Australia on or after 14 June 2016 where a WGS result was unavailable. *Salmonella* infection is a notifiable condition in all states and territories of Australia and cases were identified through routine surveillance.

Cases were interviewed using a national 7-day hypothesis-generating questionnaire to identify possible food and environmental risk factors for infection. Food exposure frequencies were compared with community consumption rates to generate hypotheses. The data on community consumption came from a cross sectional survey conducted in the state of Victoria over the preceding two months. We assumed a binomial probability distribution when comparing observed versus expected proportions of individuals consumption different foods and p <0.05 was considered significant.

Case-control study

We conducted a case-control study of cases in South Australia and NSW to test the hypothesis that *S.* Hvittingfoss infection was associated with consumption of melons, and to collect additional information on rockmelon purchasing, preparation and consumption patterns. Only confirmed outbreak cases with onset dates between 8 July 2016 and 9 August 2016 were enrolled in the case-control study. Cases were identified through routine notifications to state-based surveillance systems. Controls were recruited from notifications of either *S.* Typhimurium or *Campylobacter* in the state from which the case was notified. Controls were frequency matched by age group (<5 years, 5-14 years, 15-54 years and 55+ years) and by geographic location (rural or urban) and the control with the nearest collection date to the case was selected. Controls were required to have a specimen collection date within four weeks of the date of collection of the case. We estimated sample sizes based consumption rates of the suspect product in hypothesis-generating questionnaires and from estimated population exposure frequency rates as per in the Victorian data.

The target sample size was 25 cases and 50 controls in total using Kelsey's formula assuming 45% of cases and 15% of controls consumed the food of interest[8].

Staff from South Australia and NSW health departments interviewed the cases and controls residing within their jurisdictions. Both groups were asked about symptoms and recent travel, and exposure to a number of fresh produce items including carrots, raw tomatoes, raw cucumbers, fresh fruit from salads, kebabs or platters, consumption of fresh fruit at a child care centre (for children under 5 years old), banana, rockmelon, honeydew, strawberries and blueberries They were also asked about consumption of sultanas/raisins, desiccated coconut, chicken purchased raw and prepared at home, eggs consumed at home, food eaten outside the home, as well as knowledge of the recent recall of rockmelon and how watermelon and rockmelon was purchased, prepared, stored and consumed (e.g. cut or whole, refrigerated or not).

Responses were entered into Epi Info™ version 7.1. Data was extracted from Epi and univariate analysis conducted in Stata version 14.1 Uncorrected 2-tailed p-value was used for calculation of significance except for situations where the numerator was less than 5, in which case Fisher's Exact p-value was used. A multivariate analysis was conducted using Stata version 14.1. Included in the model were all items with an elevated odds ratio and a p-value <0.1 as well as age, sex and geographic location.

Microbiological investigation

Patients with *S.* Hvittingfoss infection were identified by reference public health laboratories in NSW, SA, WA, Victoria and QLD. *S.* Hvittingfoss isolates were identified by serotyping, according to the Kauffmann-White-Le Minor scheme[9]. 189 clinical and food isolates from QLD, Victoria, NSW, SA, WA, and ACT were forwarded to the Institute for Clinical Pathology and Medical Research (ICPMR) in NSW for WGS to determine whether they were of the outbreak-specific strain. As the number of cases increased in Victoria a number of isolates were sequenced at Microbiological Diagnostic Unit in Victoria and reads were shared between laboratories.

Human clinical isolates and food isolates with collection dates during the period March to August 2016 were sequenced. The genomic deoxyribonucleic acid (DNA) was extracted using Prepito-D (PerkinElmer). The DNA sequencing libraries were prepared using the Nextera XT DNA preparation kit (Illumina) and the sequencing was performed on the NextSeq 500 (Illumina) with 2 x 150 base-pairs (bp) paired-end chemistry. Sequencing data quality was checked by FastQC v1.0.0 (BaseSpace Labs, Illumina). Single nucleotide polymorphisms (SNP) were identified using CLC Genomics Workbench v8.0 (Qiagen) by mapping reads to the reference genome S. Hvittingfoss 16164

(sequenced by PacBio technology). The significant thresholds for SNP calling were set for a minimum coverage at 20 and a minimum variant frequency at 80%. The distance between mapped genomes was examined by phylogeny inferred using a web-based server (https://cge.cbs.dtu.dk/services/CSIPhylogeny/). Maximum likelihood trees at 100 bootstraps were generated from core genome SNP fastA file using MEGA-6[10]. A cut-off of <=10 SNP difference between individual isolates was used to define a SNP cluster.

Environmental investigation

On identification of the outbreak, food regulatory agencies in the states of NSW and SA jointly triggered the National Food Incident Response Protocol (NFIRP), which coordinates government bodies and industry to share information including product flow and industry testing results.[11] This information was obtained from major supermarket retailers and industry produce associations specifically through an established joint industry-government Food Incident Forum.

As a credible hypothesis emerged, interviewers ascertained information on the places and dates of rockmelon purchases to guide trace-back investigations. SA and NSW food authorities conducted trace-back activities from common retail premises and wholesalers, and sent product samples for testing. Food authorities in the Northern Territory conducted on farm inspections and undertook extensive liaison with the business owners, industry food safety auditors and obtained environmental samples from rockmelon farms.

Ethics

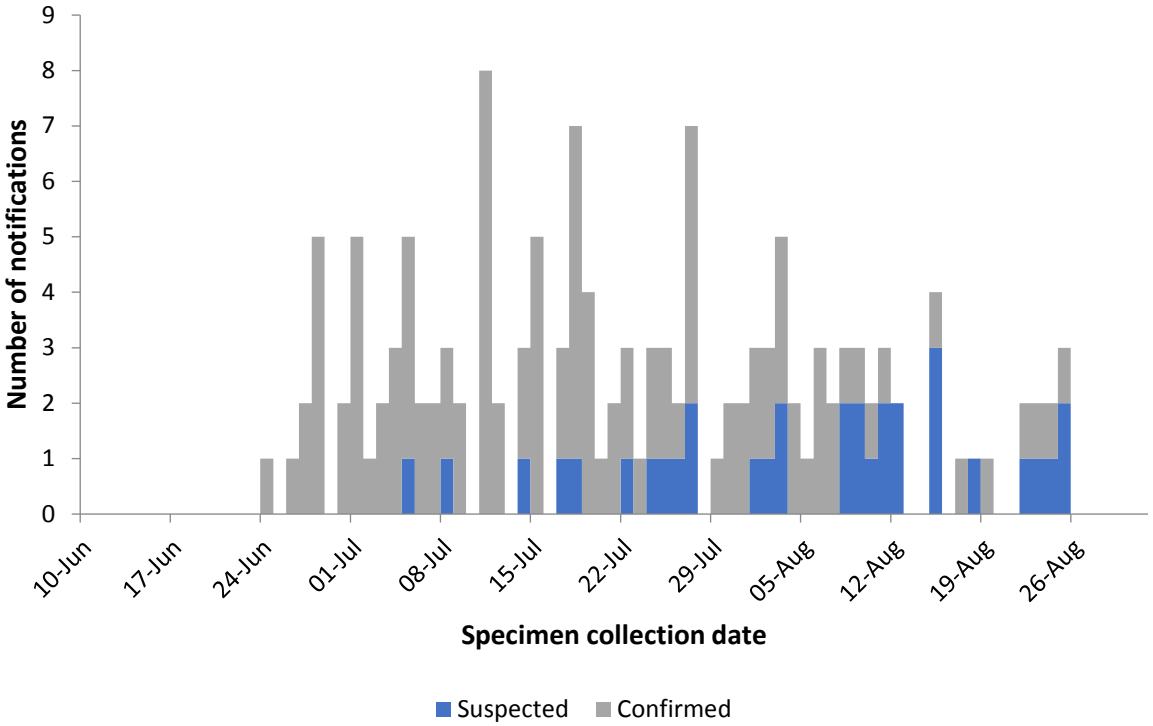
Participation in the study was voluntary and verbal consent was obtained from participants. As this was considered an investigation of acute public health importance, clearance from a Human Research Ethics Committee was not obtained. This investigation of a multi-state outbreak of infectious disease was carried out using routine State & Territory public health legislation. Each jurisdiction ensured that retention of information regarding cases and controls was maintained in accordance with relevant privacy legislation. No identifying information was entered into Epi Info for cases or controls.

Results

Case finding and demographics

There were 167 cases of infection due to *S*. Hvittingfoss notified across Australia during the outbreak period, with 110 confirmed and 33 suspected cases meeting the case definition (Figure 1). There were 24 *S.* Hvittingfoss cases that were excluded based on WGS results.

Figure 1 - Cases of outbreak associated *S.* Hvittingfoss by date of specimen collection, Australia 2016



Among the 144 confirmed and suspected cases, the median age was 4 years (range 3 months to 97 years). Cases were concentrated among the young and elderly, with 51.4% of cases (74/144) occurring in children aged less than 5 years, and 22.9% (33/144) in those aged over 65 years. 57.6 (83/144) % of cases were female.

Identificationoffoodvehicles

Food exposures commonly reported in the hypothesis-generating phase included carrots (85%), bananas (83%), apples (76%), potatoes (74%), pasteurised milk (72%), tomatoes (64%) and onions (61%). Rockmelon (also known as cantaloupe) and watermelon consumption were both reported by 55% of cases, and 85% of cases reported eating any kind of melon. I utilised the binomial probability worksheet from the Oregon foodborne outbreak Investigation toolkit, as developed by epidemiologist Dr William Keene[17] to calculate whether or not food items appeared to being consumed at frequencies higher than expected. This worksheet uses binomial probability calculations (also known as Bernoulli trials) to compare exposure frequencies against background rate estimates, essentially answering the question, "by chance alone, how likely are we to find x of n people (or more) eating a product?"[18]. On binomial comparison, foods that were consumed significantly more frequently by cases than expected included rockmelon ($p<0.01$) and watermelon ($p<0.01$).

Casecontrolstudy

We enrolled 27 cases and 48 controls in the study. Of these, 6 cases and 12 controls were from South Australia and 21 cases and 36 controls from NSW. Of the 12 controls from SA, 11 were cases of *Campylobacter* and 1 was a case of *S*. Typhimurium. Of the 36 controls from NSW, all were cases of *S*. Typhimurium. The characteristics of cases and controls are shown in Table 1.

Table 1 - Characteristics of cases and controls recruited into the Salmonella Hvittingfoss study, NSW and SA, Australia, 8 July 2016 – 9 August 2016

Characteristic	Cases		Controls		p-value
	N	%	N	%	
Age (years)					
0-4	13	48.1%	22	45.8%	0.99
5-14	3	11.1%	6	12.5%	
15-54	5	18.5%	10	20.8%	
55+	6	36.0%	10	20.8%	
Jurisdiction					
NSW	21	77.8%	36	75.0%	0.79
SA	6	22.7%	12	25.0%	
Geographic location					
Rural	2	7.4%	4	8.3%	0.88
Urban	25	92.6%	44	91.7%	
Sex					
Female	16	59.2%	30	62.5%	0.78
Male	11	40.8%	18	37.5%	
Total	**27**		**48**		

Univariate analysis

Compared with controls, cases were significantly more likely to have consumed rockmelon (OR 7.2, 95%CI 1.9-27.9), fresh fruit salad (OR 5.4, 95% CI 1.2-27.1) and strawberries (OR 3.33, 95% CI 1.1-10.7) during the 7-day exposure period (Table 2). Consumption of eggs outside the home, bananas, blueberries, raw tomatoes, cucumbers, raw carrots, watermelon, honeydew or eating outside the home were not associated with infection.

Table 2 - Association between food items/risk factors and Salmonella Hvittingfoss infection, Australia, July-August 2016

Exposure	Cases		Controls		OR	95% CI
	N	%	N	%		
Rockmelon	11/20	55.0%	7/48	14.6%	7.2	1.9 - 27.9
Watermelon	6/18	33.3%	16/45	35.6%	0.9	0.2 - 3.2
Honeydew	1/24	4.2%	1/48	2.1%	2.0	0.0 - 163.7
Strawberries	15/24	62.5%	15/45	33.3%	3.3	1.1 - 10.7
Blueberries	7/25	28.0%	7/48	14.6%	2.3	0.6 - 8.8
Bananas	17/26	65.4%	30/45	66.7%	0.9	0.3 - 3.0
Fresh fruit salad	8/24	33.3%	4/47	8.5%	5.4	1.2 - 27.1
Fresh fruit eaten at child care (aged 0-4 only)	8/13	61.5%	8/19	42.1%	2.2	0.4 - 12.0
Fresh fruit from a fruit platter	1/24	4.2%	3/46	6.5%	0.6	0.0 - 8.3
Fresh fruit kebabs	0/26	0.0%	0/48	0.0%	.	. - .

Raw tomatoes	9/24	37.5%	21/46	45.7%	0.7	0.2 - 2.2
Raw carrots	7/24	29.2%	13/45	28.9%	1.0	0.3 - 3.4
Sultanas	2/24	8.3%	11/46	23.9%	0.3	0.0 - 1.5
Raisins	0/26	0.0%	3/48	6.3%	0.0	0.0 - 2.3
Desiccated coconut	0/27	0.05	1/48	2.1%	0.0	0.0 - .
Eggs eaten at home	12/24	50.0%	31/44	70.5%	0.4	0.1 - 1.3
Chicken purchased raw and prepared at home	17/23	73.9%	31/45	68.9%	1.3	0.4 - 4.8
Food purchased from a bakery	4/25	16.0%	2/42	4.8%	3.8	0.5 - 44.4
Takeaways, including from service stations, fast food outlets etc.	9/26	34.6%	12/44	27.3%	1.4	0.4 - 4.5
Food purchased from cafés, restaurants and bars	7/25	28.0%	15/45	33.3%	0.8	0.2 - 2.5
Food eaten at social gatherings	4/25	16.0%	8/45	17.8%	0.9	0.2 - 3.8

** OR – odds ratio; CI – confidence interval*

There were no significant differences in the food preparation practices of cases consuming rockmelon when compared to controls; the majority of rockmelon was purchased already cut and unrefrigerated and stored in the fridge at home (Table 3).

Table 3 - Rockmelon preparation practices and awareness of rockmelon recall among cases and controls, Australia, July-August 2016

Rockmelon preparation and awareness of recall	Cases		Controls		*p*-value
Aware of recent rockmelon recall	23/27	85.2%	31/47	66.0%	0.07
Rockmelon storage prior to purchase (for those who purchased rockmelon)					
In fridge	1/9	11.1%	0/4	0.0%	0.89
Out of fridge	7/9	77.8%	4/4	100.0%	
Don't know	1/9	11.1%	0/4	0.0%	
Rockmelon storage at home (for those who purchased rockmelon)					
In fridge	9/9	100.0%	5/5	100.0%	.

Multivariate analysis

A logistic regression model was constructed including age, sex, rockmelon, fresh fruit salad and strawberries. After adjusting for age and sex, only rockmelon remained significantly associated with illness with an odds ratio of 5.7 (95%CI 1.5-21.9, *p*=0.01).

Genomic epidemiological investigation

In total, 189 food and human isolates from SA, NSW, QLD, Victoria, ACT and WA underwent whole genome sequencing (Table 4). The initial species inferring analysis from the raw sequences identified that all of the isolates belong to *Salmonella enterica* subsp. *enterica* serovar Hvittingfoss, except that one isolate was identified as a *S.* Typhimurium. This isolate was excluded from further SNP analysis.

A major cluster containing 126 isolates (outbreak strain 1) was identified with genetically related isolates (0-10 SNP difference between isolates). 109 of these were isolates belonging to 99 individual patients, and 17 isolates were from rockmelons. A second small cluster (outbreak strain 2) contained 13 isolates (11 isolates belonging to 10 individual patients and 2 isolates from rockmelon). An additional 50 human isolates were not clustered or occurred in very small clusters of two cases. One case from Victoria had isolation of both outbreak strains in separate specimens collected from the same individual. Cases of outbreak strain 1 were from all six affected jurisdictions (NSW, SA, ACT, QLD, Victoria and WA). Cases of outbreak strain 2 occurred in all affected jurisdictions except for the ACT and WA.

Table 4 – Results of whole genome sequencing of *Salmonella* Hvittingfoss isolates from human and rockmelon samples, Australia, July-August 2017

	Outbreak strain 1	Outbreak strain 2	Non-outbreak strains	Total
Human isolates	109 isolates from 99* individual patients	11 isolates from 10* individual patients	50 human isolates	170
Rockmelon isolates	17 isolates from rockmelon from farm A	2 isolates from rockmelon from farm A	-	19
Total	**126**	**13**	**50**	**189**

** One individual patient had isolation of both outbreak strain 1 and outbreak strain 2 on two separate specimens*

Environmental investigation

Trace-back activities implicated a single farm located in the Northern Territory of Australia. In addition, 19 rockmelon samples collected during product testing at the retail level were positive for *S.* Hvittingfoss, (17 of outbreak strain 1 and two of outbreak strain 2). All were produced by the implicated farm. Environmental testing at the farm level did not isolate *S.* Hvittingfoss but did identify a number of other *Salmonella* serovars that were also found on rockmelons obtained at retail and wholesale level. Inadequate washing and sanitising procedures were identified at inspection and a corrective order issued. This was compounded by a lack of monitoring of sanitiser levels by the company during the washing process.

Discussion

This large multi-state outbreak of S. Hvittingfoss associated with rockmelons affected all but one Australian state and territory and illustrated the potential risk of foodborne illness associated with fresh produce. Although 144 cases were identified as being part of the outbreak it is possible that

the total number of infections that occurred could have been in excess of 1000, as it is estimated that for every notified case of *Salmonella* in Australia seven more occur in the community[4].

The results of the analytical study and environmental investigation – including an epidemiological study, the convergence of traceback activities to a single farm in the Northern Territory of Australia, and isolation of both outbreak strains from rockmelons from this farm on retail produce – implicated rockmelon as the major vehicle for infection. Rockmelon contamination likely occurred on the farm; *S.* Hvittingfoss is a known environmental serovar present in northern regions of Australia (including Queensland and the Northern Territory).

This outbreak investigation highlighted the risks of fresh produce in general, and specifically rockmelons as vehicles for food-borne infection. Instances of the contamination of fresh fruits and vegetables with human pathogens and resulting foodborne illness outbreaks have been increasingly reported internationally[12]. Enteric pathogens such as *Salmonella* can contaminate raw produce at any stage of the production process[13], with potential contamination routes including via organic waste used as fertiliser, contamination of irrigation waters, direct contamination by livestock and wildlife, and hygiene errors in handling and processing[13]. Amongst fresh produce, netted melons (melons with an irregular and reticulated surface) such as rockmelon are one of the most significant vehicles of widespread foodborne illness outbreaks caused by bacterial pathogens[14] –at least 29 multistate outbreaks of foodborne infections by *Salmonella*, *E. coli* and *Listeria* associated with melons have been reported in the US and Canada since 2000, with at least 18 of these being *Salmonella* outbreaks that implicated rockmelon[14].

Rockmelon is a high-risk food for a number of reasons. Traditionally rockmelons were grown on the ground in direct contact with soil, increasing the potential for contamination with microogranisms[14], although in Australia most melons are grown on plastic matting to minimise direct ground contact and thus this risk is substantially reduced. In addition, the netted rind of rockmelon with its roughness, crevices and pits is thought to favour bacterial attachment as well as providing extra protection to microorganisms that are present and reducing the effectiveness of washing with chlorinated water and other processing practices[14]. Cutting through this thick, rough rind can cause contamination of the flesh of the rockmelon which is rich in sugars and other nutrients that promote the proliferation of bacterial contaminants. For this reason, cut melons must be refrigerated below 5°C in the United States of America, although not in Australia[14, 15]. The NSW Food Authority recommendation is that fruits should be regularly cut throughout the day using clean and sanitised equipment and sold on the day they are cut[16].

Our findings indicate that children and the elderly, including those institutions such as aged-care facilities and day care, were at higher risk of infection. The focus on healthy eating in pre-school has meant that children are increasingly consuming fresh fruit and vegetables outside the home. In this outbreak, this posed an unanticipated difficulty to the investigation in that food histories for children in day-care centres were difficult to obtain, often without details of fruits and vegetables recorded on menus. In addition, there were a number of caterers and wholesale suppliers who supplied food to aged care facilities and child care workers who were implicated in this outbreak. Childcare workers, caterers and food attendants in institutions, particularly those that serve vulnerable populations, should be aware of how to ensure that foods are purchased, prepared and served safely, particularly with high risk foods such as rockmelon.

Whole genome sequencing is an emerging technology that is increasingly being used in outbreak investigations. Due to *S.* Hvittingfoss being a rare strain in southern Australia there was a time delay at the start of the outbreak whilst a reference genome was developed by the reference laboratory, meaning that WGS results were not useful in in identifying the suspected food vehicle prior to the recall (which was conducted on the basis of the epidemiological information, environmental trace-back and samples and serotyping results), although WGS results were useful following the recall in differentiating outbreak cases from sporadic cases and confirming the link between outbreak cases and the recalled product. It is likely in future outbreaks, as the speed of WGS improves, that this information will continue to be utilised as an evidence source during outbreaks.

In addition, two unique strains of S. Hvittingfoss on WGS strains were implicated in this outbreak, leading the investigation team to initially disregard a portion of cases as being 'unrelated' to the outbreak until sequencing of product from the implicated farm, as well as isolation of both strains in a single individual, revealed that two strains were implicated. This is a potential pitfall of utilising WGS, and responders should be aware of the need to potentially modify the case definition to incorporate all available evidence as an outbreak evolves.

State/national health and food regulatory agencies, and industry associations released tailored public health messaging, aiming to simultaneously protect the public and limit loss of confidence in the rockmelon industry by identifying the source farm. Public health messaging included a public warning advising vulnerable groups to avoid consuming rockmelon, and for consumers to discard any stored rockmelon in the home given the difficulty of identifying its source. The implicated farm initiated a national voluntary trade level recall on 3 August 2016.

Limitations

This investigation had several limitations. Recall bias is a common concern in retrospective case-control studies. The case-control study occurred concurrently with a national recall that was widely publicised in the media, possibly increasing the association between rockmelon and illness in the cases' minds and overestimating the true association. However, the use of *Salmonella* Typhimurium and *Campylobacter* cases and controls may have reduced the difference in recall between cases and controls due to the similar experience of illness and contemplation of potential sources. We also asked cases and controls whether they were aware of the recent recall and there was no significant difference in awareness of the recall between groups.

Conclusion

Epidemiological, microbiological and environmental investigation of this *Salmonella* Hvittingfoss outbreak traced the source to consumption of contaminated rockmelons, a food with known potential for pathogenic contamination. WGS was a useful adjunct to the epidemiological investigation in this outbreak but as an emerging technology could contribute more with increased timeliness; public health professionals should also be mindful of the potential for multiple strains or serovars to be involved in large-scale community outbreaks. In this outbreak, the case-case study was an effective tool to rapidly identify the implicated food vehicle, allowing for prompt public health action in the form of public health advisories for vulnerable groups and a targeted recall of the affected product.

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Study protocol for Salmonella Hvittingfoss Case-Case Study

Draft Number: 3.1

Date of Draft: 12/8/16 09:30

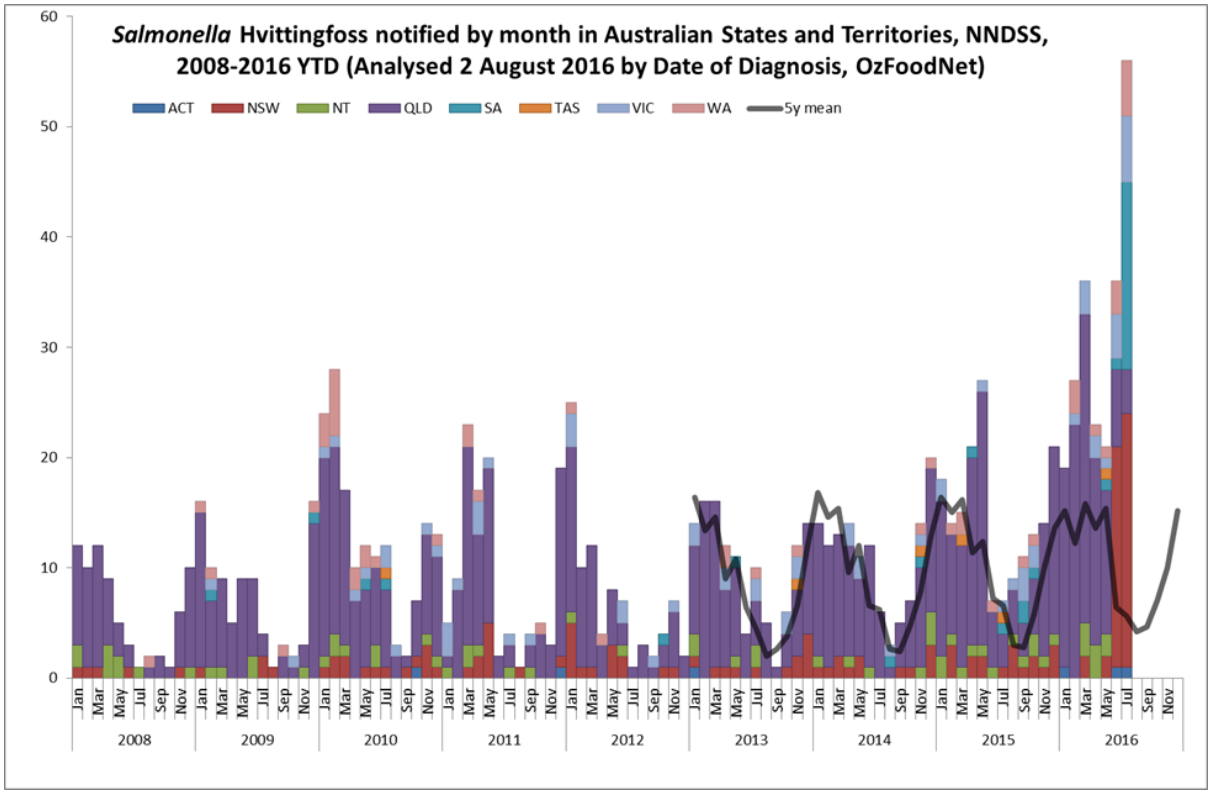
Prepared by: Katherine Todd

Background

In early July 2016, a notable increase in *Salmonella* Hvittingfoss (S. Hvittingfoss) notifications in NSW, SA and WA was detected through routine surveillance. Between June 14th and August 3rd a total of 97 suspected outbreak cases were observed, in all jurisdictions except Tasmania and the Northern Territory but most notably in NSW, SA and WA.

S. Hvittingfoss is a relatively uncommon *Salmonella* serotype in Australia. It is most common in Queensland (Figure 1), where it averages approximately 78 notifications per year with most notifications occurring in the under 5 age-group.

Figure 1: *Salmonella* Hvittingfoss notifications by month of diagnosis date and jurisdiction of residence, Australia, 1 January 2008 – 2 August 2016



NSW has seen a large increase in *S.* Hvittingfoss notifications peaking in epi week 26 of 2016, with SA peaking in epi week 27 and 28 of 2016 (Figures 2 and 3).

Figure 2: *Salmonella* Hvittingfoss notifications by week of diagnosis date and jurisdiction of residence, Australia, 1 January 2016 – 2 August 2016.

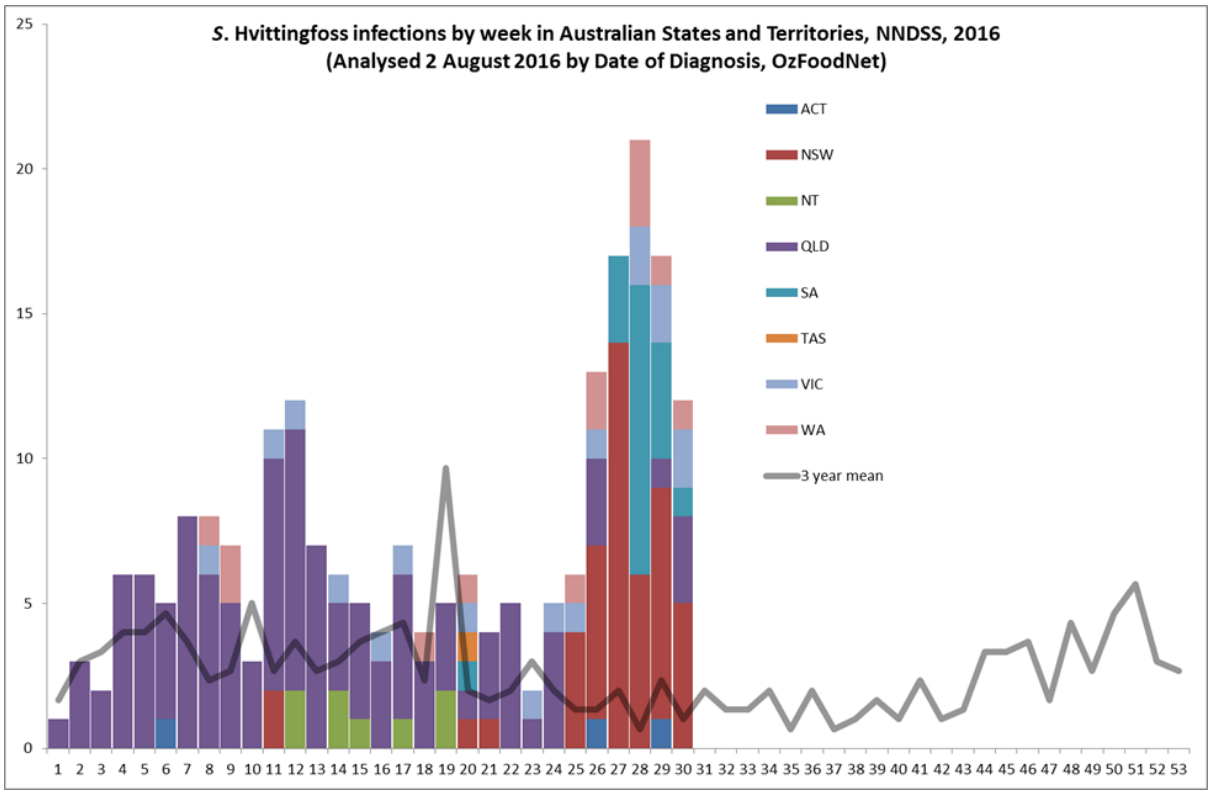


Figure 3: Number of notifications of *Salmonella* Hvittingfoss by epi week and jurisdiction, epi week 24 to epi week 29.

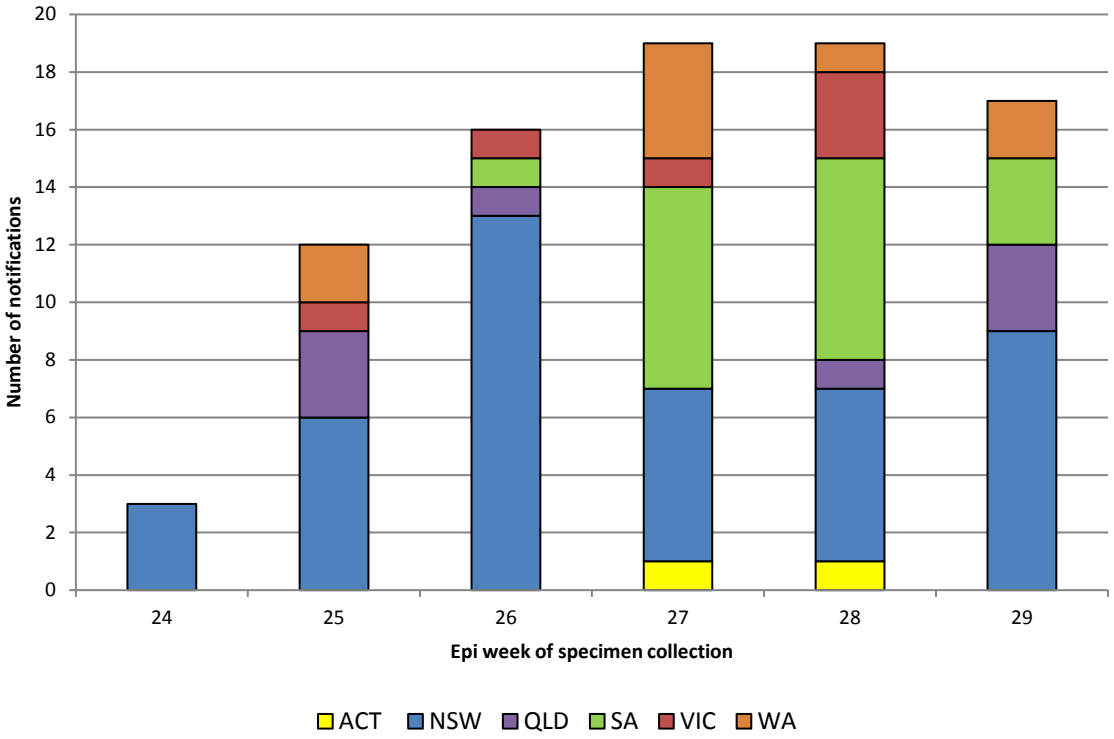
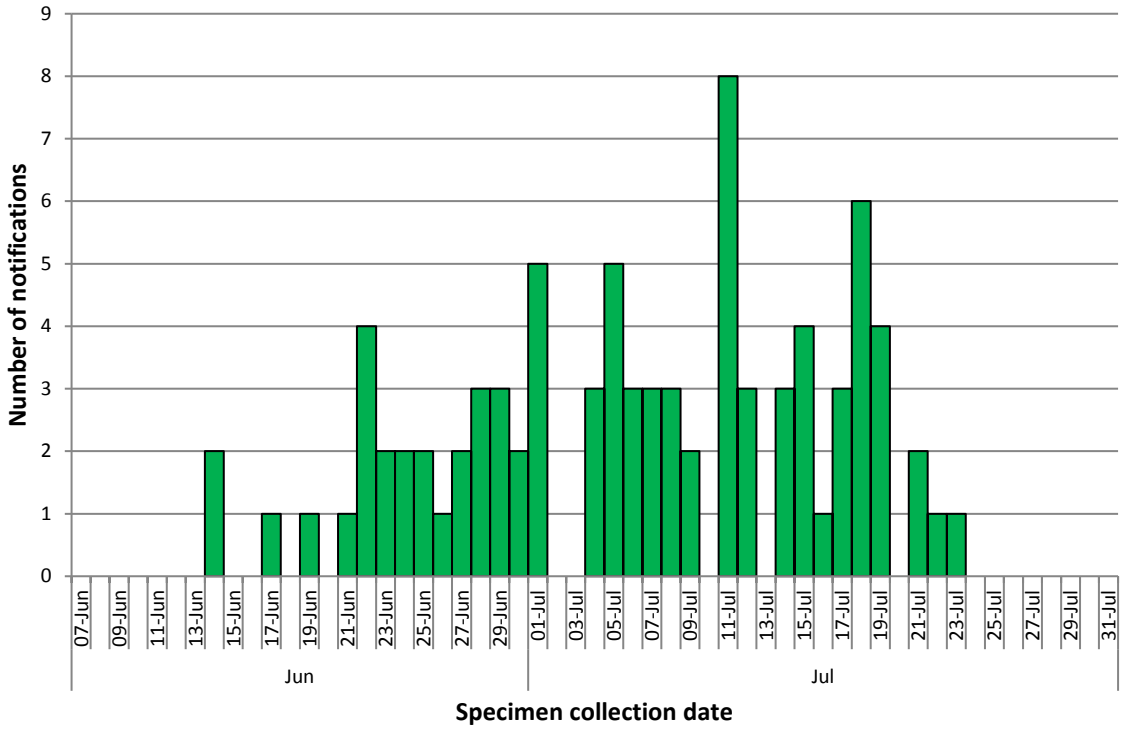


Figure 4 shows the epidemic curve of cases by collection date. The epidemic curve shows a peak in notifications collected on 11th July. Since this date cases have continued to occur in all affected jurisdictions.

Figure 4: Epidemic curve, *S.* Hvittingfoss notifications by date of onset and jurisdiction, 1 June to date.



Cases within the cluster ranged in age from infants aged under 1 to 89 years (median age 2 years) with equal numbers of male and female cases (37 female and 31 male). Cases within the cluster are strongly clustered amongst infants aged under 5, with 46 of the 68 cases (67.6%) aged from 0-4 years.

Outbreaks with this *Salmonella* serotype are very uncommon worldwide with largest being associated with the *Subway* chain of sandwich restaurants in Illinois, USA in 2010. In that outbreak no specific food vehicle was detected but lettuce, tomatoes and olives were associated with increased risk. Previous clusters have occurred in multiple states throughout Australia in 2005, 2006 and 2010 with no clear source identified.

Up to the 27th of July 2016, 42 interviews of cases of *S.* Hvittingfoss have been completed from 4 jurisdictions. This includes 21 interviews from NSW, 16 from SA, 4 from WA and 1 from ACT. Based on these interviews the commonest food and other exposures identified were carrots (86%), apples (78%), bananas (78%), any melon (rockmelon, honeydew or watermelon) (76%), pasteurised milk (72%), potatoes (72%), tomatoes (66%) yoghurt (63%) and cucumbers (63%).

Data were compared to the Hunter New England bank of food consumption data. This contains information collated from 346 hypothesis-generating questionnaires conducted with cases of *Salmonella* species, with collection dates ranging from 2006 to 2014 and from all months of the year.

Victoria provided data about fresh produce food exposures from their food frequency survey to enable a rough comparison of normal eating patterns at this time of year. This included 334 participants that were interviewed between May and June 2016, stratified by age (in 5-year age groups).

When Victorian food frequency data was compared with Hvittingfoss cases, items with a statistically significantly elevated odds ratio included (Table 2):

Table 2: Food exposures with elevated odds ratios when compared to the Victorian food frequency database, stratified by state and by age group, ranked by p-value

Food exposure	Odds ratio	95% confidence interval	p-value**
All cases			
Rockmelon	14.08	6.35-31.22	<0.001
Watermelon	6.39	3.06-13.36	<0.001
Pears	3.12	1.53-6.38	0.001
Blueberries	3.00	1.25-7.20	0.010
Strawberries	2.42	1.21-4.85	0.011
NSW only cases			
Rockmelon	8.13	2.74-24.14	<0.001
Blueberries	6.14	2.24-16.79	<0.001
Watermelon	5.68	2.04-15.83	<0.001
Pears	4.63	1.76-12.17	0.001
Honeydew	12.98	2.03-82.92	0.025
Strawberries	2.69	1.06-6.83	0.031
Cucumbers	2.81	0.98-8.06	0.046
SA only cases			
Rockmelon	26.83	8.2-87.24	<0.001
Watermelon	7.57	2.52-22.76	<0.001
Strawberries	3.88	1.24-12.15	0.013
Honeydew	18.39	2.81-120.47	0.014
Pears	3.18	1.03-9.75	0.034
All cases under 5			
Rockmelon	27.08	3.17-231.58	<0.001
Watermelon	6.96	2.10-23.05	0.001
Pears	3.98	1.30-12.21	0.014
All cases aged 5-54 years			
Rockmelon	20.63	3.21-132.46	0.004
All cases aged 55+			
Rockmelon	15.25	2.30-101.25	0.011
Apricots	15.75	1.74-142.89	0.033

**ranked by p-value*

*** for exposures where there were at least 5 cases and/or controls, uncorrected p-value was used. For those less than 5 cases and/or controls, Fisher's exact p-value was used*

Study Rationale

Cases of Salmonella Hvittingfoss continue to occur in multiple jurisdictions. Hypotheses generating interviews and information from the Victorian food frequency database indicate that melons, specifically rockmelon, watermelon or honeydew, are consumed at a higher frequency in the cases.

It is important to determine if there is an association between melons and illness in order to prevent further illness and inform future food safety measures.

Study Hypotheses

This study is designed to test the hypotheses that there is no association between S. Hvittingfoss and:

1. Rockmelon
2. Watermelon
3. Honeydew

Methods

The study design is a case-case study, with investigators recruiting two 'controls' for every case. Investigators will select 'controls' from their jurisdictions' database of *Salmonella* Typhimurium and *Campylobacter* notifications. Controls will be frequency matched with cases within broad age categories:

- 0-4 years
- 5-14 years
- 15-54 years
- 55+ years

And within broad geographic categories:

- Rural
- Urban

Cases will be frequency matched by the OzFoodNet epidemiologist.

Case Definition

A case is a person who has:

- Isolation of *Salmonella* Hvittingfoss with the outbreak strain* on whole genome sequencing (WGS) from a faecal specimen in an individual tested in South Australia, NSW or Western Australia 16th July 2016

Given the delay in WGS, suspected cases will be interviewed for the case-case study whilst awaiting typing results. If a case is subsequently excluded, a different case will be included and the controls from the initial case reallocated to new cases.

Case Eligibility

Investigators will recruit cases reported under State and Territory legislation. Cases will be **excluded** from the case-case study if:

- They cannot be reached after 6 attempts to contact them
- They are unable to recall the date that their illness began (onset date)
- They are not interviewed within 30 days of collection of a faecal specimen.
- There is a period of greater than 2 weeks between collection of a faecal specimen and onset of their illness

- Another enteric pathogen other than S. Hvittingfoss was isolated in or detected in their stool specimen.
- There has been another member of the household who has had an onset of diarrhoea in the 2 weeks prior to the onset of diarrhoea in the laboratory-confirmed case selected for the study
- They have returned from travelling overseas within the 5 days prior to onset of their illness.
- They have previously been interviewed using the *Salmonella* hypothesis-generating questionnaire
- They are unable to answer questions (e.g. dementia) or require an interpreter to complete the questionnaire
- They are part of a point source outbreak investigation

Control Selection

Investigators will select cases of either *Salmonella* Typhimurium or *Campylobacter* (herein after referred to as "controls"), from a list provided by the jurisdictional OzFoodNet (OFN) Epidemiologist. Controls will be frequency matched by age group (<5 years, 5-14 years, 15-54 years and 55+ years) and by geographic location (rural or urban) to the nearest collection date to the case.

Controls should have a specimen collection date within four weeks of the case. Controls will be interviewed regarding the 5 day exposure period prior to their illness onset.

Two controls will be interviewed per case. If interviewers are unsuccessful in speaking with a potential control after 6 attempts to contact them over 3 days, they should move onto the next potential control.

Control eligibility

A control will be **excluded** from the investigation if:

- They cannot be reached after 6 attempts to contact them
- They are unable to recall the date that their illness began (onset date)
- They are not interviewed within 30 days of collection of a faecal specimen.
- There is a period of greater than 2 weeks between collection of a faecal specimen and onset of their illness
- Another enteric pathogen other than either *Salmonella* Typhimurium or *Campylobacter* was isolated in or detected in their stool specimen.
- There has been another member of the household who has had an onset of diarrhoea in the 2 weeks prior to the onset of diarrhoea in the laboratory-confirmed case selected for the study
- They have returned from travelling overseas within the 5 days prior to onset of their illness.
- They are unable to answer questions (e.g. dementia) or require an interpreter to complete the questionnaire
- They have already been interviewed as part of an outbreak investigation
- They are part of a point source outbreak investigation

Case and control interviews

Interviewers will follow specific introductions and prompts in the questionnaire taking care not interview cases and controls differently. Both cases and controls will be interviewed about their

exposures to various foods in the five days prior to onset of their illness. To assist with case and control recall all interviewers should recommend to interviewees to have a calendar in front of them.

Interviewers should make 6 attempts to contact both cases and controls for interview. At least 3 attempts should be made between 9 am and 4 pm, and three attempts between 4 pm and 8 pm. The outcomes of case and control interviews should be recorded for quality control assessment.

Under no circumstance should interviewers give details of specific hypotheses under study, as they are only hypotheses. Similarly, if a case implicates a specific product, interviewers should remain impartial due to the difficulty of pinpointing sources of infection for individual cases. Any request for information regarding *Salmonella* infection and potential sources should be given at the end of the interview. Interviewers may offer to send out standard public health information about *Salmonella* prepared by their local health department.

As this is an outbreak investigation, results of the study may not be available publicly. If study subjects are interested in results, interviewers can inform them that results will be summarised in the Australian on-line journal Communicable Diseases Intelligence available on the Australian Government Department of Health and Ageing's website (www.health.gov.au).

If study subjects request information on the conduct of this study interviewers should indicate that it is a multi-state outbreak investigation of Salmonella that OzFoodNet is conducting with State and Territory health departments under the auspices of the Communicable Disease Network Australia (CDNA). Any complaints from study subjects about the interview or investigation should be addressed to the local CDNA member or national investigation coordinator.

Sample size

As this investigation relates to an outbreak it is difficult to reliably calculate required sample size for this case control study. Estimated sample sizes are based on information obtained from hypothesis-generating questionnaires and from the Hunter control bank exposure frequency rates. Power is calculated at a 95% two-sided confidence level with 80% power and a 2:1 case: control ratio.

Table 3: Numbers of cases and controls required to observe a statistically significant odds ratio

	Rockmelon	Watermelon	Honeydew
Estimated proportion of controls with exposure	**15%**	**30%**	**5%**
(Hunter control exposure %)	*13%*	*31%*	*5%*
(Victorian food frequency exposure %)	*6%*	*15%*	*1%*
Estimated proportion of cases with exposure	**45%**	**50%**	**13%**
(Exposure rate in HGQ to date)	*49%*	*53%*	*13.5%*
Least extreme odds ratio to be detected	**4.64**	**2.33**	**2.84**
Cases	**25**	**69**	**131**
Controls	**50**	**137**	**261**

Public health follow-up

As part of this case control study, interviewers may identify cases that work in occupations with a higher likelihood of transmitting *Salmonella* to other people, such as health care workers, child-care workers or food preparer/food handlers. If cases work in these occupations they should be referred to public health staff for follow-up, or advised not to work for a specified time after symptoms resolve.

Interviewers may also identify cases or controls that are part of an outbreak where other people are either confirmed or not confirmed as infected with *Salmonella* or *Campylobacter*. The source of outbreaks identified from interviews should be followed up with local public health staff and food enforcement agencies.

Data Entry & Analysis

OzFoodNet sites will collect data on cases and controls on paper forms. NSW Health will prepare and administer a database in Epi Info version 7. For analytical purposes, the database form on Epi Info will be the same for cases and controls and there will be a field to indicate whether the data relates to a case or control. Sites will enter these data on to Epi Info on a daily basis and package the data for export to the lead jurisdiction. Sites may extract their own data for routine analysis, or request the lead epidemiologist to provide regular extracts.

The lead jurisdiction will analyse exposure histories between cases and controls to generate odds ratios with 95% confidence intervals using an unmatched analysis.

Interim analysis will be required during the conduct of the study to examine potential associations requiring public health action. Study Leaders and Master of Applied Epidemiology scholars will conduct a final univariate and multivariate analysis once the investigation is complete, which will take into account:

1. Age and sex difference between cases and controls,
2. Variation in data by State,
3. Possible differences due to control selection methods

Ethical considerations

Participation in the study will be voluntary and verbal consent will be obtained. As this is considered an investigation of public health importance, clearance from a Human Research Ethics Committee will not be obtained. This investigation of a multi-state outbreak of infectious disease will be carried out using routine State & Territory legislation. Each jurisdiction should ensure that retention of information regarding cases and controls is maintained in accordance with relevant privacy legislation. No identifying information is to be entered onto Epi Info for cases or controls.

Study outcomes

One of the main objectives of this study is to identify food-based risk factors for infection that would allow intervention to prevent further infections. Options for public health actions will be discussed amongst members of the investigating team and CDNA. Summary results of this study will be communicated to CDNA and food safety enforcement agencies, along with industry if appropriate. Depending on the results, the investigation team will prepare a final report and a manuscript for publication.

Appendix 1: food exposures considered for inclusion in the case-control study

Food exposures considered for inclusion in case-control study

Based on frequencies among interviewed cases (frequencies of >45%):

1. Carrots
2. Apples
3. Bananas
4. Any melon
5. Milk
6. Potatoes
7. Tomatoes
8. Yoghurt
9. Cucumbers
10. Onions
11. Beef mince
12. Eggs
13. Watermelon
14. Broccoli
15. Tasty cheese
16. Strawberries
17. Rockmelon
18. Mandarins
19. Pears
20. Oranges

Based on exposures with elevated odds ratios with a p-value of <0.05 in any of the analyses (all cases, only NSW, only SA, under 5s, 5-54 years old and 55+ years old) when compared with the Victorian food frequency data:

1. Honeydew
2. Rockmelon
3. Watermelon
4. Pears
5. Blueberries
6. Strawberries
7. Cucumbers
8. Apricots

Excluded from questionnaire based on biological plausibility/mechanism

Item	Rationale for exclusion
Beef mince	Only beef product that had an elevated frequency Unlikely to cause a multijurisdictional outbreak in only some jurisdictions Eaten cooked Not commonly associated with salmonella
Potatoes	Commonly consumed product, and rate of consumption not elevated when compared to control groups Almost always peeled and cooked
Milk	Commonly consumed product, and rate of consumption not elevated when compared to control groups No predominance of brand noted in trawler interviews Unlikely to cause a multijurisdictional outbreak in only some jurisdictions
Tasty cheese	Unlikely to cause a multijurisdictional outbreak in only some jurisdictions Highly processed product
Apricots	Currently out of season with limited availability in fruit and vegetable

	shops Only significant in one age group (>55 years) and overall food frequency low (2/42, 5%)
Apples	Commonly consumed product, and rate of consumption not significantly elevated when compared to control groups Not commonly associated with salmonella
Yoghurt	Commonly consumed product, and rate of consumption not elevated when compared to control groups No predominance of brand noted in trawler interviews Unlikely to cause a multijurisdictional outbreak in only some jurisdictions
Onions	Commonly consumed product, and rate of consumption not significantly elevated when compared to control groups
Broccoli	Commonly consumed product, and rate of consumption not significantly elevated when compared to control groups
Mandarins	Commonly consumed product, and rate of consumption not significantly elevated when compared to control groups Not commonly associated with salmonella
Pears	Not commonly associated with salmonella Increased frequency of consumption not maintained in all age groups
Oranges	Commonly consumed product, and rate of consumption not significantly elevated when compared to control groups Not commonly associated with salmonella
Fish	Unlikely to cause a multijurisdictional outbreak in only some jurisdictions Eaten cooked Not commonly associated with salmonella

Appendix 2 - *Salmonella* Hvittingfoss case-control study questionnaire

Salmonella Hvittingfoss

CASE-CONTROL STUDY – version 4.3

☐ Case (*Salmonella* Hvittingfoss) ☐ Control (*Salmonella* Typhimurium)

☐ Control (*Campylobacter*)

Case Name:

Case ID: Control ID: Group ID:

Contact number:

Parents Name:

Age:

Age bracket:

☐0-4 years

☐5-14 years

☐15-54 years

☐55+ years

Geographic area:

☐Rural

☐Urban

Sex: ☐ Male ☐Female ☐ Other

State of residence: ☐NSW ☐ SA ☐ WA

Attempts to contact:

Date	*Time*	*Interviewer*	*Outcome*

1. Introduction

If the case is aged under 15 years you will need to speak to a parent or guardian.

If the case is aged 15-17 years you will need to obtain parent or guardian consent prior to interview.

"Hello, my name is Kim and I work for the NSW Department of Health.

For adults: **May I please speak with** <name of case>?

For children under 18 years:

May I please speak with the parent or guardian of <name of case>?"

When the case comes to the phone then repeat the introduction and proceed with the explanatory statement.

If the case is unavailable then arrange an alternative time for the interview.

"We are currently investigating an outbreak of gastroenteritis. As Salmonella/Campylobacter is a notifiable infectious disease, doctors and laboratories are required to notify the Health Department of all cases diagnosed in NSW. You/ your child has recently been diagnosed with Salmonella/Campylobacter infection and we would like to ask you some questions about your / your child's illness, travel history and foods consumed prior to your / your child's illness.

The questions should take about 20 minutes. Your participation is voluntary and all responses are totally confidential.

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 this outbreak of gastroenteritis and also by providing you with information to reduce the spread of illness to others.

Can you assist us in this investigation by participating?"

Is now a suitable time to ask these questions or is there a more convenient time to contact you?"

If No, arrange an alternative time to phone back to conduct the interview:

Date: __/__/____ time: __:__ a.m./p.m.

Verbal Consent given:

☐Yes ☐No

If declining interview, what is the reason for not participating?

☐No time

☐Not interested

☐Other: *Specify*

For children 15-17 years

"Do you give your consent for me to speak directly with <name of case>?"

Interviewer Note: Please note that for cases under the age of 15 years, (and those 15-17 if parent being interviewed) questions relate to the case, not the person being interviewed unless specified in the body of the questionnaire.

"Because I will be asking about specific dates around the time of your illness, it may be helpful for you to have a calendar or diary in front of you. Do you need a few minutes to get these?"

2. Clinical information

Interviewer to complete before interview:

Date of specimen collection: ___/___/_____

1. **Which of the following symptoms did you/your child have?**

Symptom	Yes	No	DK	If yes, date of onset
Fever	☐	☐	☐	
Vomiting	☐	☐	☐	
Abdominal pain	☐	☐	☐	
Headache	☐	☐	☐	
Diarrhoea	☐	☐	☐	
Tiredness/lethargy	☐	☐	☐	
Nausea	☐	☐	☐	
Muscle/body ache	☐	☐	☐	
Any other symptoms?	☐	☐	☐	
Details:				

2. **What date did you have you/your child first have symptoms?** ___/___/_____
   If unsure, prompt with date of specimen collection

If case is unable to recall onset date, END INTERVIEW with **"Since you cannot recall exactly when your illness started, we will not be able to include you in our study; however thank you very much for your time today.**

Are there any questions you would like to ask me?

Would you like some information about Salmonella/Campylobacter?

Thank you very much for your time and cooperation."

3. **How long were you/your child unwell for?** days

If case reported diarrhoea:

4. **How long did you/your child have diarrhoea for?** days

5. **Did you/your child present to an emergency department for this illness?**
   - ☐Yes
   - ☐No (*go to question 8)*
   - ☐Don't know/unsure

6. **Were you/your child hospitalised?**
   - ☐Yes
   - ☐No (*go to question 8)*
   - ☐Don't know/unsure

7. **For how many nights were you/your child hospitalised?** nights

8. **When your symptoms began, were you employed as a health care worker, child-care worker or food preparer/food handler?**

   - ☐Yes (*ensure to discuss exclusions at the end of the interview)*
   - ☐No
   - ☐Don't know/unsure

9. **In the two weeks before your/your child's illness began, did anyone in your household have diarrhoea or a stool test that was positive for *Salmonella/Campylobacter?***

   - ☐Yes *(END INTERVIEW; see below)*
   - ☐No
   - ☐Don't know/unsure

If there was someone in the case's household with diarrhoea in the 2 weeks before illness onset – END INTERVIEW with:

"Since there was someone else in your household who was unwell with diarrhoea before you, we will not be able to include you in our study. It is possible that you may have caught the

Salmonella/Campylobacter infection from them. However, we would still like to know where you ate outside the home". Go to question 35.

Interviewer note: if the case response yes to the above questions (8 & 9) you will need to ensure that this is followed up with the relevant public health action

3. Travel information

10. **In the 5 days before your illness began, did you/your child travel outside of Australia?**
    - ☐Yes *(END INTERVIEW; see below)*
    - ☐No *(go to question 13)*
    - ☐Don't know/unsure

11. **To which country or countries did you/your child travel?**

_____

_____

_____

12. **What date did you/your child return to Australia?** ___/___/_____

If the case was overseas for any of the exposure period (5 days prior to onset date) – end the interview for the case control study.

Please state: **"Since you were overseas during the exposure period, we will not be able to include you in our investigation. Thank you for your assistance today."**

13. In the 5 days before your illness began, did (you/your child) travel interstate or within the state?
    - ☐Yes *(complete questions below to confirm eligibility)*
    - ☐No *(go to next section)*
    - ☐Don't know

14. Where did you travel to?

_____

_____

_____

15. What was your date of departure? ___/___/_____

16. What was your date of return? ___/___/_____

If the case was not in SA, NSW, or WA for all the exposure period (entire 5 days prior to onset date) – END INTERVIEW for case control study:

Please state: **"Since you were interstate during the exposure period, we will not be able to include you in our investigation however thank you very much for your time today.**

Are there any questions you would like to ask me?

Would you like some information about Salmonella/Campylobacter?

Thank you very much for your time and cooperation."

4. Food exposures

Interviewer Note:

Refer to your calendar to determine the interval from the DATE 5 DAYS BEFORE ILLNESS ONSET to the DAY OF ILLNESS ONSET. Please note that this exposure period means that the person should include the five whole days prior to onset of illness and the part of the day when their illness began. PLEASE ENSURE THAT YOU CLARIFY THE DATES WITH THE PERSON BEING INTERVIEWED AND RECORD THE DATES OF INTEREST HERE.

EXPOSURE PERIOD IS BETWEEN ___/___/_____(illness onset date minus 5 days) and

___/___/_____ (illness onset date)

"For the rest of the questions, I would like to ask you about foods that you/your child may have consumed in the 5 days before [your / your child's] illness began, and the day that your/your child/s illness began. We are interested in food that you ate inside the home and outside of the home"

17. Did you/your child eat any raw carrots?

☐Yes *(if yes, please fill in table 1)*

☐No (*go to question 18)*

☐Don't know *(if don't know, prompt with the items in Table 1)*

Table 1: did you eat any of the following types of carrots? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Place of purchase or consumption
Carrots	Bagged	☐	☐	☐	
	Loose	☐	☐	☐	
	Other	☐	☐	☐	

18. Did you/your child eat any raw tomatoes?

☐Yes *(if yes, please fill in table 2)*

☐No (*go to question 19)*

☐Don't know *(if don't know, prompt with the items in Table 2)*

Table 2: did you eat any of the following types of tomato? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Place of purchase or consumption
Tomatoes	Truss (vine attached)	☐	☐	☐	
	Roma	☐	☐	☐	
	Cherry	☐	☐	☐	
	Grape	☐	☐	☐	
	General	☐	☐	☐	
	Other, please specify	☐	☐	☐	

19. Did you/your child eat any raw cucumbers?

☐Yes *(if yes, please fill in table 3)*

☐No (*go to question 20)*

☐Don't know *(if don't know, prompt with the items in Table 3)*

Table 3: did you eat any of the following types of cucumber? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Place of purchase or consumption
Cucumbers	Lebanese	☐	☐	☐	
	Continental/telegraph	☐	☐	☐	
	Other, please describe	☐	☐	☐	

20. Did you/your child eat any fresh fruit salad?

Food item	Yes	No	Don't know	Contents of fruit salad if recalled:	Place of purchase or consumption
Fresh fruit salad	☐	☐	☐		

21. Did you/your child eat any fresh fruit kebabs?

Food item	Yes	No	Don't know	Ingredients of fruit kebabs if recalled:	Place of purchase and/or brand
Fruit kebabs	☐	☐	☐		

22. Did you/your child eat any fruit from a fruit platter?

Food item	Yes	No	Don't know	Contents of fruit platter if recalled:	Place of purchase and/or brand
Fruit platter	☐	☐	☐		

For cases aged under 5 only:

23. Did your child eat fresh fruit whilst at a child-care centre?

Food item	Yes	No	Don't know	If yes, What days did your child attend childcare in the 5 days prior to illness	Name/address of childcare centre
Fresh fruit from child care centre	☐	☐	☐	☐Mon☐Tues☐Wed☐Thurs☐Fri	

24. Did you/your child eat any bananas?

☐Yes *(if yes, please fill in table 4)*
☐No (*go to question 25)*
☐Don't know *(if don't know, prompt with the items in table 4)*

Table 4: did you eat any of the following types of banana? *(Please ask about each option and fill out purchasing and brand details).*

Food item		Yes	No	Don't know	Place of purchase or consumption
Bananas	Regular/Cavendish	☐	☐	☐	
	Lady fingers	☐	☐	☐	
	Red-tipped eco	☐	☐	☐	
	Other (please provide details)	☐	☐	☐	

25. Did you/your child eat any rockmelon (also known as cantaloupe)?

Food item	Yes	No	Don't know	If yes, was it purchased:	Place of purchase or consumption
Rockmelon 	☐	☐	☐	☐Whole ☐Cut/ Sliced ☐In pieces ☐Don't know ☐Other	

26. Did you/your child eat any watermelon?

Food item	Yes	No	Don't know	If yes, was it purchased:	Place of purchase or consumption
Watermelon 	☐	☐	☐	☐Whole ☐Cut/ Sliced ☐In pieces ☐Don't know ☐Other	☐Seeded ☐Seedless

27. Did you/your child eat any honeydew?

Food item	Yes	No	Don't know	If yes, was it purchased:	Place of purchase or consumption
Honeydew 	☐	☐	☐	☐Whole ☐Cut/ Sliced ☐In pieces ☐Don't know ☐Other	

28. Did you/your child eat any fresh strawberries?

Food item	Yes	No	Don't know	Place of purchase or consumption
Strawberries	☐	☐	☐	

29. Did you/your child eat any fresh blueberries?

Food item	Yes	No	Don't know	Place of purchase or consumption
Blueberries	☐	☐	☐	

30. Did you/your child eat any sultanas?

Food item	Yes	No	Don't know	Place of purchase and/or brand
Sultanas	☐	☐	☐	

31. Did you/your child eat any raisins?

Food item	Yes	No	Don't know	Place of purchase and/or brand
Raisins	☐	☐	☐	

32. Did you/your child eat any desiccated coconut?

Food item	Yes	No	Don't know	Place of purchase and/or brand
Desiccated coconut	☐	☐	☐	

33. Did you/your child eat any chicken purchased raw and prepared at home?

Food item	Yes	No	Don't know	Date of purchase	Place of purchase and/or brand
Chicken purchased raw and prepared at home	☐	☐	☐	Date ☐ D/K	☐Prepacked Brand: ☐Deli Place of purchase: Cut/s:

34. Did you/your child eat any eggs at home?

Food item	Yes	No	Don't know	Date of purchase	Place of purchase and/or brand
Eggs eaten at home	☐	☐	☐	Date ☐ D/K	Place of purchase: Brand:

35. Thinking about food eaten outside of the home, did you eat food from?

Food premise type		Where? (Name and location of premises)	When? (date and time)	What? (What did you eat?)	Were any other diners unwell?
Cafés, restaurants and bars	☐Y ☐N ☐DK				☐Y ☐N ☐DK
Bakeries	☐Y ☐N ☐DK				☐Y ☐N ☐DK
Takeaways, including from service stations, fast food outlets etc.	☐Y ☐N ☐DK				☐Y ☐N ☐DK
Social gatherings, such as festivals, weddings, parties, religious events, work conferences	☐Y ☐N ☐DK				☐Y ☐N ☐DK

36. Are you aware of the recent recall of rockmelon?

☐Yes (*go to question 37)*

☐No (*go to question 38)*

☐Don't know/unsure

37. Where did you first learn about the recall of rockmelon?

Newspaper	☐Yes	☐No	☐Don't know/unsure
Website	☐Yes	☐No	☐Don't know/unsure
Facebook	☐Yes	☐No	☐Don't know/unsure
Twitter	☐Yes	☐No	☐Don't know/unsure
Television	☐Yes	☐No	☐Don't know/unsure
Radio	☐Yes	☐No	☐Don't know/unsure
Company web	☐Yes	☐No	☐Don't know/unsure
Friends	☐Yes	☐No	☐Don't know/unsure
Other	☐Yes	☐No	☐Don't know/unsure

If the interviewee answered yes to question 25, 26 or 27 (rockmelon, honeydew or watermelon consumption), complete questions 38 to 45. Otherwise, skip to EDUCATION section on page 13

*For those who answered yes to **watermelon** in question 26, go to next question; otherwise skip to question 39:*

38. Did you eat watermelon with the skin on?

☐Yes

☐No

☐Don't know/unsure

*For those who answered yes to **rockmelon** in question 25, go to next question; otherwise skip to EDUCATION section:*

39. Did you eat the rockmelon with the skin on?

☐Yes

☐No

☐Don't know/unsure

40. When you purchased the rockmelon you ate before you became unwell, how was it stored?

☐Refrigerated

☐Out of the fridge

☐Don’t know/not sure

41. For the rockmelon that you ate before you became unwell, how was it stored at home prior to eating?

☐Refrigerated

☐Out of the fridge

☐Don’t know/not sure

42. After cutting the rockmelon, how long was it out of the fridge prior to either be consumed or being refrigerated? (minutes/hours)

☐☐ (☐minutes/☐hours)

43. Did you wash your hands after cutting the rockmelon?

☐Yes

☐No

☐Don’t know/unsure

44. Did you wash the cutting utensils (cutting board, knife) you used to cut the rockmelon prior to using them on other items?

☐Yes

☐No

☐Don’t know/unsure

45. How long did your store the rockmelon prior to eating? (Hours/days)

☐☐ (☐Hours/☐days)

EDUCATION: Preventing Salmonella and other foodborne diseases

Keep clean

Wash your hands before handling food and often during food preparation.

Wash your hands after going to the toilet, changing the baby or being in contact with animals.

Wash and clean all surfaces and equipment used for food preparation or serving.

Protect kitchen areas and food from insects, pests and other animals.

Separate raw and cooked foods

Separate raw meat, poultry, fish and seafood from other foods.

Use separate equipment and utensils such as knives and cutting boards for handling raw foods.

Store foods in covered containers to avoid contact between raw and cooked foods.

Cook thoroughly

Cook food thoroughly, especially meat, poultry, eggs, fish and seafood. For meat and poultry, make sure juices are clear, not pink.

Bring foods like soups and stews to boiling point.

Reheat cooked food thoroughly. Bring to the boil or heat until too hot to touch. Stir while re-heating.

Keep food at safe temperatures

Do not leave cooked food at room temperature for more than two hours.

Do not store food too long, even in a refrigerator.

Do not thaw frozen food at room temperature.

Food for infants and young children and other people with low immune systems should ideally be freshly prepared and not stored at all after cooking.

Use safe water and foods

Do not use food beyond its expiry date.

Wash fruits and vegetables in safe water, especially if eaten raw.

Hygiene and preventing transmission discussed	☐Y ☐N
Would you like us to send you a fact sheet with information about Salmonella?	☐Y ☐N

CONCLUSION

"Thanks for your time today.

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.

The data collected is kept confidential and identifying information will not be disclosed for any other purpose without your consent.

If we have any further questions, could we contact you again?"	☐Y ☐N

INTERVIEW COMPLETED BY
Name of Interviewer:
Date of interview: ___/___/_____ Length of interview: minutes
How well did the case recall the information requested? ☐ very well ☐ well ☐ not well ☐ not at all
GENERAL NOTES:

Appendix 3 - Presentation at the Communicable Disease Control conference, Melbourne, Australia, June 2017

A large outbreak of *Salmonella* Hvittingfoss associated with rockmelons

Dr Katherine Todd
Health Protection, NSW
Australian National University (ANU)

Rebecca Beazley, Catriona Furlong, Bernadette Kenny, Craig Shadbolt, Alessia Centofanti, Xavier Schobben, Ben Polkinghorne, Joy Gregory, Marion Easton, Russell Stafford, Ann Koehler, Jeremy McAnulty, Vitali Sintchenko, Peter Howard, Qinning Wang, Deborah Williamson and Kirsty Hope

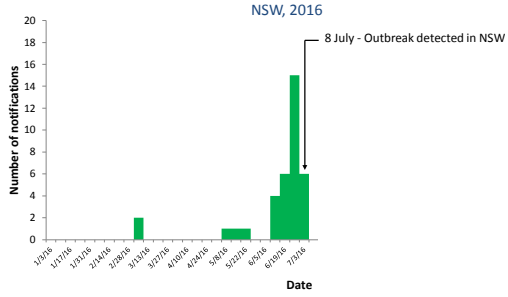
Background

- Salmonellosis is a common cause of infectious gastroenteritis
- *Salmonella* serotyping is essential for public health surveillance and action
- Whole genome sequencing (WGS) is increasingly being used to subtype *Salmonella*

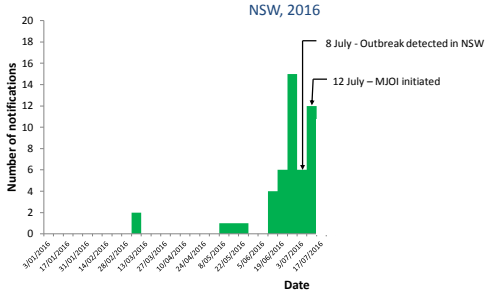
Identification of the outbreak

- Friday 8 July
  - 5 *Salmonella* Hvittingfoss notifications in 28 days
- Tuesday 12 July
  - 16 notifications in 28 days

Number of *Salmonella* Hvittingfoss notifications by specimen collection date NSW, 2016



Number of *Salmonella* Hvittingfoss notifications by specimen collection date NSW, 2016



Methods

- Epidemiological investigation
  - Hypothesis generation and descriptive epidemiology
  - Case-control study
- Microbiological investigation
  - WGS of historical and current isolates
  - Required construction of a reference genome
- Environmental investigation
  - Traceback of product from retail premises
  - Sampling of products, premises and environment

Hypothesis generation - methods

- Confirmed outbreak case:
  - *Isolation of Salmonella Hvittingfoss with the outbreak strain on whole genome sequencing (WGS) in an individual tested in Australia on or after 14 June 2016*
- Interviewed confirmed and suspected cases
- Compared consumption patterns for fresh produce items to Victorian data for community controls

Case-control study - methods

- 28 cases and 48 controls from NSW and SA
- Controls selected from cases of *Salmonella* Typhimurium and *Campylobacter*
- Frequency matched by age and geographic area

Hypothesis generation - results

Exposure	Proportion of cases exposed	Background rate (estimated)	P-value
carrots	25/30 (83%)	80%	0.43
apples	23/30 (77%)	70%	0.28
bananas	22/29 (76%)	75%	0.56
cucumbers	17/29 (59%)	50%	0.23
watermelon	14/27 (52%)	15%	<0.01
rockmelon	13/28 (46%)	10%	<0.01
strawberries	13/29 (45%)	30%	0.07

Univariate analysis

	Case exposures	Control exposures	Odds ratio
Rockmelon	11/20 (55.0%)	7/48 (14.6%)	7.16 (1.87-27.93)
Fresh fruit salad	8/25 (32.0%)	4/47 (8.5%)	5.06 (1.14-25.45)
Strawberries	16/25 (64.0%)	15/45 (33.3%)	3.56 (1.14-11.33)
Honeydew	1/24 (4.2%)	1/48 (2.1%)	2.04 (0.02-163.75)
Watermelon	6/18 (33.3%)	16/45 (35.6%)	0.91 (0.23-3.25)

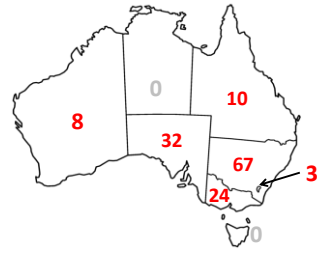
Multivariate analysis

```
Logistic regression                             Number of obs     =         57
                                                LR chi2(6)        =      17.22
                                                Prob > chi2       =     0.0085
Log likelihood = -24.241152                     Pseudo R2         =     0.2621
```

casecontrol	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
rockmelon	9.425444	7.538836	2.80	0.005	1.965521	45.19869
freshfruitsalad	1.997958	1.909418	0.72	0.469	.3069769	13.0037
strawberries	3.122617	2.414639	1.47	0.141	.6859723	14.21448
blueberries	.6745908	.672492	-0.39	0.693	.0956064	4.759855
watermelon	.9111443	.6948658	-0.12	0.903	.2043786	4.06199
honeydew	.590351	.9642276	-0.32	0.747	.0240343	14.50068
_cons	.0876022	.0613069	-3.48	0.001	.0222237	.3453136

Whole genome sequencing

- 168 probable cases identified
- 24 excluded
- 34 cases not sequenced
- 110 cases confirmed on WGS
  - 99 cases of outbreak strain 1 (OC1)
  - 10 cases of outbreak strain 2 (OC2)
  - 1 case with isolation of both strains on separate samples (OC1 & OC2)



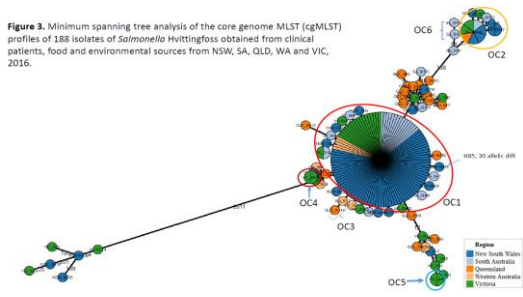
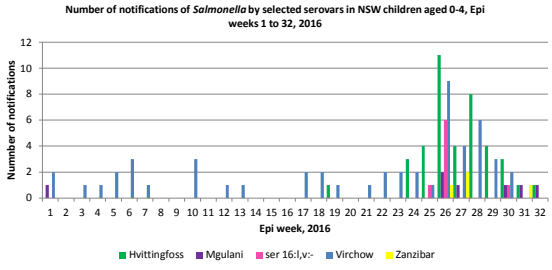
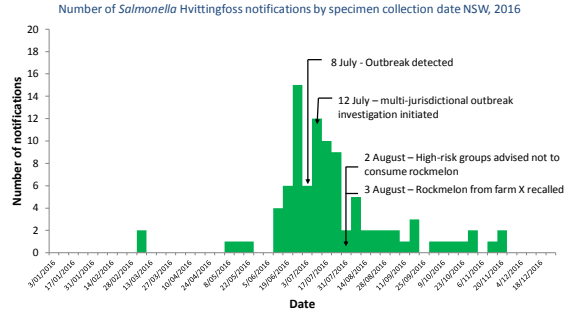


Figure 3. Minimum spanning tree analysis of the core genome MLST (cgMLST) profiles of 188 isolates of *Salmonella* Hvittingfoss obtained from clinical patients, food and environmental sources from NSW, SA, QLD, WA and VIC, 2016.

Other serovars?





Discussion

- WGS is a new and rapidly evolving technology
- Advantages of WGS
  - Can differentiate between linked and non-linked cases
  - Allows exclusion of non-outbreak cases
- Disadvantages of WGS
  - Cost
  - Timeliness
  - Utility in outbreaks of uncommon serovars
- Epidemiological links and evidence can exist independently of the WGS result and provide valuable information

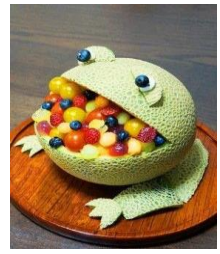
Summary

- This outbreak involved an unusual type of *Salmonella* and disproportionately affected children under 5 and the elderly
- The epidemiological, environmental and microbiological investigation implicated rockmelon
- WGS identified two different strains of *Salmonella* Hvittingfoss implicated in the outbreak

Acknowledgements

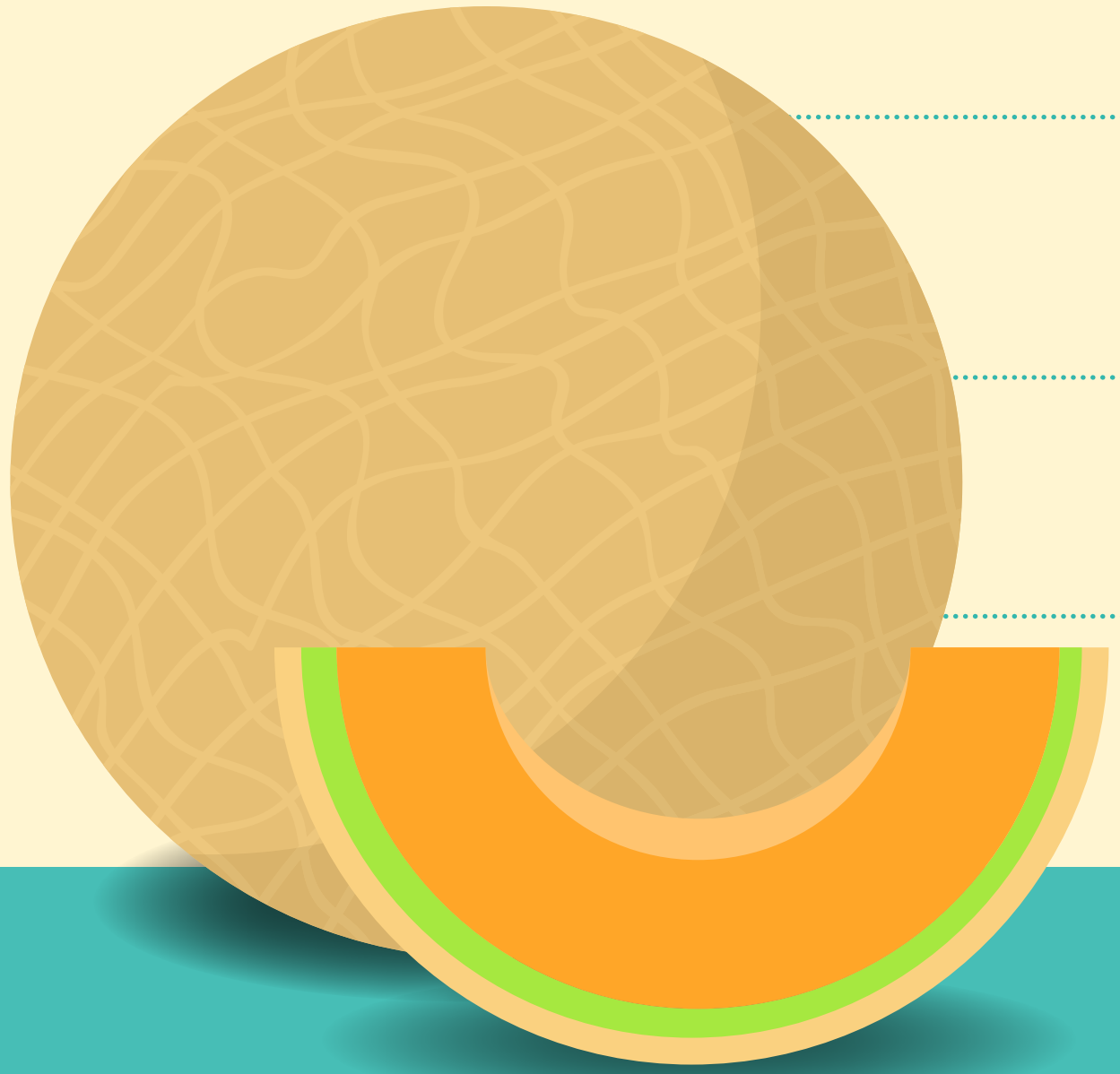
- Rebecca Beazley, Catriona Furlong, Bernadette Kenny, Craig Shadbolt, Alessia Centofanti, Xavier Schobben, Ben Polkinghorne, Joy Gregory, Marion Easton, Russell Stafford, Ann Koehler, Jeremy McAnulty, Vitali Sintchenko, Peter Howard, Qinning Wang, Deborah Williamson, and Kirsty Hope
- Martyn Kirk, Megge Miller, Vicky Sheppeard, Kim Lilly, Julie Collins, James Flint, Nevada Pingault, Barry Combs, Brett Archer
- NSW Health and NCEPH, Australian National University

Questions?



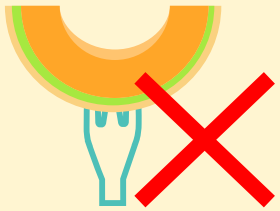
Current advice on ROCKMELONS

SA Health is advising South Australians **not to consume rockmelon** after a national outbreak of **Salmonella.**



IF YOU HAVE ROCKMELON IN YOUR HOME, DISCARD IT

AVOID CONSUMING ROCKMELON UNTIL FURTHER NOTICE



WASHING THE ROCKMELON WILL NOT REMOVE SALMONELLA

For more information visit
www.sahealth.sa.gov.au

Government of South Australia
SA Health

Part II:
Environmental Health

Blood Lead Surveillance in New South Wales

Lead makes the mind give way

Dioscorides – 2nd century BC

Minime fistulis plumbeis aqua duci videtur, si voumus eam habere salubrem
(Water should on no account be conducted in leaden pipes if we are desirous that it should be wholesome)

Vitruvius, "De architectura" – 15 BC

I found myself near to certain 'Lead-Mills' and resolved to have a look at them… it was explained that the precaution of frequently changing the women employed in the worst parts of the work (a precaution originating in their own experience or apprehension of its ill effects) was found salutary. The philosophy of the matter of lead-poisoning and workpeople seems to me to have been pretty fairly summed up by the Irishwoman whom I quoted in my former paper: "Some of them gets lead-poisoned soon, and some of them gets lead-poisoned later, and some, but not many, never".

Charles Dickens, "The Uncommercial Traveller" – 1861

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Chapter 4
The epidemiology of elevated blood lead levels in NSW, 1997–2016

Photo of Central mine, Broken Hill taken in the early 1900s: Copyright: State Records NSW[1]

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Contents

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Abbreviations used in this chapter

ABS	Australia Bureau of Statistics
AFPHM	Australasian Faculty of Public Health Medicine
BLL	Blood Lead Level
CDB	Communicable Diseases Branch
CDC	Centers for Disease Control and Prevention
EHB	Environmental Health Branch
ERP	Estimated Resident Population
HPNSW	Health Protection NSW
LGA	Local Government Area
LHD	Local Health District
NCIMS	Notifiable Conditions Information Management System
NDD	Notifiable Diseases Database
NHMRC	National Health and Medical Research Council
NSW	New South Wales
PHU	Public Health Unit
SA	Statistical Area
SAPHaRI	Secure Analytics for Population Health Research and Intelligence
SAS	Statistical Analysis System
WHO	World Health Organisation

In accordance with NSW Health policy, the term 'Aboriginal' is used throughout this document to include Aboriginal and Torres Strait Islander peoples. No disrespect is intended towards the Torres Strait Islander community.

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Prologue

My role

Elevated blood lead levels (also known as “lead poisoning”) have been notifiable in NSW since December 1996. In this time there has not been a consistent practice of reviewing the epidemiology of notifications of elevated blood lead levels at the state level. I completed a review of the epidemiology of notifications in NSW to provide a snapshot of elevated blood lead levels in NSW and to inform my evaluation of the NSW elevated blood lead surveillance system, discussed in further detail in Chapter 5.

I conceived the project with the assistance of my field supervisors Jeremy McAnulty and Ben Scalley. I wrote the project plan and identified key datasets. I accessed NSW notification data via the Notifiable Condition Information Management System (NCIMS) and SAPHARI, the NSW Health data analytics warehouse, to analyse data on elevated blood lead levels. I performed the data analysis using Microsoft Excel, SAS version 6.1 and STATA version 14.1. To disseminate the results, I wrote up the results as a report and managed contributions from co-authors. Ben Scalley, Jeremy McAnulty and Martyn Kirk supervised the process through conception, execution and analysis, as well as assisting significantly with the write-up and preparation of the final chapter, conference presentations and journal articles; an editing process which required many iterations.

Lessons learned

I learned several skills throughout the course of this project. These included data manipulation skills in Stata 14.1 such as identifying duplicates, merging datasets, reshaping data, management of string data (including forced `destring` and cutting strings), using do files, cleaning and collapsing population data, calculating rates and constructing graphs.

I also gained a greater understanding of the challenges of data management including the difficulties with completeness and the challenges of managing large datasets with wide variation in data entry methods. With regards to surveillance data, I learned the importance of a database being designed with analysis in mind as well as process documentation – particularly if this is one of the goals of the surveillance system.

As well as practical skills in data analysis I learned a significant amount about managing the process – this included accurately documenting the methods used including writing methodology as-you-go, the importance of file and version management, and the value of a data analysis plan.

Public health implications

Through completing this project, I identified that changes to the case definition have increased both the number and rate of notifications of elevated blood lead levels in NSW, and that notifications are distributed disproportionately between different geographical areas. This has implications for policy, particularly in a context where the notification level has been consistently revised downwards, as well as in resourcing public health units. In addition, completing the project allowed me to recommend changes to how data is collected, stored and retrieved in NCIMS to allow for ongoing and more frequent analysis of the epidemiology of elevated blood lead levels in NSW.

An early draft of this report was submitted to the Australasian Faculty of Public Health Medicine (AFPHM) as a workplace report to meet assessment requirements for fellowship of the faculty. Versions of this report were also presented as oral presentations at the 9th Global TEPHINET conference in Chiang Mai, Thailand in August 2017 (Appendix 4); and at the International Society for Environmental Epidemiology (ISEE) Conference in Sydney, Australia in September 2017 (Appendix 5). A journal article is also being prepared for submission to *Public Health Research and Practice*.

Abstract

Background/Aim:

Elevated blood lead levels (formerly classified as “lead poisoning”) have been notifiable in New South Wales (NSW), Australia since December 1996. In that time the notifiable blood lead level has been reduced twice, from 15µg/dL to 10µg/dL in 2012 and to 5µg/dL in 2016. We reviewed the epidemiology of notifications from January 1997 to December 2016 and evaluated the impact of these changes to the case definition on notification rates in NSW, and assessed the characteristics and quality of surveillance data.

Methods:

We analysed notification data for 1997-2016 by age, sex, geographic area, exposure and occupation. We calculated notification rates and compared these over time and between geographic regions. We also described the characteristics of the surveillance dataset and made recommendations for improvement. We used Stata version 14.1 for all analyses.

Results:

There were 9,486 notifications from 1997–2016, with an average annual notification rate of 6.9 per 100,000. In 2016 the notification rate of 13.0 per 100,000 was double the average rate for the preceding five years. When only notifications of blood lead levels above 15µg/dL were considered, the notification rate for 2016 was 1.8 per 100,000, the lowest rate during the 20-year study period. Notification rates in rural regions where lead mining has occurred, and where there is systematic screening, were significantly higher than in other regions. Key limitations of the data included the lack of a single comprehensive data source, high rates of missing data, and the presence of free-text responses in the dataset. These limitations made it difficult to analyse notification rates, particularly by risk and exposure history.

Conclusions:

Changes to the case definition increased notification rates of elevated blood lead. However, when considering only notifications above 15µg/dL, rates are at their lowest since state-wide surveillance began. It is important to improve data completeness in the blood lead surveillance system to enhance understanding of the epidemiology of elevated blood lead levels in NSW and factors which lead to increased risk, particularly as area demographics and risk profiles may change over time.

Background

Lead was one of the first metals smelted and used by humans, due to its low melting point and high malleability, and today is the most widely used non-ferrous metal[2]. It has a variety of uses including waterproofing, electrical and radiation shielding, and the production of ammunitions, paints, plastics, ceramics, glass, and explosives[2]. The legacy of industrial lead use has been persistence of lead in the environment due to these human activities (mining, smelting, refining and recycling lead products) as well as due to the use of lead in paint, petrol and water systems.

Lead acts as a cumulative toxicant, with effects on multiple body systems. Lead exposure in adults can cause anaemia, renal damage and hypertension, and at levels above 80µg/dL, cause encephalopathy and death. Chronic low-level exposure (such as occupationally) has been shown to be associated with subtle cognitive deterioration and brain matter loss[3]. Children are much more vulnerable to lead poisoning than adults, partly because they absorb four times more lead than adults and also because they are more likely to be exposed to lead from crawling on floors and hand-to-mouth activity[4]. Effects in children occur at lower levels than adults, and population-level studies have shown that even among asymptomatic children exposure to lead can have significant effects on the developing brain including a reduction in IQ and behavioural disturbances[3].

The toxicity of lead has been recognised since antiquity[5] and Australia has played a significant role in recognising the toxicity of lead in children – the first international clinical reports of lead poisoning among children (described then as "plumbism") were made in Brisbane, Australia in 1890s, with the source ultimately identified as paint on rails in the children's homes[5-7]. In 1922 Queensland was one of the first jurisdictions in the world to pass legislation regulating the use of lead paint in households, nearly 57 years before similar legislation was introduced in the United States[5, 7].

Infants, young children and pregnant women are most susceptible to the toxic effects of lead. Children are particularly at-risk due to their higher absorption of lead from the gastrointestinal and respiratory tract, and their smaller proportional size. The most significant impact in children is due to the neurotoxicity of lead, which can cause serious and potentially irreversible neurological damage[2]. Preventing and reducing exposure to environmental lead is the single most effective intervention against lead poisoning[8, 9].

In Australia, blood lead levels have declined significantly since lead was removed from petrol, significantly reduced in household paint, and regulations were introduced to restrict or prevent the use of lead in consumer goods, medicines and imported products [10]. The regulation of lead has been significantly strengthened over the last three decades in response to research that has reported health effects of lead at levels that had previously been regarded as safe [11]. Meta analyses have

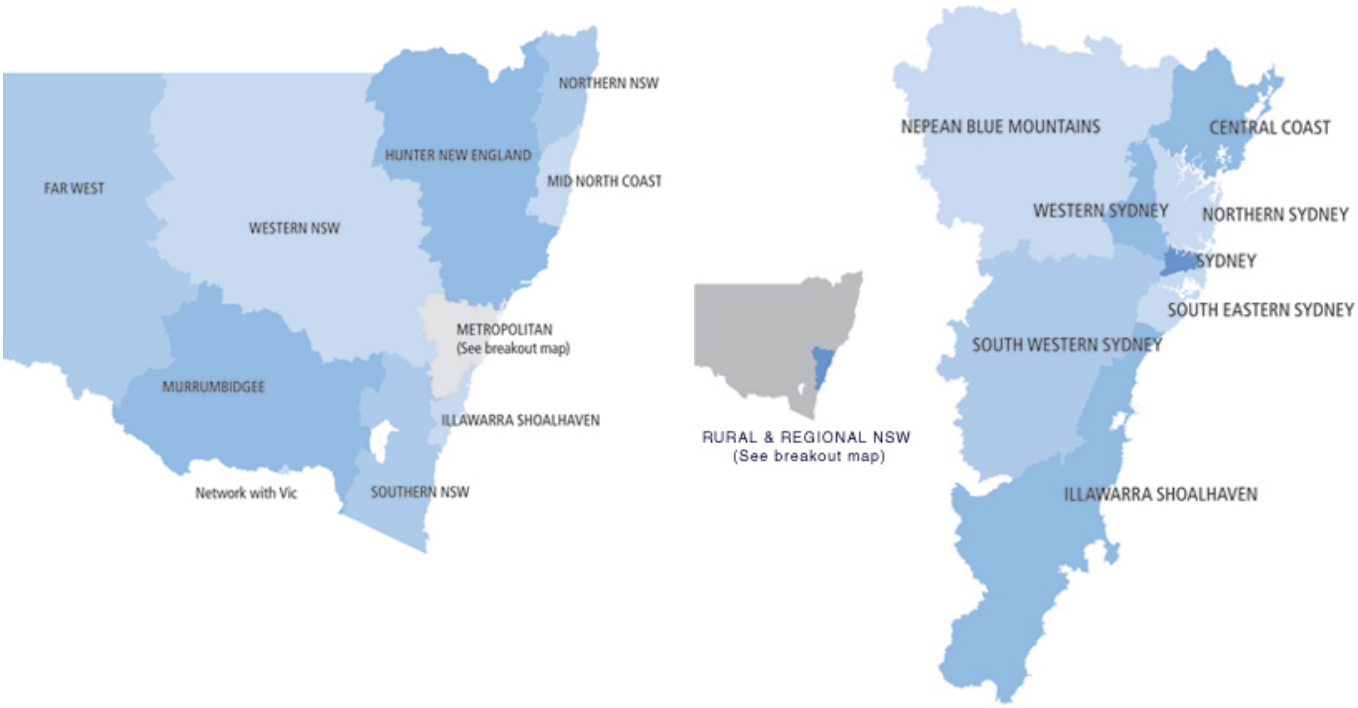
demonstrated an inverse association between lead exposure and IQ, and the US Centers for Disease Control and Prevention (CDC) has consistently revised downward the definition of a "normal" blood lead level (BLL) in children, from 60µg/dL in the 1960s to <5µg/dL in 2012[2].

A person with elevated lead levels may be asymptomatic, and when symptoms do occur they are often relatively non-specific. Laboratory investigations are the only reliable way to diagnose lead-exposed individuals. Blood lead testing is therefore used for surveillance of lead poisoning and in the assessment of occupational and environmental lead exposure [9].

Blood lead surveillance in NSW

The NSW Ministry of Health governs the NSW public health system, operating health services through a network of Local Health Districts (LHDs). There are 15 LHDs (Figure 1) throughout NSW; each LHD is served by one or more Public Health Units (PHUs) that are responsible for responding to reports of notifiable diseases within their jurisdictions. Centrally within the NSW Ministry of Health, Health Protection NSW is responsible for overarching surveillance and public health response including monitoring the incidence of notifiable diseases at a state-wide level[12].

Figure 1 – Local Health Districts in New South Wales



The NSW blood lead surveillance system was established in the early 1990s and has two main objectives[13, 14]:

1. To identify cases and recommend appropriate risk reduction measures
2. To monitor the epidemiology of elevated blood lead levels to inform the development of better risk reduction strategies

Under the *NSW Public Health Act 2010*, pathology laboratories are required to notify cases of elevated blood levels to their local PHU on identification[13]. The case definition of an elevated blood lead level has changed over time – under the current case definition, a confirmed case is:

*A person with a venous blood lead level of **≥5 µg/dL** (0.24µmol/L)*

Prior to February 2016 the level for notification was ≥10 µg/dL (0.48µmol/L), and prior to May 2012 it was ≥15 µg/dL (0.72µmol/L)[13].

Notifications are entered into the online Notifiable Conditions Information Management System (NCIMS), which has been in use since 2010[14]. NCIMS is a confidential application that provides state-wide data capture, management and reporting of scheduled medical conditions notifiable under the *NSW Public Health Act 2010* from pathology laboratories, general practitioners and hospitals[15]. NCIMS is routinely used as a tool to follow-up and manage individual notifications rather than for wider analysis; however, it does have the function to export aggregate data in spreadsheet form. Surveillance data entered in NCIMS is stored in the Secure Analytics for Population Health Research and Intelligence (SAPHaRI) digital warehouse. SAPHaRI is designed to provide data in a format that is ready to be analysed and reported for the purposes of epidemiology and surveillance, and contains databases of health, demographic population and geographic data[16]. The SAPHaRI analytics system does not typically export all information recorded in NCIMS: the NCIMS export dataset contains 551 variables (Appendix 1) compared to the 300 core variables routinely extracted in SAPHaRI (Appendix 2).

Response to a notification of an elevated blood lead level is done at the LHD level by the PHU. The response protocol following a notification involves the PHU:

1. Confirming with the treating doctor any symptoms associated with exposure, including the onset date
2. Contacting the case (with permission of the notifying doctor) to interview the case or their parent/guardian
3. Identifying household contacts who may also be at risk of elevated blood lead levels

Actions that should be taken are determined by the age of the case and the blood lead level (Table 1). If the source of the exposure is not clear after the initial investigation has taken place, the PHU arranges an environmental assessment of the residential area if the case's blood lead level is in excess of 25 µg/dL (1.2 µmol/L) and/or the implicated source may affect the broader community[13]. SafeWork NSW, the state workplace health and safety regulator, is consulted if there is any suspicion of a cluster of occupationally exposed cases occurring or if blood lead levels of >25µg/dL are notified in an adult who may have been exposed in the workplace.

Table 1 - Blood lead levels and corresponding actions taken by PHU according to age

Blood lead range	≥5 but 10<µg/dL	≥10 but 25<µg/dL	≥25 but 45<µg/dL	≥45µg/dL
< 5 years	Consult doctor Standard letter May need to test household members	Consult doctor Standard letter Offer counselling/risk assessment May need to test household members Retest BLL after 6 months	As for level 2 plus: Preliminary environmental assessment including home visit, exposure pathways and sampling Expert advice re: BLL retest	As for level 3 plus: Ensure treating doctor aware of result as levels ≥45 µg/dL may require chelation
≥5 years	Consult doctor Standard letter May need to test household members	Consult doctor Standard letter Advise to discuss with employer Inform Safe work if cluster of cases Offer counselling/risk assessment May need to test household members	As for level 2 plus: Preliminary environmental assessment including home visit, exposure pathways and sampling Strongly suggest consultation with SafeWork NSW	As for level 3 plus: Ensure treating doctor aware of result as levels ≥70 µg/dL may require chelation

Aims and Objectives

The aim of this review was to look at how the epidemiology of elevated blood lead notifications had changed in NSW over time. The objectives were to:

1. Describe the characteristics of notified cases including age, gender, and potential exposures in NSW between 1997 and 2016
2. Describe how notifications have changed over time, including the impact of changes to the case definition on notification rates of elevated blood lead level
3. Assess the quality of data present in NCIMS and SAPHaRI, including describing how data is recorded, stored and retrieved and its characteristics.

Methods

Notification data

Surveillance data for the condition ***"lead poisoning"*** for the period 1997-2016 were extracted from SAPHaRI using SAS 61 and exported as a Microsoft Excel file. This was imported into Stata version 14.1. The initial dataset included 300 variables; those variables that contained no data were removed.

Blood lead levels

NCIMS is a person-based rather than an event-based surveillance system; thus, although it is possible for an individual to have multiple notifications of an elevated blood lead at different points in time, these will all be identified in the system as a single individual (and therefore notification) with multiple blood lead levels recorded. SAPHaRI only provided the first 5 lab results from all the available lab results; these varied between representing the 5 most recent blood lead results and the 5 earliest blood lead results due to idiosyncracies of data entry. A data export containing all laboratory results was extracted from NCIMS and merged onto the core dataset to ensure inclusion of all laboratory results recorded throughout the life of the surveillance system, rather than just the five most recent results. The earliest notified lead level for each individual was used to represent that notification regardless of any later blood lead levels notified.

Blood lead levels had been entered as free-text, leading to significant variation in the format and syntax of entries. Variations included numbers, letters, symbols and indication of units in the values field. Examples included:

- Pb=11.4
- 4.11 miumol/L (sic)
- umol/L 8.81 µg/dL 16.8".

To convert these to numerical values, the `destring` and `force` commands were used iteratively in Stata by length of response, with a small number of results re-entered manually. An example of the process for destringing, cleaning and checking each individual lab results for biological plausibility is illustrated in Appendix 1. In addition, a new variable was created based on the category of the earliest blood lead level notified. First notifications were categorised as "<10µg/dL", "10-15µg/dL" and ">15 µg/dL".

Date

A date variable was generated based on the date of the first lab test. The ***"calculated onset date"*** variable was used for date if there was no lab test date available. This variable is automatically generated by NCIMS is based on a simple earliest date formula, taking the earliest date of:

1. Diagnosis date
2. Symptom Onset Date
3. Specimen Date
4. Notification Sent Date
5. Notification Received Date
6. Event create date

Results were analysed by year of onset.

Geographical location

NCIMS and SAPHaRI automatically generate multiple options for geographical location based on the address of the person at the time of notification. If this address is inadequate, the geographical location is assigned based on the doctor's address. The geographical borders of local health districts have changed over time in NSW. The current LHD borders (defined in 2010) were chosen as the unit for geographical analysis.

Aboriginal status

There were initially 5 options for Aboriginal status: "Aboriginal", "Both Aboriginal and Torres Strait Islander", "Not Aboriginal or Torres Strait Islander", "Not stated or unknown", and "Missing". For clarity and in line with accepted NSW Health terminology these were condensed into three variables as follows:

- *Aboriginal* - includes "Aboriginal," and "Both Aboriginal and Torres Strait Islander"
- *Non-Aboriginal* - includes "Not Aboriginal or Torres Strait Islander"
- *Missing* - includes "Not stated or unknown" and "Missing"

Occupation

There were three variables initially available for occupation – ***occupation***, ***high risk occupation***, and ***high-risk occupation – other (description)***.

- ***Occupation*** included 176 unique variables with entries for 4836 individuals
- ***High risk occupation*** included 22 unique variables with entries for 1758 individuals
- ***High risk occupation – other (description)*** included 202 unique variables with entries for 280 individuals

The 22 categories of occupation from ***high risk occupation*** were reduced to 14 by combining similar categories (e.g. 'lead miner" and "miner" were combined into single category) and classifying some non-relevant occupations as "other" (e.g. sex worker). All categories of ***occupation*** with greater than 50 results were created a new variable within ***high risk occupation*** or absorbed into existing high-risk categories. All children aged 14 and under were categorised as "no high-risk occupation".

Exposure

The details of lead exposure are not contained in SAPHaRI, however this information is routinely collected in NCIMS. To obtain this information, data was extracted from NCIMS as an Excel spreadsheet for the period 1/1/1997-31/12/2016 by ***"Calculated Onset Date"*** for the condition ***"Lead Poisoning"***. This was imported into Stata and merged onto the core dataset on the variables of ***eventid*** and ***personid*** present in both datasets.

Risk factors

15 separate risk factors categories were asked about in the NCIMS question package. In the exported dataset, a separate field had been generated for those who had multiple risk factors ticked (i.e. a child who had the risk factors of ***"Pica"*** and ***"a sibling with a positive blood test"*** would be included in a risk category of their own labelled "Pica/Sibling with a positive blood test"). The initial table with 36 variables was exported into Microsoft Excel and aggregate counts done manually for the 15 separate risk category options.

Population data

Denominator data to calculate rates by age, sex, jurisdiction and year were obtained from the SAPHaRI portal and exported as a Microsoft Excel worksheet. These data were generated by the Centre for Epidemiology and Evidence within the NSW Ministry of Health. Age- and sex-specific estimated resident populations (ERPs) for NSW Statistical Areas (Levels 1 and 2) (SA1 and SA2) at 30 June were obtained from the Australian Bureau of Statistics (ABS) for use with calendar year data. Populations of NSW Local Health Districts (LHDs) were derived by aggregating the appropriate Local Government Area (LGA) or SLA-level ERPs where possible. When LHD populations could not be calculated using LGA or SLA-level ERPs, these populations were calculated using either SA1 or CD (census collection district) estimates.

Projected populations were produced by the NSW Department of Planning and Environment. The projections are based on the 2011 estimated resident population as published by the ABS. The projections result from assumptions about future trends in fertility, mortality and migration and incorporate information from the ABS, Commonwealth Department of Immigration and Border Control and the NSW Ministry of Health. The inter-census year projections from 2012-2015 were produced by the Centre for Epidemiology and Evidence by interpolating the census-year (2016) projection provided by Department of Planning and Environment.

Ethics

Ethics committee approval was not required for this project as the data is collected mandatorily under the auspices of the NSW Public Health Act (2010), and for this project was used for the primary purpose for which it was collected, namely:

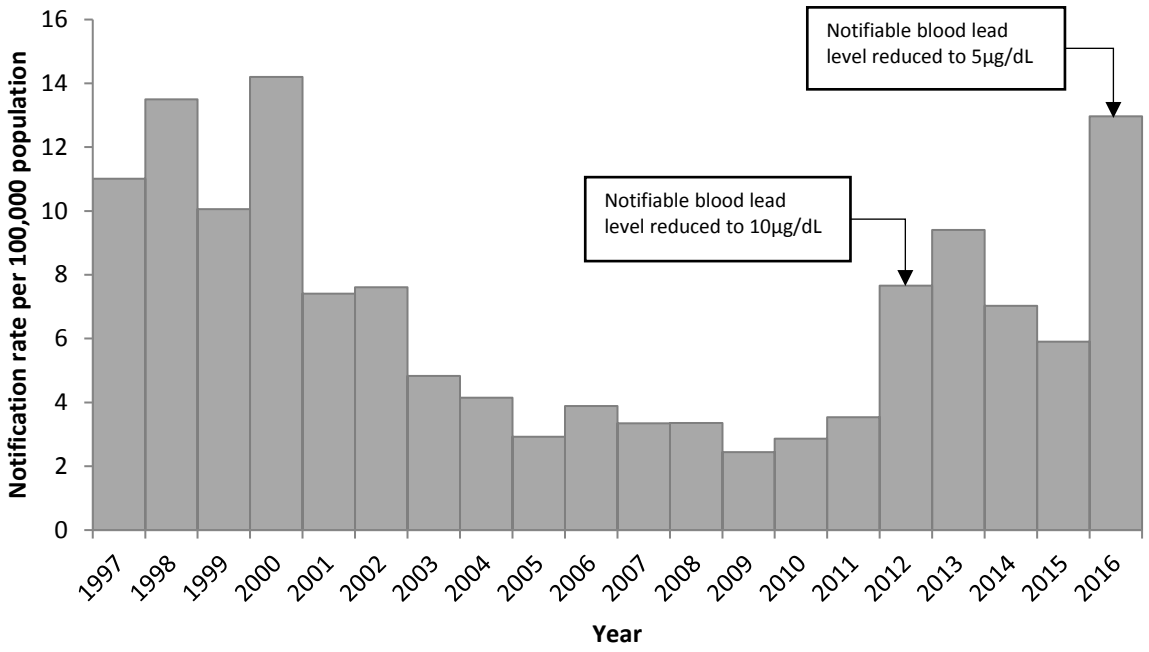
> "To identify cases of elevated blood lead levels and recommend appropriate risk reduction measures and to monitor the epidemiology of elevated blood lead levels to inform the development of better risk reduction strategies".

Standard NSW Health guidelines were followed with regards to the protection of potentially identifying data.

Results

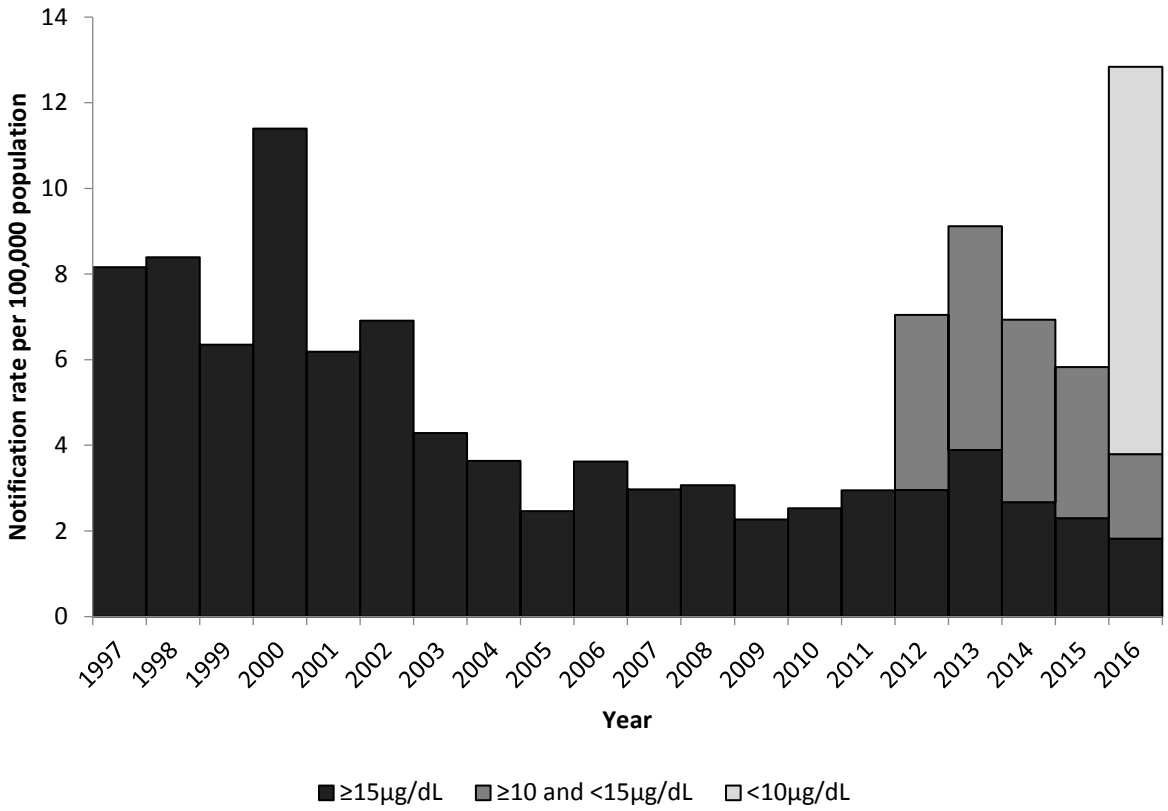
There were 9486 cases notified in NSW residents in the study period, with an average overall notification rate of 6.9 cases per 100,000 people. Following an initial peak in the year 2000 of 14.2 notifications per 100,000, notification rates remained static at between 2 and 4 per 100,000 between 2005-2011, until changes were made to the case definition. Reductions in the notifiable blood lead level increased the notification rate in 2012, and again in 2016 (Figure 2).

Figure 2 – Notification rate of elevated blood lead levels in NSW per 100,000 population, 1997-2016



Of the 9486 notifications, 8104 (85.43%) had a blood lead level recorded on NCIMS and met the case definition in the year they were notified (Figure 3). The number of notifications of ≥15µg/dL trended down over the study period, and the increase in the number of notifications between 2012-2016 was accounted for by changes in the case definition – particularly in 2016 where more than half of notifications were <10µg/dL. For blood lead levels of 15µg/dL or above, the notification rate remained at between 2 and 4 per 100,000 for the period 2012 to 2015, and in 2016 it fell to its lowest point of 1.8 per 100,000.

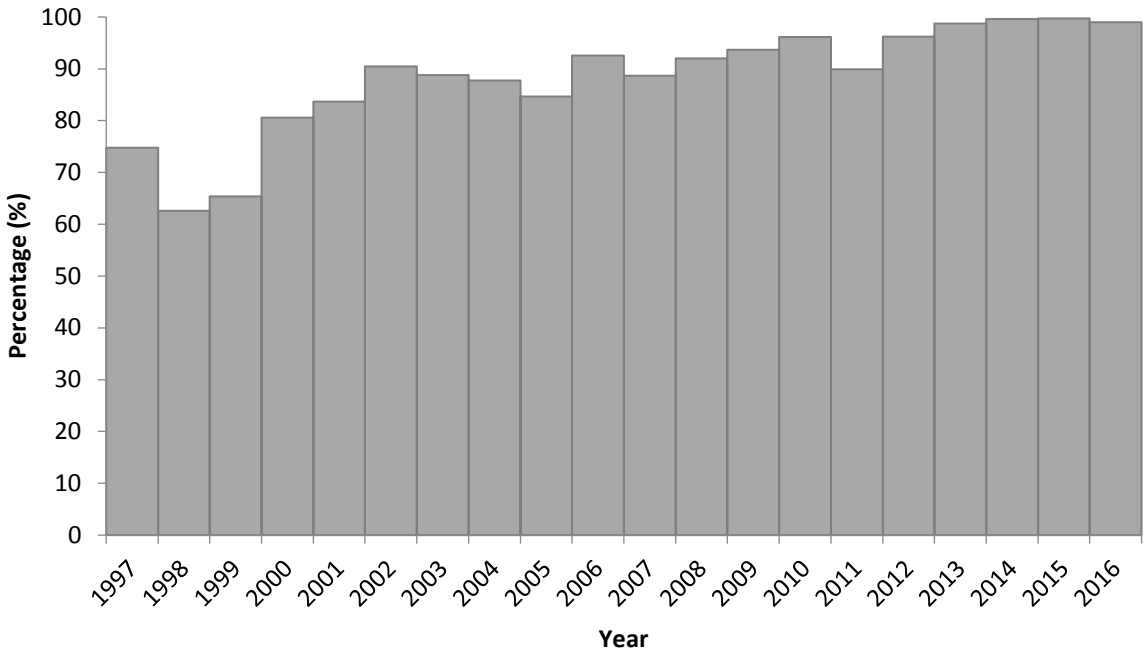
Figure 3 - Number of notifications by range of first lead level notified and year, NSW, 1997-2016



Data completeness - blood lead levels

Data completeness improved during the study period. The number of notifications for which a corresponding blood lead level was recorded ranged from a low of 62.8% in 1998 to a high of 99.8% in 2015. Reasons for this improvement could include the increased proportion of results transmitted via electronic laboratory reporting (ELR) and the change of system from the Notifiable Diseases Database (NDD) to NCIMS in 2010, although the improvement appears steady over the entire study period.

Figure 4 - Proportion of notifications who have a blood lead level recorded following data cleaning, NSW, 1997-2016

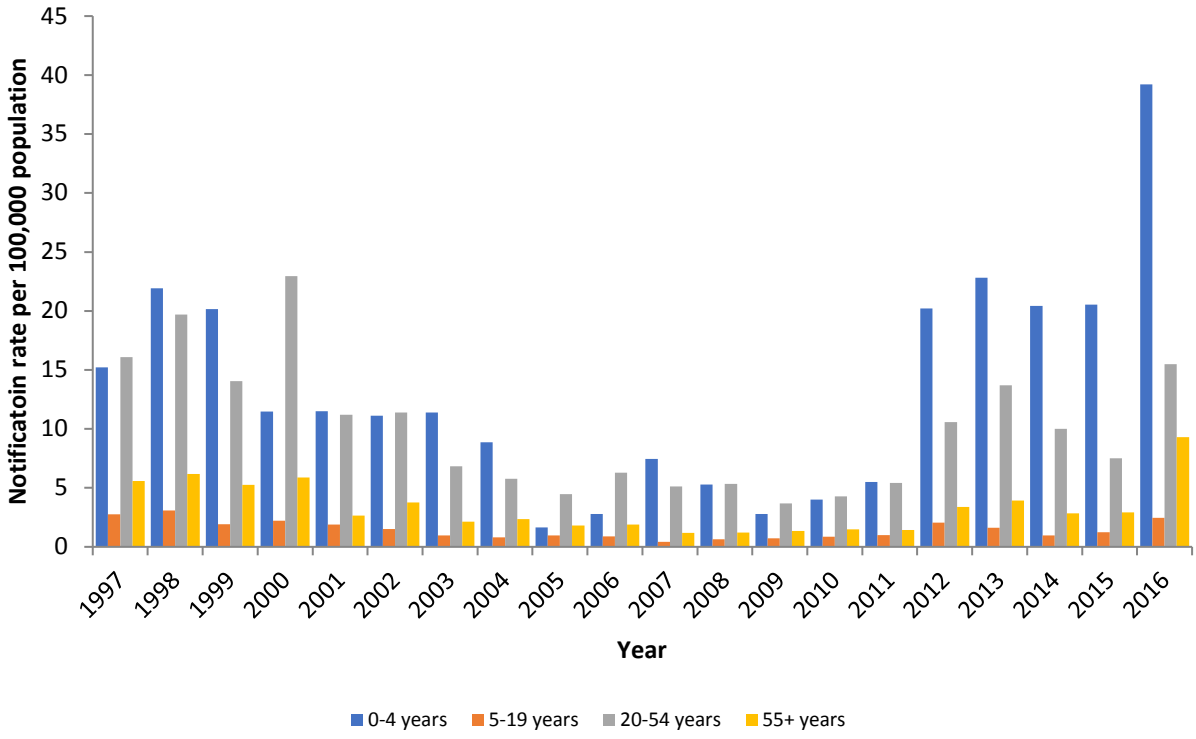


Characteristics of notifications

Age

The greatest number of notifications during the study period came from children aged 0-4 years, with a second peak in young adults aged 25-34 years. This corresponds with the two known risk categories for lead exposure of young children and industrial workers (who are more likely to be younger adults of working age). In 2012, and again in 2016, there was an increase in the notification rate for all age groups, particularly amongst young children aged 0-4 years (Figure 5).

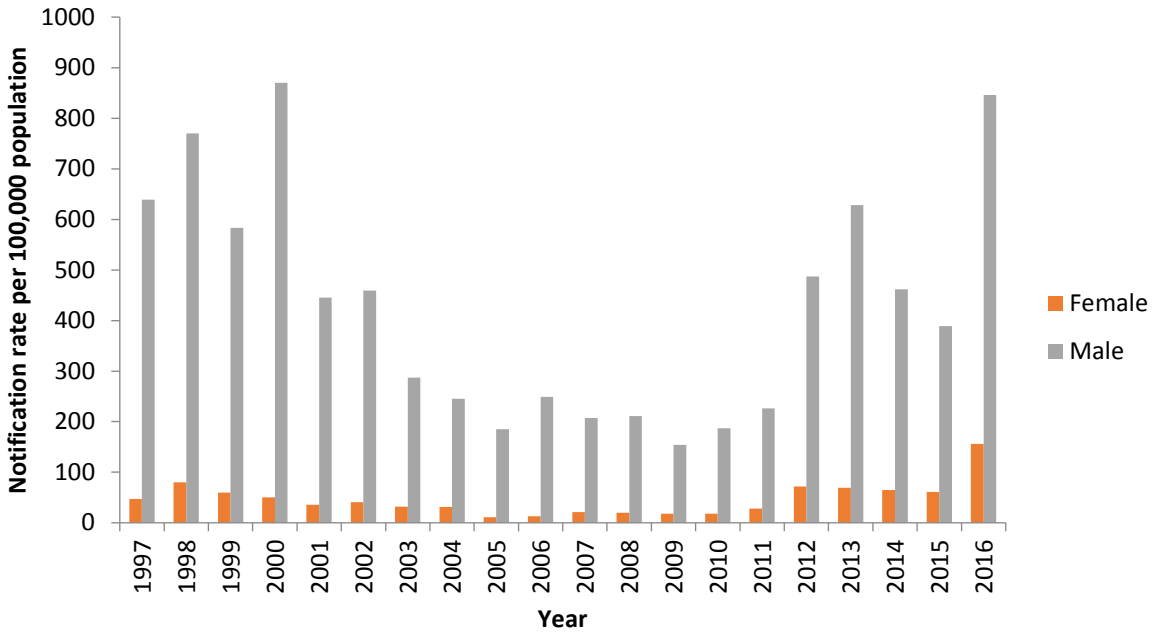
Figure 5 - Notification rate per 100,000 by age group, NSW, 1997-2016



Sex

Sex was recorded for 99.7% (9458/9586) of notifications. Of those with sex recorded, 90.2% were male. Men had higher notification rates than women in every year (Figure 6), although between 2004 and 2011 the notification rate among men was substantially lower than in other years. In the 0-4 year age group where the notification rate amongst females was highest, females represented 42.1% of notifications. The lowest proportion of females occurred in the 15-19 year age group, with females representing 2.5% of notifications.

Figure 6 – Notification rate per 100,000 populations by sex and year, NSW, 1997-2016



Aboriginalstatus

Aboriginal status was recorded for 26.9% (2551/9486) of notifications. The LHD with the greatest proportion of notifications that were identified as Aboriginal among notifications where this field was completed was Far West NSW at 26.4%, followed by the Illawarra Shoalhaven at 14.3% and Sydney LHD at 11.8%. This was higher than might be expected given the Aboriginal populations in these locations in 2011 were 11.7%, 2.4% and 1.1% respectively[16a].

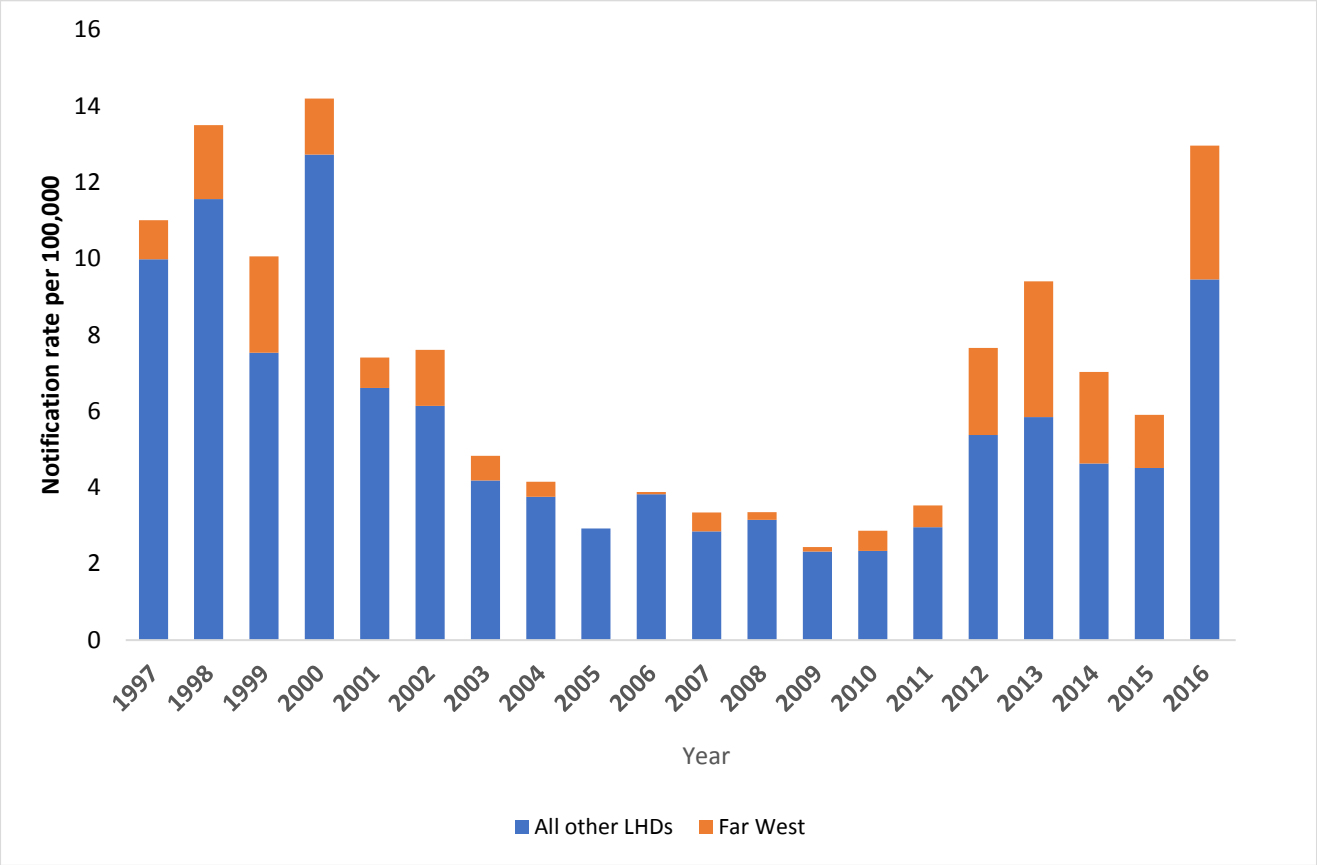
Aboriginal status was recorded to varying levels of completeness across the LHDs. The lowest completion rates were in Northern Sydney LHD, with 232 of 233 notifications (99.6%) having Aboriginal status recorded as "(blank)" or "unknown/not stated". Highest completion rates were in Far West LHD with only 281 of 1790 (26.9%) missing.

Appendix 2 shows data completeness for the Aboriginal status field by LHD for the study period.

Geographic location

The largest number of notifications came from Far West Local Health District. Far West LHD is the smallest LHD in terms of population; its resident population in 2016 was 30,740, representing 0.4% of the total population of NSW. Figure 7 compares the relative contribution of Far West to the overall notification rate for NSW, and shows that from 2012 Far West LHD contributed increasing proportions of the overall notification rate.

Figure 7 – Relative contribution of Far West LHD to the overall notification rate, NSW, 1997-2016



Further information about notification rates by LHD is included in Table 5 and Figure 9 and Figure 10 in Appendix 3, which shows notification rates per 100,000 for the 15 LHDs in NSW by year. The lowest average notification rates over the study period was 1.4 per 100,000 in Northern Sydney LHD, whilst the highest was 278.0 per 100,000 in Far West LHD. In the early years of the surveillance system Hunter New England LHD had the second highest rates of notifications, replaced in recent years by Western NSW LHD. Apart from Far West LHD, with an average notification rate of 278.0 per 100,000, no other LHD exceeded a notification rate of 60 per 100,000 in any year. The next highest average notification rate was Hunter New England with 13.3 per 100,000.

Exposure

Information on exposure history was present for 539 notifications. There were 15 different exposure options available (Table 2). 539 of the 9486 notifications (5.7%) had at least one documented risk exposure, with 1127 total exposures identified for these 539 individuals. The most frequently indicated risk exposure category was “Recent demolition of houses nearby" (31.4%), followed by “Lives in a house... with recent renovations” (24.0%).

Table 2 – Frequency of risk exposure categories for notifications in NSW, 1997-2016

Risk exposure category	Number of times noted
Car batteries dismantled at place of residence	1
Alternative medicines	3
Chews/sucks on painted toys	2
Live house built < 1970 - peeling paint	7
Live house built < 1970 - recent painting	5
Live house built < 1970 - recent renovations	270
Lives in an area where there is a lead industry	7
Live in or near a house built before 1970	9
Lives near main road/highway	85
Participates in risk hobbies	20
Person suffers from Pica	11
Recent demolition of houses nearby	354
Sibling/other household member with elevated blood lead	46
No identifiable risk	42
Other	265
TOTAL	1127

A risk exposure category was recorded for 38 of the 1389 children notified (2.7%), with 49 exposures identified for these 38 children. The most common exposure categories for children were ***“Person suffers from Pica”*** and ***“Other”***; both occurred 24.5% of the time.

Occupation

Occupation was recorded for 6200 of the 9486 notifications. The most frequent risk exposure category was “Miner”, followed by “Smelter Worker”. Table 3 lists the high-risk exposure categories in descending order of frequency. Two categories, “Plumber” and “Stained Glass Manufacturer” occurred less than 10 times over the twenty-year study period.

Table 3 – High risk occupations by frequency of reporting

High risk occupation	Total	Total percentage
No high risk occupation	1528	16.1
Miner	615	6.5
Smelter Worker	548	5.8
Contractor	396	4.2
Factory Worker	209	2.2
Metal Worker	205	2.2
Lead Miner	182	1.9
Painter	132	1.4
Automotive Worker	61	0.6
Foundry Worker	26	0.3
Metal Recycler	18	0.2
Demolisher	10	0.1
Plumber	7	0.1
Stained Glass Manufacturer	2	0.02
Other/Unknown	2261	23.8
MISSING	3286	34.6
Total	9486	100.0

Data quality

The data exhibited considerable variation in quality. A variety of strategies were required to extract the best data for different variables. In general, demographic data was for the most part complete particularly for the key variables of age, date of birth and notifying jurisdiction.

Laboratory data was generally disorganized and sometimes of poor quality. Electronically transmitted data was of better quality than manually entered data. Blood lead levels were reported in µg/dL only slightly more frequently than µmol/L, with a significant number of notifications reported in both. Frequently the units corresponding with the reported level were not indicated and could only be inferred. The data entry field for blood lead levels in NCIMS was free-text, leading to significant variation in the format and syntax of entries and making analysis difficult. Variations

included numbers, letters, symbols and indication of units in the values field. This data was neither easily cleaned nor analysed.

There were also several apparent idiosyncratic entries for blood lead level, where the same individual had multiple notifications from the same date and the same laboratory accession number, but different values – in one individual five very different blood lead levels were reported for the same laboratory accession number on the same day.

Overall the data was difficult to access and analyse. That multiple methods and data sources were required to export, clean and merge the relevant data led to difficulties analysing the data, particularly when essential numbers such as case count were different when using different export methods. There was a significant amount of missing data, particularly for occupation and exposure. Additionally, "occupational exposure" was not a listed risk exposure category, and it is likely that many of those without a risk category identified had an occupational exposure.

Discussion

Changes to the case definition for elevated blood lead levels in recent years have led to increases in notifications, both in terms of crude numbers and population rates. However, notifications in the highest range of >15µg/dL have declined, with levels in 2016 at their lowest since elevated blood lead became notifiable in NSW. This mirrors trends seen worldwide that have shown reductions not only in the total number of cases of elevated blood lead but also to population-level mean blood lead concentration, following reductions in the use of lead in petrol, paint and other industrial processes[17]. In Australia exposure to lead has fallen significantly due to public health measures restricting the use of lead in manufactured products as well as the shutdown of previous sites of lead industry[18].

Notification rates were highest in children aged 0-4 years, reflecting the findings of Freeman et al[14] in their previous review of blood lead levels in NSW. This likely represents higher levels of testing in this age group and awareness that children under 4 are more vulnerable to elevated blood [19], as well as the existence of screening programs in specific locations where is environmental lead is endemic such as Broken Hill[20], and because testing is recommended for children with a new diagnosis of behavioural problems[21]. Notification rates in older children were very low.

Among adults, a noteworthy proportion of the increase in notifications following changes to the case definition in 2016 appeared to be among older adults aged 55+ years. In 2016 the notification rate among ages 55-59 years was higher than for 25-29 years, which represented a significant deviation

from trends over the previous five years. This could potentially reflect findings in the literature that older people generally have higher blood and bone levels than younger adults both due to their accumulated exposure to lead over time, particularly in historical periods of less-stringent regulation, as well as the mobilisation of lead from bone due to conditions such as osteoporosis[22, 23]. This apparent disproportionate rise in the notification rate among older adults warrants further investigation with regards to whether it is geographically clustered, for example in regions of high historic lead exposure such as Hunter New England. It may also represent increased testing in older adults who are undergoing screening of cognitive changes such as dementia, as the population ages.

In line with historic trends[14], notification rates were highest in the rural local health districts of Western NSW and Far West, areas with a history of lead mining activity. The notification rate in Far West LHD in 2016 was 884.84 cases per 100,000 population, more than 16 times the rate of Western NSW with 53.01 notifications per 100,000. No other LHD exceeded 14.0 per 100,000. The elevated notification rate in Broken Hill occurs against a backdrop of high community awareness and voluntary screening of all children in Broken Hill linked with existing routine health programs[20], and thus may represent higher levels of testing as well as higher levels generally. Overall all PHUs saw an increase in notifications in 2016 following changes to the case definition. This has implications regarding the resourcing of PHUs, particularly if there are any further changes to the case definition.

It was challenging in this analysis to analyse risk factors and exposure as they were generally poorly recorded. This means that potential newly-emerging exposures may not be identified. This could be problematic for ongoing surveillance as many cases of severe lead toxicity in adults are actually not associated with occupational exposures but rather with more exotic exposures, such as ingestion of Ayurvedic medicines, imported foods, use of imported cosmetics and exposure to unusual hobbies (such as shooting and lead lighting)[2].

Recommendations

The quality of data collected could be improved significantly with simple changes to the data entry mechanism on NCIMS – this could include updating and/or clarifying the potential list of exposures, including occupation as a potential exposure, converting the entry field for “blood lead level” to a numerical field, and creating a drop-down box for the units for which the level was recorded. There could also be a note reporting that only one unit was required to be recorded, or a mechanism for automatically converting all lead levels to a single measure (i.e. µg/dL). In addition, the analysis function in NCIMS could be significantly improved, particularly if a regular reporting form in NCIMS, such as that utilised in Communicable Disease Branch which generates a standardised “MMWR” style report, was used. This could allow for regular analysis to be conducted within NCIMS and

negate the need for regular data exports and complex data transformation and analysis methods. This could enable the identification of missing data early and allow for comparisons of data completeness between different PHUs.

A future ideal database would have a single dataset that was able to be extracted easily, that was complete and accurate, that was reasonably easy to analyse with simple software (e.g. Microsoft Excel) and that contained numerical blood lead levels.

Limitations

This data analysis had many significant limitations, owing particularly to challenges in the data set. There was a significant volume of missing data, particularly surrounding occupation and exposure, which meant that interesting and potentially useful analyses that could have led to public health interventions was not able to be undertaken. The frequency of missing data remained relatively static over time, suggesting that the changes to the case definition have not had a significant impact on data completeness. This volume of missing data meant that detection of possible trends in exposure, or meaningful conclusions – such as, for example, that exposures due to lead mining in the area have decreased over time – were not able to be made.

However, identification of these limitations provided key information on the attributes and usefulness of the surveillance system as it currently stands. Both simple and more complex changes that could be made, in data collection, storage and analyses, were identified that were useful to the evaluation of the blood lead surveillance system discussed in Chapter 5, and are incorporated into recommendations regarding future improvements to the surveillance system.

Conclusion

Changes to the case definition have increased the number and rate of notifications of elevated blood lead levels in NSW, which are distributed disproportionately between LHDs. There were significant volumes of missing data regarding risk factors for exposure, which meant that meaningful conclusions about whether risk factors had changed over time could not be drawn. It is recommended that changes be made to how data is collected, stored and retrieved in NCIMS to allow for ongoing and more frequent analysis of the epidemiology of elevated blood lead levels in NSW.

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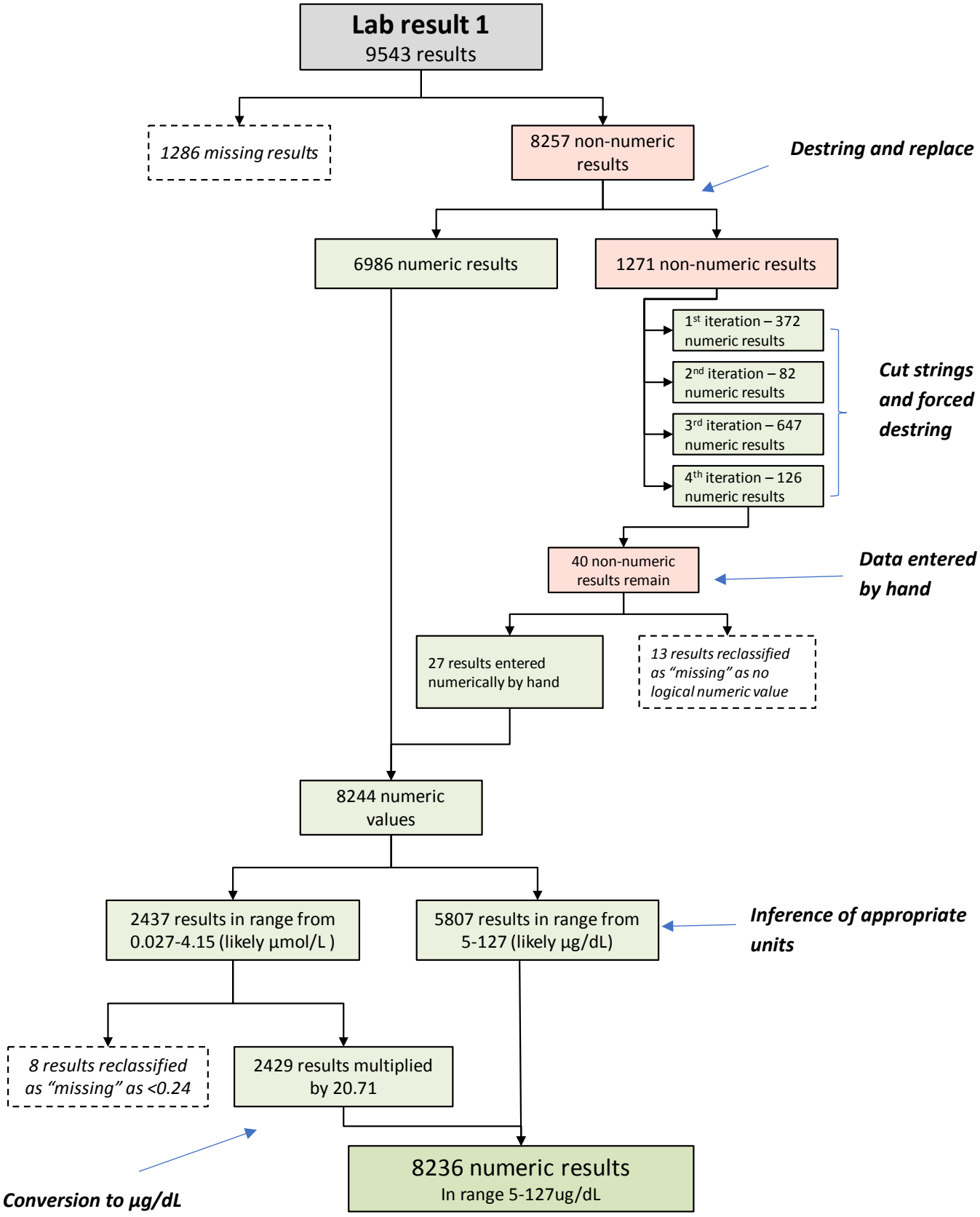
Appendix 1 - Data cleaning process

Figure 1 –Example data cleaning process required for blood lead levels in field "lab result 1"



Appendix 2 - Data completeness for Aboriginal status

Table 4 – Data completeness for Aboriginal status among elevated blood lead level notifications by LHD, NSW, 1997-2016

LHD	Missing	Total	% complete
Northern Sydney	232	233	0.4
Illawarra Shoalhaven	376	383	1.8
Western Sydney	676	698	3.1
Sydney	414	431	3.9
Hunter New England	2010	2167	7.2
Murrumbidgee	320	364	12.1
South Eastern Sydney	355	411	13.6
Nepean Blue Mountains	301	351	14.2
Western NSW	747	1043	28.4
Northern NSW	130	191	31.9
Central Coast	108	160	32.5
Southern NSW	65	98	33.7
South Western Sydney	686	1086	36.8
Network with Vic	14	23	39.1
Mid North Coast	20	57	64.9
Far West	481	1790	73.1
Total	6935	9486	26.9

Appendix 3 - notification rates by LHD

Table 5 – Notification rates by NSW Local Health District and Year, 1997-2016

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*MEAN*
Sydney	2.68	17.87	9.78	6.48	3.63	5.00	2.37	2.34	1.73	2.84	2.41	1.81	0.71	1.39	2.41	1.86	3.82	2.93	3.04	6.25	*4.07*
South Western Sydney	11.29	25.15	11.71	17.76	6.69	4.76	4.11	4.61	3.72	4.30	1.94	2.62	2.11	1.50	2.85	5.40	3.65	4.34	2.77	12.00	*6.66*
South Eastern Sydney	3.49	4.80	3.30	4.85	2.09	2.85	1.16	0.90	1.40	4.18	1.62	1.47	0.84	0.95	1.41	2.68	2.76	2.04	1.57	6.36	*2.54*
Illawarra Shoalhaven	8.25	5.54	13.55	4.83	9.88	10.90	2.50	4.98	0.28	3.03	5.72	1.35	3.45	0.52	1.30	2.06	9.96	4.04	3.25	9.14	*5.23*
Western Sydney	5.96	13.06	4.87	9.98	7.98	6.45	4.30	4.51	3.76	2.91	2.59	1.51	1.47	1.56	2.48	4.86	4.41	3.09	1.94	5.17	*4.64*
Nepean Blue Mountains	7.68	10.37	3.62	8.37	4.47	5.35	2.68	2.69	4.49	2.40	1.79	4.11	2.33	2.31	2.58	7.97	9.56	5.00	1.10	13.03	*5.09*
Northern Sydney	1.05	3.67	2.99	2.19	1.28	2.04	2.16	1.27	0.89	1.26	0.74	0.49	1.32	0.59	0.23	1.16	1.14	1.12	1.32	1.87	*1.44*
Central Coast	1.81	14.64	1.75	1.72	2.38	2.35	0.33	2.67	2.65	0.66	0.65	0.96	0.32	0.94	2.17	2.46	4.57	2.72	2.40	4.42	*2.63*
Hunter New England	46.41	19.86	19.83	55.20	22.92	19.06	14.18	9.13	6.54	4.95	2.63	4.37	5.61	2.31	1.37	5.31	5.36	4.98	3.51	11.63	*13.26*
Northern NSW	3.58	5.88	6.19	4.20	1.14	3.00	1.11	4.42	0.37	1.45	1.08	2.49	2.82	1.05	0.69	3.46	3.43	4.78	4.73	12.60	*3.42*
Mid North Coast	0.57	3.93	2.76	1.63	1.62	4.25	4.20	0.52	0.00	0.51	1.01	0.00	0.98	0.00	0.00	0.48	0.95	2.36	0.47	3.21	*1.47*
Southern NSW	4.89	2.42	2.98	2.34	1.73	1.13	1.12	1.66	4.37	2.70	1.60	0.53	0.52	2.05	2.03	2.52	1.00	2.98	3.95	9.58	*2.60*
Murrumbidgee	2.99	2.56	3.41	2.97	3.40	1.70	2.14	0.86	0.43	1.71	1.71	4.68	3.81	15.19	25.70	25.62	25.57	9.57	5.80	13.23	*7.65*
Western NSW	3.05	7.96	3.02	4.88	6.39	5.65	8.34	8.77	8.42	25.29	24.08	30.35	8.26	15.24	14.77	33.28	31.91	34.14	57.21	53.01	*19.20*
Far West	181.64	349.92	464.13	275.39	152.43	288.58	129.93	79.76	0.00	12.53	106.64	44.11	25.38	121.28	131.72	537.32	851.67	579.39	343.03	884.84	*277.98*
Network with Vic	4.57	2.26	0.00	0.00	6.62	2.18	0.00	0.00	2.12	2.10	2.07	2.06	0.00	6.09	0.00	0.00	9.94	5.87	1.93	0.00	*2.39*
NSW COMBINED	**11.01**	**13.50**	**10.06**	**14.20**	**7.41**	**7.61**	**4.83**	**4.15**	**2.93**	**3.89**	**3.35**	**3.36**	**2.44**	**2.87**	**3.53**	**7.66**	**9.41**	**7.03**	**5.91**	**12.97**	***6.91***

Figure 9 - Notification rate by NSW Local Health District, 1997-2016

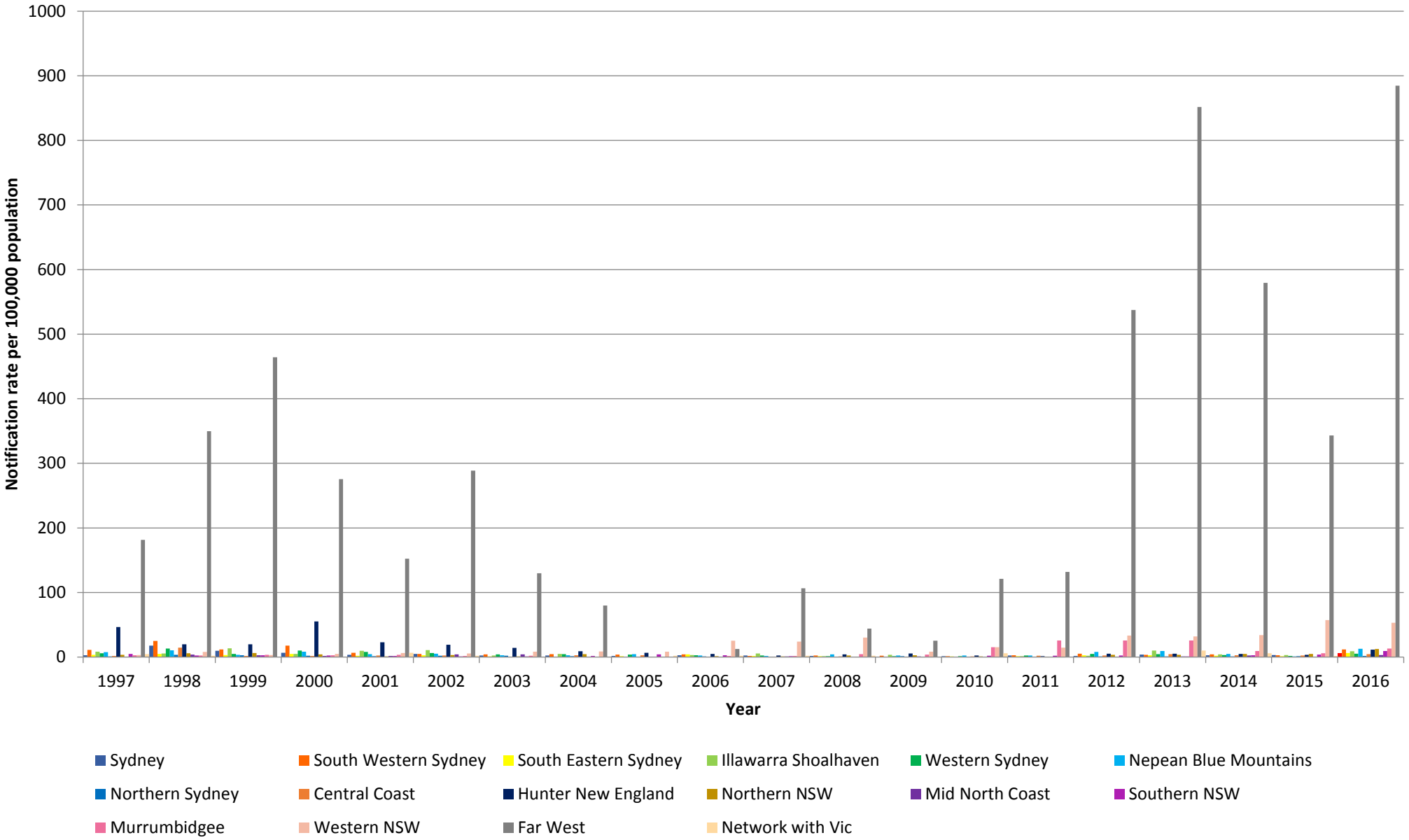
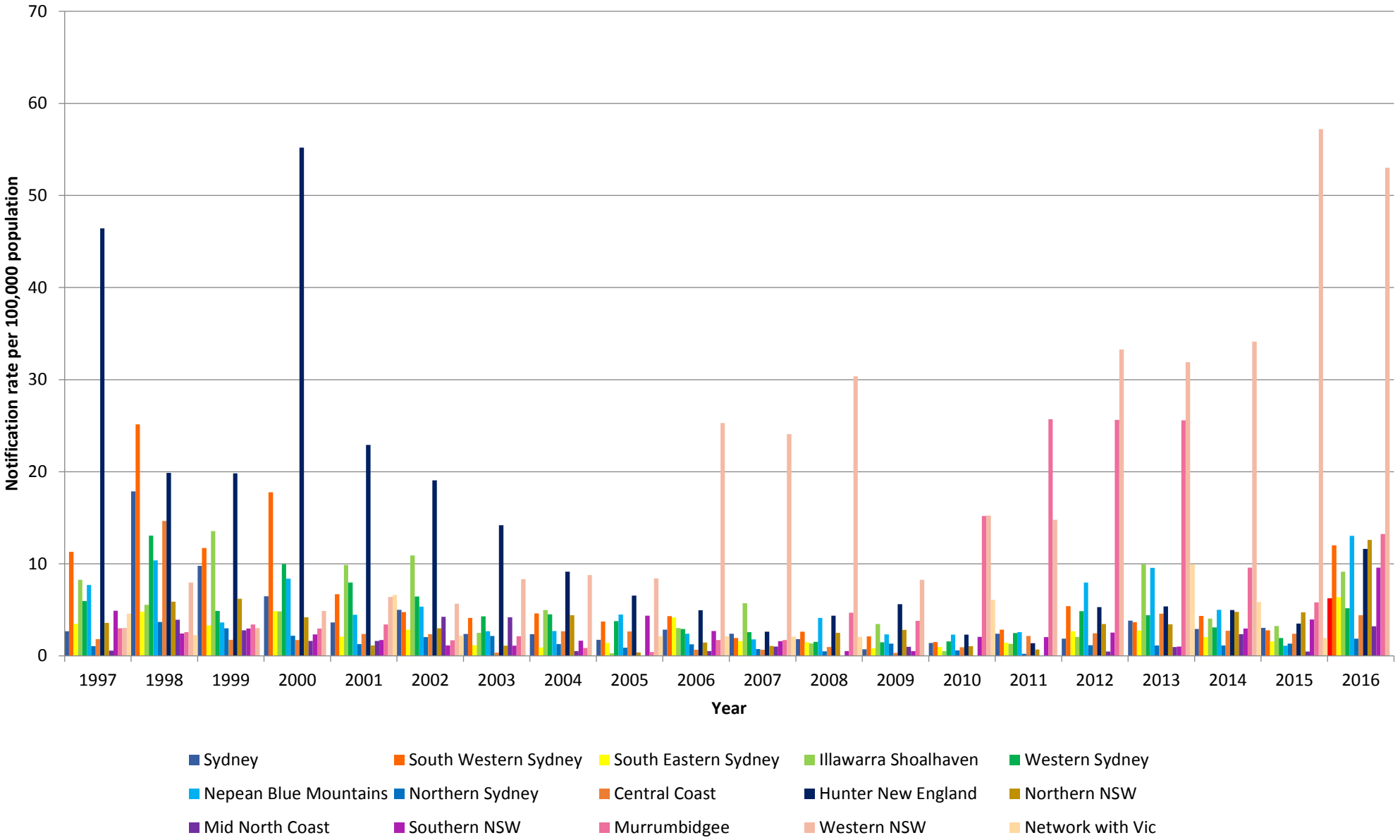


Figure 10 - Notification rate by NSW Local Health District, 1997-2016 (Far West LHD excluded)



Appendix 4 - Presentation at 9th Global TEPHINET Conference, Chiang Mai, Thailand 2017

Australian National University

The epidemiology of elevated blood lead level notifications in New South Wales, Australia, 2011-2016

Dr Katherine Todd
Australian FETP

Australian National University

Introduction

- Lead is a metal that persists in the environment
- Results from human activities
- Acts a cumulative toxicant
- 0.6% of the global burden of disease (2004)

Australian National University

New South Wales

- Highest population
- Population ≈ 7.7 million
- 15 local health districts

Australian National University

Blood lead surveillance in NSW

- Increased regulation of lead since 1970s
- Removal of lead from petrol and paint
- Notifiable in NSW since 1996
- Case definition changed over time

Australian National University

Project aims

1. Describe how recent changes to the case definition have affected notification rates in NSW
2. Evaluate the quality of data in the NSW blood lead surveillance system

Australian National University

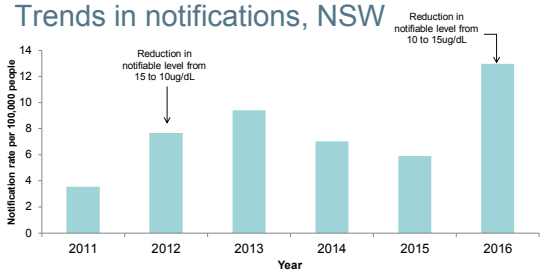
Methods

- Data extracted from surveillance system
- Two separate datasets linked
- Rates calculated using census data for 2011
- STATA version 14.1

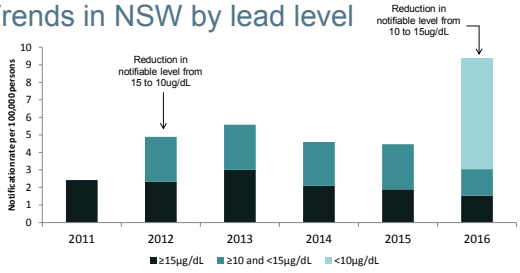
Results

- In NSW between 2011-2016:
  - 3490 notifications
  - M:F ratio of 6:1
  - 18.2% aged under 5 years
  - Average notification rate 7.7 per 100,000

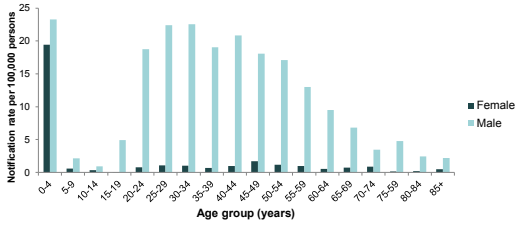
Trends in notifications, NSW



Trends in NSW by lead level



Notifications by sex, NSW, 2011-2016



Notification rate by age group

Age group	2011-2015 Average rate per 100,000	2016 Rate per 100,000	Rate rise
0-4 years	17.9	39.2	219%
5-19 years	1.4	2.5	179%
20-54 years	9.4	15.5	164%
55+ years	2.9	9.3	320%
TOTAL	*6.7*	*12.9*	*193%*

NSW Local Health District	2011	2012	2013	2014	2015	2016
Far West	**131.7**	**537.3**	**851.7**	**579.4**	**343.0**	**884.8**
Western NSW	14.8	33.3	31.9	34.1	57.2	53.0
Murrumbidgee	25.7	25.6	25.6	9.6	5.8	13.2
Nepean Blue Mountains	2.6	8.0	9.6	5.0	1.1	13.0
Northern NSW	0.7	3.5	3.4	4.8	4.7	12.6
South Western Sydney	2.9	5.4	3.6	4.3	2.8	12.0
Hunter New England	1.4	5.3	5.4	5.0	3.5	11.6
Southern NSW	2.0	2.5	1.0	3.0	3.9	9.6
Illawarra Shoalhaven	1.3	2.1	10.0	4.0	3.2	9.1
South Eastern Sydney	1.4	2.7	2.8	2.0	1.6	6.4
Sydney	2.4	1.9	3.8	2.9	3.0	6.3
Western Sydney	2.5	4.9	4.4	3.1	1.9	5.2
Central Coast	2.2	2.5	4.6	2.7	2.4	4.4
Mid North Coast	0.0	0.5	1.0	2.4	0.5	3.2
Northern Sydney	0.2	1.2	1.1	1.1	1.3	1.9
Network with Victoria	0.0	0.0	9.9	5.9	1.9	0.0

Data Quality Issues

- Database structure
- Lack of a single comprehensive data set
- Large quantities of free-text data
- Missing data
- Systematic differences in data quality

Discussion

- Higher notification rates in children reflects increased rates of testing and existence of screening programs
- Disproportionate rise in rates among older adults warrants further investigation
- Concentration of notifications rurally has resourcing implications
- Current system makes reviewing and reporting epidemiology challenging

Conclusion and recommendations

- Notifications of elevated blood lead have increased over time in NSW line with changes to the case definition
- Recommend system improvements to improve data quality
- Consider resource implications prior to any further changes to the case definition

Acknowledgements

- Dr Ben Scalley
- Dr Jeremy McAnulty
- Associate Professor Martyn Kirk
- NSW Health
- Australian National University, Canberra

Appendix 5 - Presentation at the International Society for Environmental Epidemiology (ISEE) Conference, Sydney, Australia, September 2017

The epidemiology of elevated blood lead level notifications in New South Wales, Australia, 1997-2016

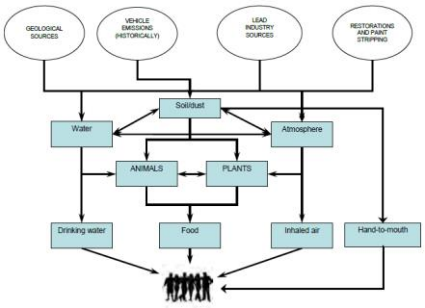
Katherine Todd, Ben Scalley, Martyn Kirk, Jeremy McAnulty
Environmental Health, Health Protection NSW
Master of Philosophy (Applied Epidemiology), Australian National University

NSW Health
Australian National University

Background

- Lead is a naturally occurring metal that is widely used in manufacturing processes
- Lead accumulates in the environment over time
- Populations can be exposed to lead in a variety of ways

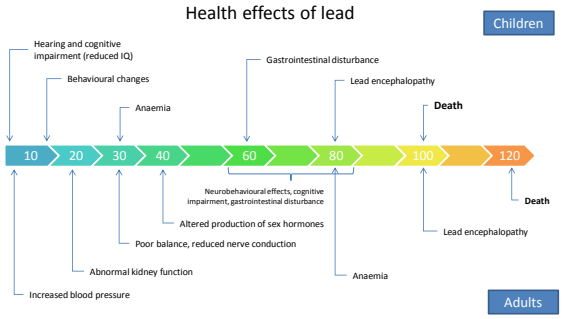
Figure 1: Principal pathway of lead from the environment to humans



Source: Environment Protection Agency (USA). Air Quality Criteria for Lead, Volume I (2006).[10]

Health effects of lead

- Exposure to lead can cause health impacts
- 0.6% of the global burden of disease (2004)
- The average background exposure in the Australian population is not known but the average blood lead level is estimated to be less than 5µg/dL



New South Wales

- Largest population in Australia
- Population ≈ 7.7 million
- 15 local health districts

Blood lead surveillance in NSW

- Increased regulation of lead since 1970s
- Notifiable in NSW since December 1996
- Case definition changed over time in line with NHMRC recommendations
  - 1996 –2011: ≥15 µg/dL
  - 2012-2015: ≥10 µg/dL
  - **2016 onwards: ≥5 µg/dL**

Project aims

Describe trends in lead notification rates in NSW since 1996

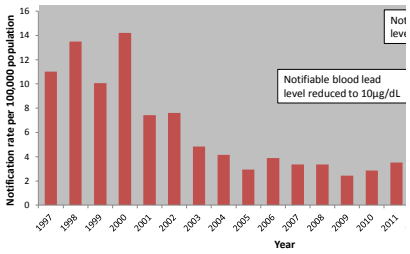
Methods

- Data extracted from surveillance system
- Population rates calculated using information from the Australian census
- Data analysis STATA version 14.1

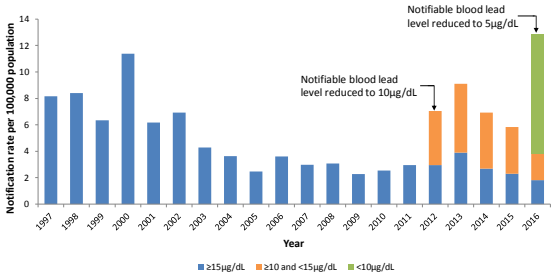
Results

- In NSW between 1997-2016:
  - 9,486 notifications
  - M:F ratio of 9:1
  - 13% aged under 5 years
  - Average notification rate 6.9 per 100,000

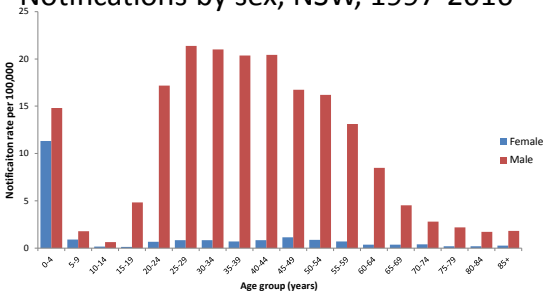
Trends in notifications, NSW



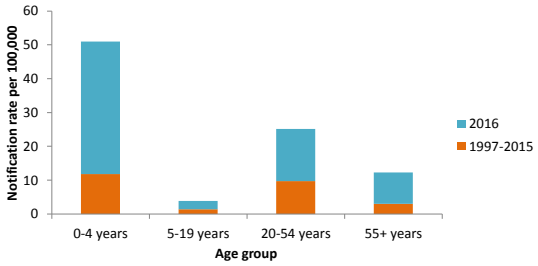
Trends in NSW by lead level



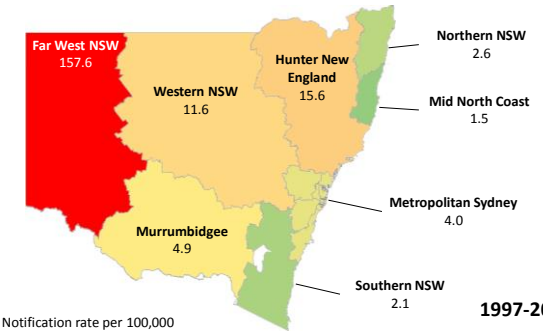
Notifications by sex, NSW, 1997-2016



Notification rate by age group

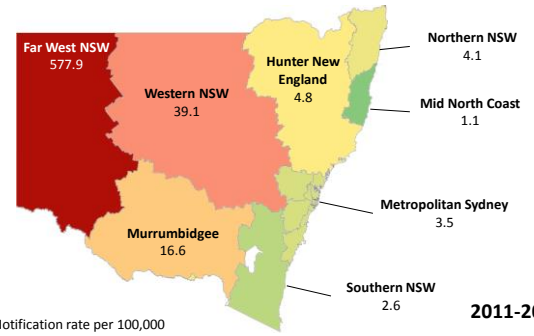


Notification rate by Local Health District



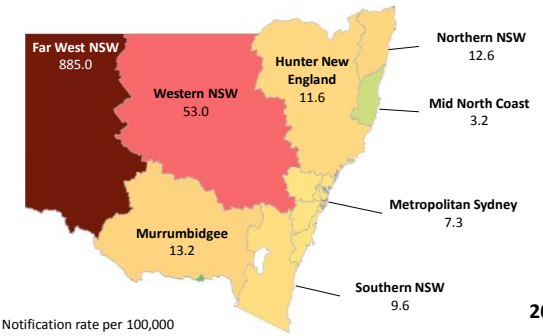
Notification rate per 100,000

1997-2011



Notification rate per 100,000

2011-2015



Notification rate per 100,000

2016

Limitations of the analysis

- Large quantities of free-text data
- Missing data
- Lack of data regarding exposure
- Systematic differences in data quality

Summary

- Notifications of elevated blood lead have increased over time in NSW line with changes to the case definition
- Notifications over 15µg/dL have declined over time
- Notification rates are highest in children aged 0-4 years and in Far West NSW Local Health District
- Current data capturing system makes reviewing and reporting epidemiology challenging

Conclusion and recommendations

- Decline in notification rates over 15 µg/dL
- Highest rates in age 0-4 year group likely represents increased rates of testing
- Disproportionate rise in rates among older adults warrants further investigation
- High rates in Far West LHD represent both environmental exposure and existence of screening program
- Recommend system improvements to improve data quality

Chapter 5
An evaluation of the NSW elevated blood lead surveillance system

View of the Broken Hill Line of Lode and Miner's Memorial, as seen from the window of the Broken Hill Public Health Unit, August, 2017

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Abbreviations used in this chapter

CDB	Communicable Diseases Branch
CDC	Centers for Disease Control and Prevention
EHB	Environmental Health Branch
GP	General Practitioner
LHD	Local Health District
NATA	National Association of Testing Authorities
NCIMS	Notifiable Conditions Information Management System
NHANES	National Health And Nutritional Examination Survey
NHMRC	National Health and Medical Research Council
NSW	New South Wales
PHU	Public Health Unit
QLD	Queensland
SA	South Australia

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Prologue

My role

I spent the period from November 2016 to July 2017 within Environmental Health Branch of Health Protection NSW. The surveillance of elevated blood lead levels was identified as a key area within the branch where improvements could be made. The evaluation of the lead surveillance system was going to be my first project conducted during my placement in environmental health; however, as I gained an understanding of the complexities of the database and the data (consisting of surveillance data for over 20 years, from December 1996), the analysis of the database became my first project, and the evaluation became my second project.

I took the lead role in this project, supervised by Dr Ben Scalley, the Director of Environmental Health Branch, as well as my field and academic supervisors Dr Jeremy McAnulty and Associate Professor Martyn Kirk. I wrote the initial protocol outlining the project plan and objectives of the evaluation. I designed the semi-structured questionnaire (Appendix 3), which I consulted on in draft form with key stakeholders to incorporate their comments into the final questionnaire.

I conducted all interviews. This involved travelling to several public health units (PHUs) in NSW (including Liverpool in Sydney's southwest, Newcastle, and Broken Hill) as well as speaking with key people in Health Protection NSW.

The majority of information collected was qualitative. I analysed the interview notes thematically and identified key trends and concerns. I had originally planned to conduct further consultation as required, but key themes emerged early on and were consistent between key stakeholders, and thus I felt I had achieved thematic saturation. Some information gaps were identified during the analysis and writing process and thus PHUS were further consulted via the dissemination of a short questionnaire (Appendix 4).

I wrote the final report of the evaluation, and will report a summarised version of the results back to key stakeholders within Health Protection NSW and the Public Health Unit network.

Lessons learned

I learned several lessons during the execution of the project. In many ways, this was the most challenging project of my MAE as it was so unlike anything I had completed before.

In retrospect, although I consulted with key people in the development and completion of this project, I would have found it useful to have conducted more extensive consultation earlier. I identified many "unknown unknowns" via speaking with key people, such as nuances in how the

system worked or people with key knowledge of the system that I hadn't identified, that would have been very useful information earlier in the process. Overall, I think I persisted too long on my own without appreciating the knowledge others could provide.

It was also challenging to strike a balance between quantitive and qualitative information gathering. I identified many specific questions I wished I had asked as I wrote the report, for example average time frames for notification response by PHU. In future evaluations, I would have focused more evenly on quantitative and qualitative data rather than taking such a heavy focus on qualitative information, I would also have allowed for more time to complete the process iteratively to allow for emerging issues to explored more fully during the analysis process, either by a secondary survey or subsequent interview.

I learned to be flexible and to take the lead in this project. When we travelled to Broken Hill, although it was intended that a delegation from Environmental Health Branch of myself, Ben and Jeremy would go, flight delays meant that at the last minute only I was able to make the trip. I had to represent NSW Health, establish relationships rapidly and identify key people to speak with during my limited time there. I was proud of how I met the challenge and found this a great learning experience.

If I were to do this project again I would have approached it quite differently, allowing more time for iterative information gathering, undertaking earlier and more comprehensive formal and informal consultation, as well as appreciating the value of a team-based approach more. Nevertheless, I feel that the knowledge gained from this project will be valuable for improving the lead surveillance program in NSW and making it more effective and useful for users and the community.

Public health implications

Many weaknesses of the lead surveillance system were identified during this evaluation. Systems can accumulate a complex legacy over time and via incremental changes, and periodic evaluation is essential to ensure their effective ongoing operation. I also identified that surveillance systems can be ineffective if the surveillance cycle (of dissemination of results) is not completed; this can also lead to a perception that the surveillance system is not useful or indeed necessary.

Abstract

Introduction

Surveillance is an essential feature of epidemiological and public health practice, providing information about health events and outcomes and supporting policy development and research. Lead is a metal widely used in human activities, and lead exposure can cause acute and chronic health effects. Lead surveillance systems are in place in NSW to monitor blood lead levels and facilitate case management, and take appropriate public health action to minimise exposure. I evaluated the surveillance system for elevated blood lead in NSW to see whether it was meeting its aims and objectives, and to gain perspectives from users on its data quality, simplicity, flexibility, acceptability, representativeness, timeliness, stability and sensitivity.

Methods

I used the United States Center for Disease Control and Prevention (CDC) guidelines for evaluating surveillance systems. I conducted 16 face-to-face semi-structured interviews with key stakeholders from across NSW Health, including in Health Protection NSW and Public Health Units. I distributed a short questionnaire to public health units to gather further information. I also incorporated the results of a review of the data stored in the system, described in further detail in Chapter 5.

Results

Elevated blood lead poses a unique challenge in NSW, as the only non-infectious notifiable condition under surveillance. Weaknesses in the data collection system and poor-quality data have led to a lack of regular review and reporting of surveillance information, meaning that the cycle of surveillance is not complete. Key barriers to the effective use of the surveillance system included the use of alternative databases in parallel with the system in some public health units, confusion around and heterogeneity in application of the response protocol, differences in thresholds for notification of elevated blood lead between NSW Health and Safe Work NSW, and a lack of information about how risk factors for lead exposure have changed over time. I made a number of recommendations to improve blood lead surveillance system in NSW, with those pertaining to data entry and data quality deemed most urgent for rectification.

Conclusions

The surveillance cycle is incomplete as there is no regular dissemination of surveillance data to those who need to know, nor coordinated public health action rising from this. Improvements should be made to the response protocol and NCIMS database to streamline collection and analysis of data, and promote a uniform response to notifications across the state.

Background

Introduction

Public health surveillance involves the systematic and continuous collection, analysis, interpretation and dissemination of data. Surveillance is an essential feature of epidemiological and public health practice and provides the evidence-base required for informed decision-making and to conduct public health prevention and control programs. Surveillance data should not only provide information about the health events and outcomes under surveillance but also lead to policy development and research, by identifying issues requiring action or further information needs[1-3].

Periodic evaluation of surveillance systems is essential in order to ensure their ongoing usefulness and cost-effectiveness[4]. Evaluation of public health surveillance systems should include consideration of:

1. The public health importance of the event
2. The usefulness and cost of the surveillance system (e.g. whether it is meeting its goals and at what cost)
3. The explicit attributes of the quality of the surveillance system, including sensitivity, specificity, representativeness, timeliness, simplicity, flexibility, and acceptability[1].

In addition, the timely dissemination of surveillance data to those who need to know, including regular publication of the data together with interpretation and analysis, is an essential component of a useful surveillance system[1].

The public health importance of lead exposure

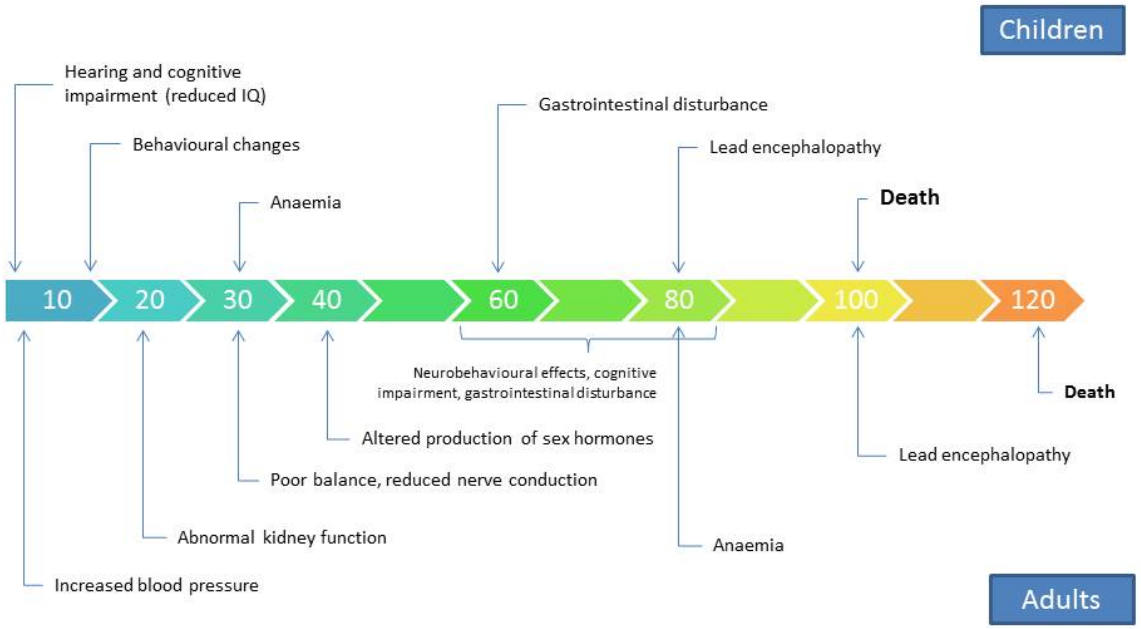
Lead is a naturally occurring metal whose physical properties (including low melting temperature and malleability) and relative abundance make it useful for a wide range of human applications. These include the production of solder, batteries, x-ray shielding, ceramic glazes, and ammunition. Some historical applications of lead compounds such as use in leaded paints and petrol have been reduced or eliminated in much of the developed world due to evidence of adverse health effects from lead; nevertheless lead remains ubiquitous in the environment[5, 6].

The toxic effects of lead have been known since antiquity, and in the 19th century with the Industrial Revolution lead poisoning became a common occupational disease[6]. Lead poisoning in Australian children was first recognised in the late 1890s, in a case series of 10 children with clinical symptoms of lead poisoning later connected to exposure to weathered lead-based paint on veranda rails. This

led in in 1922 to one of the first acts of legislation in the world regulating the use of lead, when lead-based house-paints were banned in Queensland[7].

Lead accumulates in the body over time and affects many body systems (Figure 1).

Figure 1 - Health effects of lead at various blood lead levels (in µg/dL) for adults and children[8]



Lead exposure in adults can cause anaemia, renal damage and hypertension, and at levels above 80µg/dL, cause encephalopathy and death. Chronic low-level exposure (such as occupationally) has been shown to be associated with subtle cognitive deterioration and brain matter loss[5]. Children are much more vulnerable to lead poisoning than adults, partly because they absorb four times more lead than adults and also because they are more likely to be exposed to lead from crawling on floors and hand-to-mouth activity[7]. Effects in children occur at lower levels than adults, and population-level studies have shown that even among asymptomatic children exposure to lead can have significant effects on the developing brain including a reduction in IQ and behavioural disturbances.

The Australian Government National Health and Medical Research Council (NHMRC) evaluated two moderate-quality systematic reviews on the health effects of lead and drew the following conclusions:

1. Blood lead levels <5µg/dL are associated with adverse cognitive effects in children, although literature suggests uncontrolled confounding may play an important role in the findings regarding IQ
2. Blood lead levels <10µg/dL are associated with the following health effects:

- Adverse behavioural effects among children
- Delay in sexual maturation or puberty onset in adolescents
- Increased blood pressure and risk of hypertension among adults and pregnant women (although there is uncertainty regarding the clinical significance of this)[5].

The management of elevated blood lead levels in individuals involves identifying the source of exposure (including consideration of multiple lead sources in the environment), and then interrupting the exposure pathway[9]. General interventions depend on the route of exposure. The renovation of houses built before 1970 remains a significant potential risk for lead exposure[10]. Renovation of old houses may involve scraping and burning of lead-based paints off walls and window frames – a typical house built in 1900 may contain anywhere between 200 and 600 kilograms of lead in the paint layers[11]. If the source is renovation of older homes, sealing of the affected area during home renovations, thorough cleaning of homes using a HEPA filtered vacuum cleaner, and wet mopping prior to reoccupation is recommended. Those who participate in lead-related hobbies (such as lead-lighting or shooting) should utilise personal protective equipment and restrict access by children to areas the hobbies are carried out. People should avoid purchasing and using lead-containing products, particularly those purchased overseas such as cosmetics and Ayurvedic medicines. Those who work in lead industry should keep clothing that may be contaminated with lead separate from other clothes (ideally at the workplace) and not comingle these in family washing. Those who live in lead-endemic areas should be provided with education about preventative strategies such as frequent vacuuming, mopping, providing appropriate grass cover for outdoor areas, and the importance of hand washing. In some instances complete removal of the source of lead exposure may not be possible or practical[9].

Lead surveillance in NSW

In Australia, public health surveillance for elevated blood lead occurs at the state level. Not every state has elevated blood lead as a notifiable condition, and the level at which an elevated blood lead level is notifiable also varies (Table 1).

Table 1 – Lead surveillance within Australian jurisdictions and New Zealand in 2017

Jurisdiction	Notifiable?	Notifiable blood lead level
New South Wales	Yes	A person with a venous blood lead level of ≥5µg/dL
Tasmania	Yes	<5µg/dL where the person has not been occupationally exposed to lead
Queensland	Yes	Blood lead level of ≥10µg/dL
Victoria	Yes	Blood lead >5µg/dL
Australian Capital Territory	No	-
South Australia	No	-
Northern Territory	Yes	Blood lead >5µg/dL
Western Australia	Yes	Concentration of lead in a person's whole blood at or above 5µg/dL
New Zealand	Yes	Whole blood lead level ≥10µg/dL. At this level, public health interventions are required for children and non-occupationally exposed adults

Significant community-wide lead exposure in children is now uncommon in Australia, and is limited to towns where exposure results from mining, processing or transporting lead. These towns include Broken Hill (New South Wales), one of the largest lead mine ore sites in the world, Port Pirie (South Australia) where there is a major lead smelter, and Mount Isa (Queensland), a site of extensive lead, sliver and zinc mining[7]. All of these communities have ongoing targeted monitoring and intervention programs that have been successful in reducing the lead exposure of children[7].

The NSW public health system is governed by the central Ministry of Health, which purchases health services through a network of Local Health Districts (LHDs). There are fifteen LHDs throughout NSW, each served by one or more Public Health Units (PHUs) that are responsible for responding to reports of notifiable diseases within their jurisdictions. Centrally, Health Protection NSW is responsible for coordinating surveillance and public health response including monitoring the incidence of notifiable diseases at a state-wide level[12].

Elevated blood lead levels (also known as "lead poisoning") have been notifiable in NSW since December 1996, one of a number of surveillance systems managed by NSW Health[13].The NSW blood lead surveillance has two main objectives[14, 15]:

1. To identify cases and recommend appropriate risk reduction measures

2. To monitor the epidemiology of elevated blood lead levels to inform the development of better risk reduction strategies

Under the *NSW Public Health Act2010*, pathology laboratories are required to notify cases of elevated blood levels to their local PHU on identification[14]. The case definition of an elevated blood lead level has changed over time – under the current case definition, a confirmed case is:

*A person with a venous blood lead level of **≥5 µg/dL** (0.24µmol/L)*

Prior to February 2016 the level for notification was ≥10 µg/dL (0.48µmol/L), and prior to May 2012 it was ≥15µg/dL (0.72µmol/L)[14]. These changes to the notification level were made on the basis of NHMRC recommendations, which found based on a review of the literature that a blood lead level of greater than five micrograms per decilitre suggests that a person has been or continues to be exposed to lead at a level above what is considered the average "background" exposure in Australia, and that therefore the source of exposure should be investigated and reduced[16]. These changes closely mirror changes made in the United States of America by the Centers for Disease Control and Prevention (CDC), which in 2012 reduced the level of concern to ≥10µg/dL in blood, and in 2016 changed the threshold to 5µg/dL based on the 97.5th percentile of the National Health and Nutrition Examination Survey (NHANES) which measured the distribution of blood lead values in children. The CDC also changed the terminology to remove the descriptor "level of concern", reflecting evidence from population-wide surveys that suggest there is no "safe" level of lead[17].

In NSW, pathology laboratories are required to notify a positive result for a specified notifiable disease using the specified form (Appendix 2) either in writing by fax or mail to the local PHU, or by electronic laboratory notification directly to the Notifiable Conditions Information System (NCIMS)[18]. NCIMS has been in use since 2010 and is a confidential application that provides state-wide data capture, management and reporting of scheduled medical conditions notifiable under the *NSW Public Health Act 2010* from pathology laboratories, general practitioners and hospitals[15, 19]. NCIMS is routinely used as a case-management tool rather than an analysis tool; however, it does have the function to export aggregate data as a spreadsheet.

Surveillance data entered in NCIMS are stored in the Secure Analytics for Population Health Research and Intelligence (SAPHaRI) digital warehouse. SAPHaRI is designed to provide data in a format that is ready to be analysed and reported for the purposes of epidemiology and surveillance, and contains databases of health, demographic population and geographic data[20]. The SAPHaRI analytics system does not typically export all information recorded in NCIMS: the NCIMS export dataset contains 551 variables, compared to the 300 core variables routinely extracted in SAPHaRI.

Response to a notification of an elevated blood lead level is done at the LHD level by the PHU. The response protocol (Appendix 1) following a notification involves the PHU:

1. Confirming with the treating doctor any symptoms associated with exposure, including the onset date
2. Contacting the case (with permission of the notifying doctor) to interview the case or their parent/guardian
3. Identifying household contacts who may also be at risk of elevated blood lead levels

Actions that should be taken are determined by the age of the case and the blood lead level (Table 2).

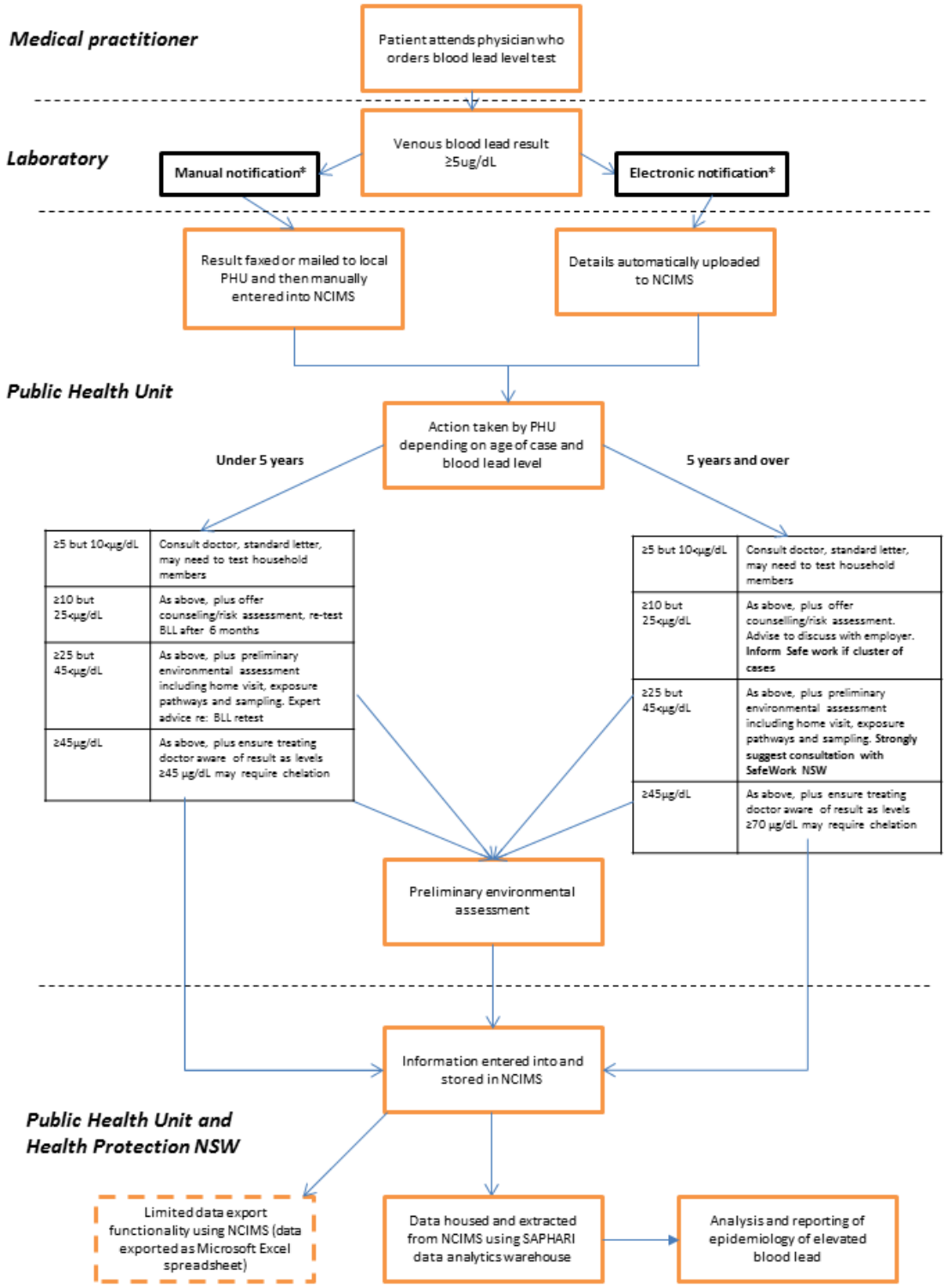
Table 2 - Blood lead levels and corresponding actions taken by PHU according to age

Age	Blood lead range			
	≥5 but 10<µg/dL	≥10 but 25<µg/dL	≥25 but 45<µg/dL	≥45µg/dL
< 5 years	Consult doctor Standard letter May need to test household members	Consult doctor Standard letter Offer counselling/risk assessment May need to test household members Retest BLL after 6 months	As for level 2 plus: Preliminary environmental assessment including home visit, exposure pathways and sampling Expert advice re: BLL retest	As for level 3 plus: Ensure treating doctor aware of result as levels ≥45 µg/dL may require chelation
≥5 years	Consult doctor Standard letter May need to test household members	Consult doctor Standard letter Advise to discuss with employer Inform Safe work if cluster of cases Offer counselling/risk assessment May need to test household members	As for level 2 plus: Preliminary environmental assessment including home visit, exposure pathways and sampling Strongly suggest consultation with SafeWork NSW	As for level 3 plus: Ensure treating doctor aware of result as levels ≥70 µg/dL may require chelation

If the source of the exposure is not clear after the initial investigation has taken place, the PHU arranges an environmental assessment of the residential area if the case's blood lead level is in excess of 25µg/dL (1.2µmol/L) and/or the implicated source may affect the broader community[14]. SafeWork NSW, the state workplace health and safety regulator, is consulted if there is any suspicion of a cluster of occupationally exposed cases occurring or if blood lead levels of >25µg/dL are notified

in an adult who may have been exposed in the workplace. Figure 2 illustrates the Surveillance system in full.

Figure 2 - Blood lead surveillance system in NSW: flow chart



**Not all private laboratories in NSW are enabled for electronic laboratory reporting (ELR). Those that are not send manual notifications to the PHU by mail or fax*

Aims of the evaluation

The aims of this evaluation were to systematically evaluate the attributes of the current surveillance system in use for elevated blood lead levels in NSW and highlight areas for improvement.

Methods

I used the United States Centre for Disease Control guidelines for evaluating surveillance systems for this evaluation[21]. The evaluation focused on the both the framework around which the surveillance system operates (such as protocols, data repositories and stored data) as well as the value gained from surveillance and whether the surveillance system is meetings its objectives. This included stakeholder consultation as well as analysis of the database that houses the notification data, analysis interpretation of the collated data and the feedback mechanisms to stakeholders.

The assessment of quantitative system attributes (timeliness, data quality and representativeness) was conducted by an analysis of NCIMS data including an analysis of data completeness of sex, Aboriginal status, and blood lead level data fields. Qualitative system attributes (simplicity, flexibility and acceptability) were assessed through semi-structured in-person interviews with stakeholders. Additional information was obtained via an email survey of public health unit staff.

It was beyond the scope of this evaluation to evaluate processes used by SafeWork NSW in assessing and managing occupational lead exposures, however the results from this evaluation will be important for SafeWork NSW and a collaborative approach by both agencies going forward will ensure that occupationally exposed persons with elevated blood lead levels are identified and managed appropriately.

Stakeholders

The main stakeholder groups and methods of consultation are described below:

- Health Protection NSW staff
    - Environmental Health Branch staff
        - Executive
        - Policy officers
    - Communicable Disease Branch staff
        - Surveillance staff
        - Laboratory liaison staff

- Public Health Unit staff
    - Public health nurses
    - Environmental health officers
    - Directors
    - Epidemiologists
    - Public health physicians
    - Administrative staff
- Additional stakeholders
    - Health Service directors
    - Community health nurse
    - Aboriginal health nurse

Data collection and analysis

Sampling

Semi-structured interviews

Semi-structured interviews were conducted with key personnel using the questions outlined in Appendix 3. I conducted all interviews, which lasted between 30 and 60 minutes. Approximately half of interviews had notes taken by hand during the interview which were then analysed for themes. The other half of interviews were recorded and then transcribed and analysed for themes.

Questionnaire

A short questionnaire was disseminated to public health unit directors, requesting that they provide it to the key person responsible for managing lead notifications in their unit for comment and return. It contained a series of yes/no questions with additional room for comment on: the usefulness of NCIMS; whether the PHU used any additional database to collect and store data; whether the PHU utilised a dedicated questionnaire; who at the PHU routinely followed up notifications; whether the PHU routinely produced reports describing the epidemiology of elevated blood lead levels; how the PHU sourced aggregate data, and whether the person completing the questionnaire had any suggestions for improving the surveillance system or other comment.

Results

A total of 16 face-to-face interviews were conducted with key stakeholders. Everyone who was approached for interview agreed to be interviewed (100% response rate). Nine short questionnaires were received back from 16 Public Health Units (56% response rate). Several non-responders to the

questionnaire had previously been interviewed during the face-to-face interview stage, so that only two of the 16 Public Health Units did not provide any feedback to the evaluation.

Objectives and utility

The lead surveillance system has the objectives of:

1. Identification of cases and recommendation of appropriate risk reduction measures
2. Monitoring the epidemiology of elevated blood lead levels to inform the development of better risk reduction strategies

In practice, the first objective was well achieved. All consulted PHUs followed up lead notifications to some degree, although the time frame this was done in varied. For some PHUs if there were more pressing issues, lead was treated as less of a priority:

> *"In general sense, we try and respond within a week or two… if we are short on resources it can get left [longer]".*

The degree of response varied by where the case was notified (with some PHUs following up more than others) and on the lead level notified (the higher the blood lead level of the case, the greater the response from the PHU). There was some disagreement about whether the lead surveillance system was useful or indeed necessary:

> *"The value of lead notifications needs to be questioned".*

> *"Lead is a less significant issue now that it has been in the past".*

> *"Certain PHUs are more reactive than others – some don't see lead as a problem."*

PHUs identified a lack of clarity around the protocol and guidelines, as well as a lack of visibility of lead generally and unclear understanding of what was wanted from the system, as barriers to the system being useful for them. Front-line staff were willing to follow up lead notifications but sometimes felt their efforts were a waste of time, and they felt they didn't understand exactly what was wanted from the state health department.

> *"[It would be good to] clarify the guidelines and ensure they make sense, and for there to be feedback to PHUS about what we want to know about, particularly risk factors.*

> *"The protocols should be more prescriptive."*

The monitoring of epidemiology occurred less consistently across the network, with only 56% of surveyed PHUs producing reports on the epidemiology lead notifications within their LHD. These reports were solely for internal use apart from Far West LHD, which produces an annual report describing the Lead Health Program including discussion of the epidemiology of elevated lead notifications annually[22]. At the state level, the number of notifications of elevated blood lead annually was reported in the Health Protection Annual Report with other notifiable disease counts, but not elsewhere. Challenges in using the dataset and a low perceived importance of lead as a public health issues were two of the key limitations identified in reviewing the epidemiology of lead.

> *If I could improve one thing about lead notifications, it would be the data quality and completeness, to better enable us to do centralised analysis and reporting [at the state level]*

A general theme among stakeholders was that elevated blood lead was an overlooked and challenging notifiable disease, particularly as it is unique among notifiable conditions as being a marker of potential disease rather than an acute problem, usually asymptomatic, and non-infectious. There was a sense of a lack of strong ownership of lead surveillance by any one body or group.

> *"There are issues with usability [of the system] due to a lack of strong ownership… there is no-one driving the agenda for lead."*

The decentralised nature of public health in NSW further made it difficult for any one person to have an overarching grasp of lead as a public health issue. This lack of ownership had impacted on the usability of the system as it was used to satisfy legislative requirements and for individual case follow up but not for ongoing research, evaluation or systematic public health action.

> *"Clarifying the requirements and aims of the system would be useful, and making it clearer who ultimately owns the issue."*

RECOMMENDATION:

1. Review the lead response protocol to ensure the response required from PHUs is clear, both in terms of case follow-up and information collection and reporting requirements
2. State explicitly in the response protocol who has responsibility for specific actions, including clarification of the roles of PHUs and of Environmental Health Branch

Uses of data

Data collected from notifications is primarily used to follow-up individual cases. On a state level, aggregate data in the form of number of notifications is reported in the annual report by local health district, but there is no regular analysis or further breakdown by age, sex, or exposure.

Reasons that the data was not further utilised for the purposes of surveillance were primarily due to weaknesses in the data collection system, including significant volumes of missing data and challenges in extracting and cleaning it to allow it to be analysed in aggregate.

> *"I feel [lead] is falling through the gaps a bit as there is no real reporting or analysis."*

> *"Extracting the data can be challenging and the system is difficult to use. It is sometimes difficult to answer basic questions – this is due to both the system and the data quality. I think the design of the system leads to poor quality."*

> *"The data collected is good for general things; time, place and person [within the notifications] is somewhat covered. However, go anything beyond basic information (such as trying to look at levels or exposure) and it all falls apart."*

In addition, Environmental Health has responsibility for elevated blood lead, but the data collection and management is overseen by the Surveillance team in the Communicable Disease Branch. Environmental Health staff identified that they lacked experience in this area and that surveillance is not typically part of their core business.

> *"The Surveillance team maintain the system that collates the data, but they don't do anything with it – Environmental Health are responsible for monitoring."*

> "*Environmental Health don't usually do surveillance… it is not our core business, we have skills in other areas that are not necessarily surveillance."*

Overall the surveillance data wasn't being used to its full potential, both due to the complexity and weaknesses of the dataset and because the custodians of the data did not have primary responsibility for its analysis.

RECOMMENDATION

3. Introduction of regular reporting requirements for lead (such as a quarterly or annual review of the epidemiology and of data completeness) would lead to timely identification of challenges with the dataset and provide information for ongoing improvements to the system
4. Continuing education for Environmental Health branch staff in the collection and analysis of surveillance system data and in the use of NCIMS and SAPHARI would lead to improved confidence of the staff in owning the lead surveillance system
5. Regular data review meetings between the Surveillance team and the Environmental Health team would enable both groups to have a greater understanding of the current state of lead surveillance in NSW

System operation

Legislation

In NSW, notifiable conditions are legislated under the *Public Health Act 2010*. The Act has the following objectives: to promote, protect and improve public health; to control risks to public health; promote the control and prevent the spread of infectious diseases; and to recognise the role of local government in protecting public health.

Schedule 1 of the Public Health Act lists elevated lead as a scheduled medical condition in **category 3**, with the following definition:

Lead in blood (as defined by a blood level of or above 5µg/dL)

For items in category 3, the *Public Health Act* requires pathology laboratories to notify the Secretary or delegate if:

1) A pathology test is carried out at the request of a registered medical practitioner for the purpose of determining whether a person has a category 3 condition, and
2) The test has a positive result.

In these circumstances, the person who certifies the test results (the certifier) must send to the Secretary (or delegate) a report, in the approved form, as to those results as soon as practicable.

Notifications to the system depend on laboratories being aware of their obligations and reporting the results to Public Health Units; this can lead to challenges when new, inexperienced or unaccredited laboratories are used, particularly when these are chemical and not pathological laboratories.

> *"The Public Health Act has some loopholes… new labs aren't always aware that there is a requirement for notification. We need to ensure labs understand their obligations"*

Under SafeWork legislation, laboratories performing occupational surveillance of elevated blood lead need to be accredited by NATA, the National Association of Testing Authorities Australia. However, in practice use of NATA-accredited laboratories did not always occur:

> *"In the case I was involved with, the company (a heavy metal recycling facility) was getting the results and then the company was sacking them [if they were high]. The results had been coded by the company and the lab initially refused to release the results so that we could do follow-up – they classified them as 'commercial in confidence'."*

> *"[There are] differences in how it was notified – e.g. biochemistry labs may not have been notifying although pathology labs might have been; this is a gap under the Public Health Act".*

In October 2017, the legislation was amended to the following:

1) A pathology test is carried out at the request of a registered medical practitioner **or other person of a class prescribed by the regulations** for the purpose of determining whether a person has a category 3 condition, and
2) The test has a positive result.

This was done to close the loophole by which non-medical personnel were requesting blood lead levels from biochemical laboratories and then not notifying them. This amendment strengthens the legislation around surveillance of elevated blood lead in NSW.

RECOMMENDATIONS

6. NSW Health and Safe Work NSW should collaborate to regularly communicate with laboratories (NSW health) and workplaces (Safe Work NSW) to provide education about blood lead and remind of them of their testing and notification obligations

Data sources and information collected

The initial data source for notifications is laboratories, including any detail included by the doctor on the request form when ordering the test. The key information collected from the laboratory is shown in the laboratory notification form in Appendix 2. In practice, not all the information is routinely collected or included. Following notification of an elevated blood lead level, additional information about symptoms, exposure, occupation and risk factors is collected by either environmental health officers, surveillance officers, public health nurses, administrative officers or community health workers depending on the PHU and added to NCIMS. The data stored in NCIMS is secured using a username and password, and access is audited.

> *"NCIMS is quite sophisticated. It is web-based and secure. It is internet accessible so this does it expose it somewhat; however, access is audited".*

A further layer of security via two-factor authentication is anticipated to be added in the coming months for the entirety of surveillance in NSW. This will involve users outside of the Health Network (for example, the access NCIMS over the internet) to supplement their user name and password with a code sent via SMS. This will make data protections even stronger.

Challenges included classifying notifications by address vs place of exposure, particularly for occupational exposures. Some PHUs reported issues with the address recorded as being the workplace rather than the home, which had implications for coding of the notification.

> *"Quite often we will get worker notifications – it takes a lot of time to get their residential address. Often the employer will be reluctant to provide this; this can take a lot of time to follow-up."*

> *"Different PHUs enter the data differently – for example some list the address where the individual was exposed and other list the home address. This might hide clusters."*

Transfer and management of information

As outlined earlier, information is transferred either electronically or via mail or fax from the laboratory to the public health unit. The laboratory notification system, specifically ELR (electronic laboratory reporting) was identified as a strength of the system; however, a lack of awareness among some laboratories was a weakness.

Information sharing between Safe Work NSW and NSW Health was identified as a particularly unclear component of the system with a lot of uncertainty about what information could be shared and when.

> "[*We would like] written clarity of the mechanisms by which we can contact SafeWork and identify a workplace or a staff member with elevated lead issues or concerns".*
>
> *"Clarification in the Control Guidelines is required to clarify what information can legally be disclosed to SafeWork NSW and to an employer by the PHU. Not all employers are requiring their staff to undertake blood lead test, so an employee may find out they have an elevated blood lead level without their employer's knowledge of the test being conducted. There are potential risks to the privacy of individuals and their continued employment, particularly with small employers and/or small communities, if notification of a perceived occupational exposure to SafeWork results in workplace inspections."*
>
> *"There is not much sharing with any other agency. If we were to share with Safe Work there would be significant legal challenges [to overcome] – although workplaces and Safe Work are interested [in sharing information]."*

PHUs identified potential risks to the privacy of individuals and their continued employment, particularly with small employers and/or small communities, if notification of a perceived occupational exposure to SafeWork results in workplace inspections. GPs were also concerned about data sharing (see Box 1).

BOX 1 – Challenges of managing occupational cases

A case is aged in his/her early 30's and is an employee at a small electroplating company (approximately 15 employees) in a small town. With symptoms of gross fatigue & lethargy, the case has had significant time off work on sick leave and has a blood lead level of twice the NHMRC recommended level. The case believes that the other workers have far greater exposure to lead than s/he, yet is aware of no other staff having had blood tests. The premises next door is also an electroplating company and case believes none of those staff have blood tests either.

The case's GP contacted the PHU and advised that he expected that PHU would notify SafeWork as it is a notifiable condition. The GP did not feel that he could contact SafeWork or the employer, as that would be a breach of patient confidentiality. The case was not comfortable discussing this with the employer or WorkCover, as s/he felt that it could jeopardise their employment.

Occasionally, who "owned" the information reported to the surveillance system was unclear – some workplaces felt they owned the health information of their employees rather than any treating doctor. This in a few cases led to non-notification of the result, but more frequently complicated the follow-up by the PHU.

"[In one case] the results had been coded by the company and the lab initially refused to release the results so that we could not do follow-up – they classified them as 'commercial in confidence'."

This is a unique complication of lead notifications and one that merits greater scrutiny, particularly if workers perceive lead testing to be a punitive measure that may jeopardise their employment rather than an action taken to protect them from health effects from workplace exposure.

RECOMMENDATION

7. Provide written clarity within the protocol about data sharing provisions with Safe Work NSW, including what information can be shared and when, and who to ask if they have uncertainty (e.g. Environmental Health Branch)
8. Clarify with Safe Work NSW what information is provided to employees and employers about blood lead testing and public health follow up, and if deficiencies are identified work with Safe Work NSW to ensure that information is provided that is clear and comprehensive (e.g. a brochure that outlines to workers that they should be having blood lead testing regularly if they are employed in a high-risk occupation, and that they can expect contact from the PHU if their level is high)

Analysis, interpretation, reporting and dissemination of data

Regular reporting of surveillance data was limited, primarily due to issues with data quality and usability. The changes to the notification level have also meant that comparing trends over time is made more challenging, particularly the data has been entered in a format that makes it nearly impossible to obtain easily interpretable information without significant cleaning.

"The changes to the notification level have meant that comparisons cannot be made easily over time."

"Data quality and follow-up is missing from the system."

"Data is not easily analysable at the state level due to the varying quality."

"Centralised analysis and reporting capability is not currently occurring."

Challenges include lack of sufficient detail and numbers not agreeing with each other across different data sets (for example, an export from SAPHARI will yield different case counts than an export from NCIMS). Data analyses are not done regularly at the state level, with the most recent

published report based on lead notification data was a review published in 2008[15]. This means that trends over time or changes in the epidemiology of notifications are difficult to monitor.

Overall, apart from the annual report and any individual PHU activities (which were limited), there is no dissemination of the results of surveillance, a key attribute of surveillance systems.

> *"I haven't seen any robust analysis of the data."*
>
> *"The cycle of surveillance is not complete in terms of analysis, interpretation and dissemination."*

This has limited the ability of the surveillance system to provide evidence to guide prevention activities.

RECOMMENDATIONS

9.	Implement regular reporting of surveillance data, both centrally and from PHUs, on a regular basis (e.g. quarterly or annually). This may require the development of a reporting template

Evaluation of system attributes

Simplicity

The protocol for lead surveillance in NSW is relatively short and simple; complexity arises in the variation in the application of the protocol in different PHUs and in different population groups (children are typically managed differently to occupational exposures).

> *"We try to make it as simple as possible, however there are complexities in lead as a whole which make it difficult [to design a simple system] – it is hard to be clear in a complex issue."*

The amount of follow-up that PHUs felt they were required to do varied. Some PHUS investigated extensively with home visits and environmental testing even for low lead levels, whilst others did no follow-up at all on notifications in the range 5-10µg/dL. Some PHUs had adapted or changed the existing protocol to better align with their own processes and/or resource limitations. This was often done in accordance with the importance the unit attached to elevated blood lead as a public health issue (which varied from being seen as an important problem, to an issue of little significance).

> *"Due to increased numbers [of notifications] since the decrease in the notifiable lead level, we have determined our own protocol to determine what notifications to investigate."*
>
> *"We address lead investigations for all minors as if they were children under 5 (as 16 or 17 is still a young age and not an occupational exposure), using the precautionary principle."*

"Lead is infrequently tested for or reported in --------. The PHU communicable diseases team liaise with the EHO team, who undertake inspections and sampling if the patient is agreeable and it is warranted, and discuss with the GP follow-up testing."

The entry of data into the surveillance system via laboratories was straightforward. Collecting other data could be challenging, for example, following up with GPs to gather information on occupational exposure. In addition, identifying the LHD to case belongs to – some are notified from the workplace and others from the home address so it is not always clear who should be doing follow up.

"Similar to follow up of other types of notifications, the medical practitioners who look after the cases are quite busy and some may not return telephone calls, even after leaving repeated messages. This is making it quite difficult to follow up with the case if the GP has not provided permission to contact the case (and to advise the case that the PHU will be contacting them".

Managing data and entering in the system was identified as having improved over time.

"There are differences between electronic and manual notifications; it's definitely getting easier with ELR."

Electronic lab notifications had significantly reduced the workload but some of the fields in NCIMS were thought to be irrelevant or not useful. This was reflected in the number of PHUs (44%) who maintained a separate data collection system (typically an excel spreadsheet) alongside NCIMS.

"We record information in a general EH inspection/complaint database".

"The data is really messy when you download it! We tried to download it and it's not great, particularly when you put "other" and we write about the hobbies. Which you can tick, but it doesn't really help you as it doesn't indicate which hobby it is. It's clunky!"

"I can't tell if the data is complete or of good quality".

Methods for analysing and disseminating the data were scant. Several stakeholders commented on the difficulty of extracting data from the system, particularly for some fields such as risk exposure. Some PHUs had developed their own methods (e.g. a SAS file that they ran weekly) but others simply never reviewed the data. At the state level, review of data was a complex process that had not been carried out for some years. Part of the reason for this was that the data sits between Environmental Health Branch and the surveillance team, and so no single person that was across all aspects of the system.

"There is a lack of visibility of some parts of the system and ways to extract the data can be challenging [and] are difficult to use. It can be difficult to answer basic question – due to both the system and data quality; but sometimes the design of the system also leads to poor data quality."

A familiarity with NCIMS or SAPHARI was also required to be able to analyse and understand the data.

"The system is easy to use if you know NCIMS."

Overall the system was relatively simple to input data into but not always particularly useful (see acceptability, below), and it was very difficult to extract data from the system quickly.

RECOMMENDATIONS

10. Make the lead response protocol more explicit to promote a uniform response to elevated blood lead level notifications across PHUs
11. Identify key data fields in NCIMS that are challenging for data entry and extraction (such as blood lead level and exposure) and address these as a matter of urgency to improve the usability of the system for data analysis (discussed in more detail in recommendations 12-14, below)

Flexibility

Changes to the surveillance system that have occurred over time include changes to the notification level and changes to the data storage system. The Public Health Act was amended in October 2017 to close a loophole regarding laboratory reporting as discussed previously. Potential future changes to the case definition that have been proposed include introducing a "possible" case as determined by capillary blood lead level testing.

One of the strengths of the NSW blood lead surveillance system is the ease with which changes to the case definition can be implemented – this included at the laboratory reporting level and operational public health unit level.

This was highlighted particularly with regards to laboratory notifications:

"The system has been adaptable to changes in the notification level and can change data fields reasonably easily "

"When a change happens to the case definition it is easy to inform labs – we just tell the labs via email and communicate with chemical pathologists. The labs can then just change the flag in their system"

"When we changed to NCIMS [from the NDDs] we moved from event-based surveillance to person-based surveillance, which has been a good change"

The ease with which changes to the surveillance system were made and implemented likely reflected the strength of surveillance systems in NSW generally, and the position of lead surveillance as a component within a larger surveillance system.

Some drawbacks to changes to the surveillance system over time included the accumulation of a "legacy" of changes, particularly missing or poor-quality data that had migrated from older to newer systems. Another drawback was a lack of awareness or confusion around the meaning of changes to the surveillance system among PHUs and the inability to gain an overarching perspective of the function of blood lead surveillance at the state level.

"I feel a lot of features [of the system] aren't relevant"

"NCIMS has a lot of pages – do we really need all that information? The information collected needs to be useful and helpful on the ground, it doesn't need to be cumbersome"

"I'm not really sure how information is collected and used"

The system is also not very flexible in terms of getting data out of the system to analyse.

"The enhanced data, for example exposure, is not easily accessible."

Changes to the case definition to incorporate capillary testing are planned; implementation of these will be simple and involve adding a field to NCIMS and changing the protocol.

Data quality and completeness

As previously outlined in Chapter 4, there was considerable variation in data quality within the blood lead surveillance system. Some key variables were of very poor quality with a significant volume of missing data. In general, demographic data was for the most part complete particularly for the key variables of age, date of birth and notifying jurisdiction.

Laboratory data was generally disorganized and sometimes of poor quality. Electronically transmitted data was of better quality than data that had been manually entered by PHU staff. The

data entry field for blood lead levels in NCIMS was free-text, leading to significant variation in the format and syntax of entries and making analysis very difficult. Variations included numbers, letters, symbols and indication of units in the values field. Examples of this idiosyncratic data entry include "Pb=11.4", "4.11 miumol/L" (sic) and "umol/L 8.81 µg/dL 16.8". This data was neither easily cleaned nor analysed. There were also several apparent duplications, where the same individual had multiple notifications from the same date and the same laboratory accession number.

Overall the data were difficult to access and analyse. Multiple methods were required to export the relevant data, which lead to difficulties in analysis, particularly when essential numbers such as case count were different when exporting from NCIMS as opposed to SAPHARI. Data for geographical area was organised by PHU office location, rather than by LHD – this was particularly troublesome for local health districts that are served by multiple public health units, as in the case of Dubbo and Bathurst (both located in Far West LHD) and made drawing conclusions about the rates in different LHDS a more complicated process.

There was a significant amount of missing data, particularly for occupation and exposure. Exposure was only recorded for 12.9% of notifications. Additionally, "occupational exposure" was not a listed exposure category, and it is likely that many of the blank exposures had an occupational exposure. It is likely that a lot of information missing from NCIMS had been collected in the parallel data systems (such as excel spreadsheets) that several of the PHUs maintained. The volume of missing data meant that detection of possible trends in exposure, or meaningful conclusions – such as, for example, that exposures due to lead mining in the area have decreased over time – were not able to be made with the system as it currently stands.

"The data is of limited use given the large numbers of missing values."

The quality of data collected could be improved significantly with simple changes to the data entry mechanism on NCIMS – this could include updating and/or clarifying the potential list of exposures, including occupation as a potential exposure, converting the entry field for "blood lead level" to a numerical field, and creating a drop-down box for the units for which the level was recorded. There could also be a note reporting that only one unit was required to be recorded, or a mechanism for automatically converting all lead levels to a single measure (i.e. µg/dL). In addition, the analysis function in NCIMS could be significantly improved, particularly if a regular reporting form, such as that utilised in Communicable Disease Branch which generates a standardised "MMWR" style report, was used. This could allow for regular analysis to be conducted within NCIMS and negate the need for regular data exports and complex data transformation and analysis methods. This could

enable the identification of missing data early and allow for comparisons of data completeness between different PHUs.

A future ideal database would have a single dataset that was able to be extracted easily, that was complete and accurate, that was reasonably easy to analyse with simple software (e.g. Microsoft Excel) and that contained numerical blood lead levels.

RECOMMENDATIONS

12. Convert the entry field for blood lead level to a numerical field and create a drop-down box to record the units (or alternatively require all blood lead levels to be entered in a single type of units, e.g. µg/dL)
13. Create within NCIMS a standardised reporting form that is automatically generated and can be reviewed regularly (such as weekly or fortnightly) to allow ongoing monitoring of trends and identify problems with data quality or timeliness as they occur
14. Further explore with PHUs what parallel systems they use for data collection and what these offer that is missing from NCIMS to make NCIMS more acceptable to PHUs for the collection and recording of surveillance data

Acceptability

Generally, follow-up of lead notifications was thought to be of some public health importance, but was also seen as unwieldy with variable perspectives on whether following up notifications at low levels was useful and an appropriate use of limited public health resources.

> *"The value of lead notifications needs to be questioned"*

Some public health units (typically those with legacy sites of industrial lead use or ongoing lead concerns) invested significant resources including time and manpower to follow up every notification, whilst others limited their follow up to young children and to adults above a particular level.

The differences between the limits for notification to PHUs under the NSW Public Health Act and to Safe Work NSW under occupational legislation was a concern. The notification level under the Public Health Act is ≥5µg/dL, however the blood lead levels for removal from the workplace for occupationally-exposed workers under Work Health and Safety Regulation 2017 are:

- >50ug/dL for females not of reproductive capacity and males
- >20ug/dL for females of reproductive capacity

- >15ug/dL for females who are pregnant or breastfeeding

The significant difference between the two levels was felt to undermine the efforts of PHUs to follow-up notifications in occupationally exposed adults, as these individuals would continue to be exposed in their workplace regardless of any PHU action, and led to PHUs feeling that their efforts in following up these notifications were futile.

> *"There's not much point in sending letters out to the same person… of all the letters we send out to the occupational ones, we never get anything back. No one ever rings us. I don't think everyone appreciates our intervention – the see us perhaps as a nuisance at times rather than letting them get on with what they are doing".*

> *"[We should be] aligning SafeWork NSW and NSW Health notification levels and intervention protocols as much as possible."*

> *"We need to identify a more robust mechanisms for occupational reporting to SafeWork regarding exposures, and clarify investigative limits to align more closely with occupational safety limits."*

Parents of young children were typically well engaged with the system and amenable to follow up. For occupational exposures, where follow up typically consisted of a letter, there was usually never a response.

> *"For employees with workplaces exposures – the level under the Safe Work legislation is very high and this means it is not picked up or treated as much as it could be. This poses legislation and collaboration challenges with Safe Work. Also, this age group is nonchalant about risk."*

The use of alternative databases by public health units indicated that the NCIMS system was not particularly acceptable in terms of being a useful way to collect and store data. The use of local dual systems also lead to the loss of granular data in NCIMS as there was frequently information stored either in a separate system at the public health unit level or as free text, which meant the loss of this data when it came to being able to analyse epidemiology and trends.

> *"I don't have a lot of trust in the information in the system given it hasn't been evaluated for some time."*

> *"It's not great when you put down "other" and write about the [exposure]… it's not very useful in that way. There's no real ability to share information about novel exposures."*

RECOMMENDATIONS

15. Work in partnership with Safe Work NSW to more closely align notification levels for occupationally exposed adults
16. Review the fields in NCIMS to ensure they are capturing information that is relevant and useful in a form that is easy to analyse – this could include changing some of the risk categories and making selection of options (such as hobbies) from a drop-down list

Representativeness

Overall the representativeness was thought to be variable with some groups very well represented (or over-represented), and others underrepresented.

Key groups thought to be very well represented were those who were occupationally exposed and those living in Broken Hill; both these groups have programs in place for systematic screening of elevated blood lead levels.

> *"[The representativeness] depends on area – i.e. in Broken Hill surveillance is much more systematic; they are testing a large percentage of the population."*

> *"Our surveillance is a bit two-streamed (active vs. passive) and very skewed towards certain groups. In essence, there are two streams: active surveillance for workplace exposures and kids at higher risk and then passive surveillance for everyone else."*

The over-representativeness of these two groups was thought to be appropriate given their higher risk profile; however, there was some concern that groups who may also be at risk for elevated blood levels are not being captured. These included home renovators, and those from culturally and linguistically diverse backgrounds. Stakeholders relied on their experience and anecdotal reports for these views. It was suggested by several stakeholders that those from culturally and linguistically diverse backgrounds may be under-represented among notifications, particularly given that subsets of this population may be at increased risk due to the use of Ayurvedic medicines and cosmetics purchased from overseas where regulation about lead content in products is not as stringent as in Australia. It was suggested that targeted messaging to these groups to make them aware of the risk of lead poisoning would be useful.

> *"Certain ethnic groups who believe in/use traditional medicines – we don't really have a handle on traditional medicines as they are not regulated at all. If we knew more about these groups we could provide education and risk information in their own languages."*

"Cases from taking medications (e.g. Ayurvedic medicines) and certain ethnic groups may be more at risk. If we are thorough we should capture this and could then liaise with TGA and regulatory bodies (fair trading) etc."

"We are probably not identifying NESB; this group seems less likely to seek help and more at risk."

"There is no evidence to suggest we are missing any particular groups, however I suspect we are missing young adults and non-occupational exposures (i.e. home renovators), as well as possibly the elderly."

"We may not be capturing home renovation type people."

The main limitation to representativeness was thought to be lack of awareness among treating clinicians of the potential for lead exposure (discussed further below), as well as the fact that elevated blood lead is typically asymptomatic at notifiable levels (or alternatively presents with non-specific symptoms).

RECOMMENDATION

17. Develop targeted messaging towards populations of culturally and linguistically diverse backgrounds regarding risk factors for lead exposure, including those of particular relevance to specific groups (such as Ayurvedic medicines)
18. Make information and fact sheets about elevated blood lead levels available in a variety of languages

Timeliness

No specific data on timeliness was collected. In general, notifications of elevated blood lead at low levels were not considered urgent by PHUs.

"Lead is often a lower priority at times"

"It is very administrative now with lots of letters, and following up a notification can be time consuming… if we are short on resources it can get left. In a general sense, we try and respond in a week or two."

"I think response times are reasonable – lead is not as time critical an issue as infectious disease notifications"

The move from manual- to electronic transfer of information was seen to have greatly increased the timeliness of notifications being received by PHUs.

> *"Electronic notifications come through continuously; where manual data entry is required there could be a delay"*

Several factors affecting timeliness of follow-up were noted. These included delays in being able to contact the ordering doctor (or even the lack of an ordering doctor, particularly for occupational notifications), and the fact that lead was often a low priority in a busy public health unit, meaning that if there were more pressing matters it was deprioritised.

> *"Due to increased numbers since [the] decrease in lead level for notification, we have determined our own protocol to determine what notifications to investigate"*

> *"Quite often we will get occupational notifications –it takes a lot of time to get their residential address. Often the employer will be reluctant to provide this; this can take a lot of time to follow-up"*

> *"Our current issue is the non-reporting of blood lead from one local lead recycling plant that uses a non-accredited laboratory for testing and test results are not overseen by a medical officer"*

> *"It would be very useful if the doctors would put the occupation in the clinical notes"*

One possible solution to reduce the time taken for follow-up could be that the request form for blood lead requires the ordering clinician to indicate whether the notification represents an occupational exposure, and if so to indicate the occupation. However, changes to the laboratory request forms require complex processes to implement.

> *"There are challenges involved in getting forms changed by laboratories. We have tried it before and it was nearly impossible."*

Stability

As a component of NCIMS, the lead surveillance system is very stable. It is very well supported in terms of manpower and electronic resourcing with dedicated staff working full-time to maintain it. This is a strength of the lead surveillance system.

The increasing use of electronic lab notifications has significantly reduced the amount of time needed to be spent entering data into the system as well as reduced the delay between collection of a specimen and receipt of information regarding that individual into the system.

However, the complexity of the system, particularly the difficulties of extracting all relevant data from the system, was a limitation of the system. This could be improved by training Environmental Health staff on how to extract and analyse data from the system.

RECOMMENDATIONS

19. Provide training to Environmental Health staff in how to extract and analyse data from the system to build capacity within EHB and increase confidence in use and oversight of the system

Sensitivity

Given that at the level of blood lead included in the case definition cases are likely to be asymptomatic, the sensitivity of the system in terms of the proportion of actual cases of elevated blood lead in the community that are detected is likely to be low. The exception to this would be in areas like Broken Hill where there is systematic screening, and among occupationally exposed adults working in high risk industries where monthly screening is required under industrial law. The lead evaluation system in NSW is a mix of active and passive surveillance. A series of flow charts showing the differential way in which cases can be notified and how this may influence case ascertainment and notification to the system is shown in Figure 3-Figure 6, below.

Figure 3 - Surveillance of elevated blood lead in the community

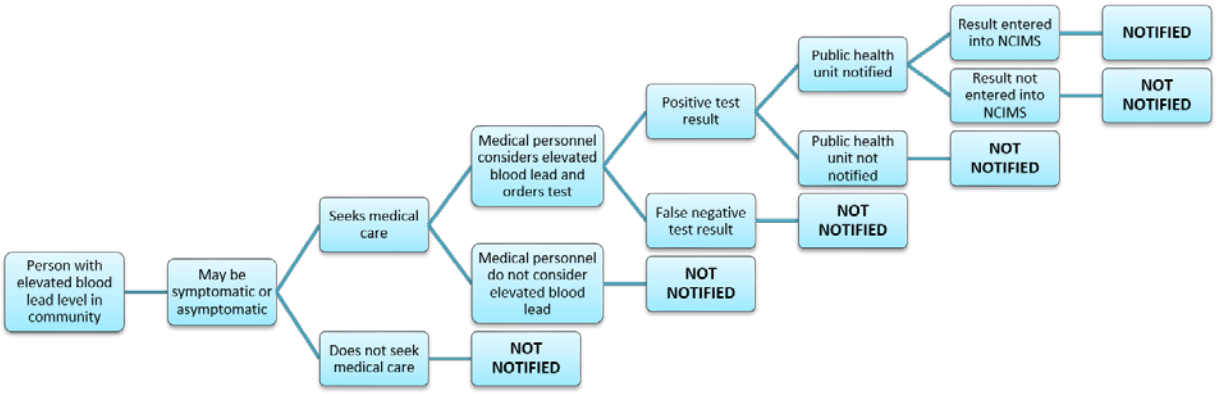


Figure 4 - Surveillance of elevated blood lead in those working in high risk occupations

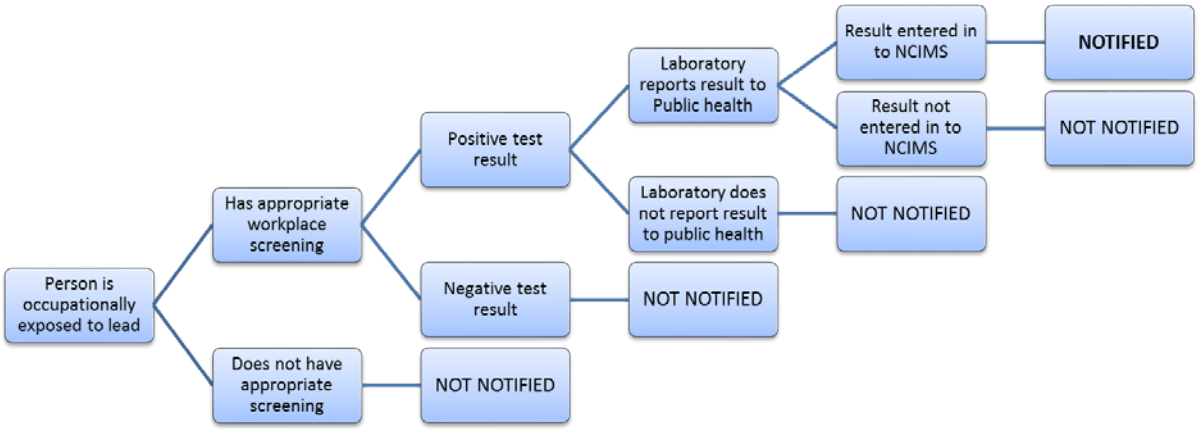
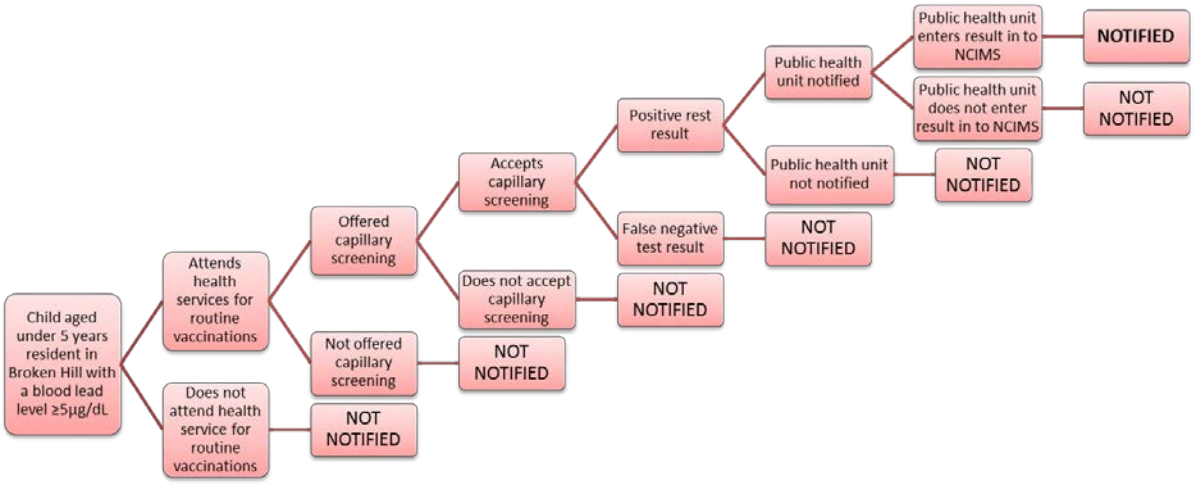


Figure 5 - Surveillance of elevated blood lead in children under 5 years in Broken Hill, NSW



This lack of sensitivity was well recognised by users of the system.

> *"We are not identifying all levels of 5 or less. As the levels get higher the sensitivity gets better and better [however] now that we are at low levels, there is no way of capturing all of it".*

> *"I am not sure we are identifying most/all cases. There is workplace screening targeting high risk workers and programs to monitor children, [however] we miss people outside these two groups and the system relies on someone presenting to a GP."*

A key identified weakness of case ascertainment was lack of understanding of GPs about lead testing and lead surveillance, and particularly the need to consider lead exposure in at-risk groups.

> *"[The sensitivity of the system] really depends on GPs doing testing – GPs need to consider lead an issue and then ask for a test. In endemic areas where we know it is a problem we do good surveillance; in non-endemic areas, it is up to GPs."*

> *"We need Improved awareness of physicians of when to test: this includes both in endemic areas and of at risk groups/areas."*

> *"We need to Identify where high-risk areas are and ensure awareness among doctors about when to test."*

An additional challenge to the sensitivity of the system is the use in Broken Hill of capillary testing to test children under 5 years old, which is not used elsewhere in the state. This tool has not been validated at the state level, although in Broken Hill they have completed their own validation process and have strict protocols for testing. The capillary test is known to be less specific than venous blood testing[23]. Thus, its use may be over-estimating the burden of disease in Broken Hill when compared with other PHUs.

The system was thought to do poorly at identifying clusters unless there was a clear epidemiological link and the cases were tightly clustered in time and place. There was no documentation maintained of clusters that had been detected by the system.

> *"The inability of the system being able to detect clusters is a major issue. We can look centrally but could be missing clusters both in the workplace and geographically. It would be good if there was some kind of alert system in NCIMS."*

> *"I think a cluster of reasonable size that is easily linked (i.e. occupational) would be detected, however any that are more geographically dispersed would be much harder."*

Key limitations in the ability to detect clusters was the lack of a clear mechanism for identifying or recording occupational exposures that may be linked, and the decentralised nature of the Public Health system in NSW. This meant that if employees of a single workplace resided in different PHUs there is a possibility that the link between cases will not be identified. An additional limitation is the staffing arrangements at PHU's and the fact that multiple people may be following up one or more notifications.

> *"How do you know you have a cluster if four different people are following-up a blood lead?"*

"I don't think we are able to detect clusters very well – it depends on a PHU identifying more than one related case".

Suggestions to improve the ability of the system to detect clusters included mapping.

"There isn't really a mechanism to detect clusters; this would require someone to look at or map it. It could be mapped as the notifications are geocoded"

RECOMMENDATIONS

20. Update the case definition to include capillary testing (perhaps as "probable" case) to reduce misclassification bias in the system, with clear requirements about when confirmatory testing is required. This may also increase testing among younger children and lead to increased sensitivity of the system as a whole
21. Develop a mechanism by which clusters could be more easily detected – this could include a requirement to record workplace in NCIMS or an automated mapping process that generates maps based on home or workplace address periodically.

Discussion

Lead surveillance poses a unique challenge for public health systems. A person with an elevated blood lead level at the lower range (5-10µg/dL) will typically be asymptomatic. Elevated blood lead levels can be chronic and persistent, and the individual can be re-exposed in the future. Management of elevated blood lead focuses on removing the exposure. Within NSW, lead is the only non-infectious notifiable condition, as well as the only notifiable condition for which Environmental Health Branch has responsibility.

Blood lead levels in the community, as well as risk factors for exposure, have changed over the last two decades in NSW. Chronic environmental exposure has been reduced due to legislation barring leaded petrol and paint and is now mainly limited to those living in lead-endemic areas and those participating in lead-exposure occupations. The breadth and range of potential exposures appears to have changed. Anecdotally, lead-exposed individuals are increasingly exposed from a diverse range of potential exposures, ranging from home renovation to consumption of Ayurvedic medicines or use of imported cosmetics. Unfortunately, weaknesses in the lead surveillance system and data collection mean that although it is perceived that exposure categories are changing, the data is not available to support this assertion.

The system utilised in NSW has elements that both promote and hinder surveillance. Two key components, the use of electronic lab reporting and the use of the NCIMS information management system, help integrate lead surveillance into wider surveillance in NSW. NCIMS is well established and there is sufficient expertise and resources available to support its use. However, lead as a notifiable condition has several idiosyncrasies that have introduced some challenges. These include the need for the blood lead level to be recorded and monitored over time, and the fact that exposure category is difficult to record and export from NCIMS. Deficiencies in the quality of data recorded about blood lead level, especially the fact that it is recorded as free-text rather than a numeric field, is the single most important barrier to effective, monitoring of blood lead levels in NSW.

In addition, lead surveillance involves several different bodies – not only within NSW Health (including the Surveillance team and Environmental Health Branch as well as PHUs), but also with other agencies including SafeWork NSW, general practitioners, and occupational health physicians. This introduces complexity into the system and has resulted in gaps where parallel systems differ. One of these is the significantly different notifiable levels under Work Health and Safety regulation when compared to the NSW Public Health Act. Prior to October 2017 there were also loopholes with the NSW Public Health Act that, that meant that responsibility for notification of laboratory test was unclear.

Overall the system is meeting some but not all its goals and objectives. Cases are all managed by PHUs to varying degrees, although this varies from simply entering cases into NCIMS (either electronically or by hand) with no further follow-up, through to a full response involving home visits and environmental testing. The response varies both by blood lead level and by PHU responsible. Ideally this variability would be reduced to increase uniformity in responses across the state.

The epidemiology of lead notifications is not well understood or monitored, mainly due to difficulties accessing the data system. Weakness in data collection instruments are almost solely responsible for this, and review of the data fields in NCIMS and how data is entered and stored, including introducing some rules to make data entry effective and easily extracted, could have a significant impact on this, as could reporting requirements for summary epidemiology reports both at the PHU level and the state level.

Overall the system as it currently stands was reasonably flexible, accommodating changes to the notifiable blood lead level and Public Health Act without significant challenge, but was neither simple nor acceptable. The existence or parallel systems of data collection and storage used by PHUs

as well as the identification of significant challenges accessing data within the system were reflective of this. Changes should be made to the database so that there are no parallel systems or duplication, which should involve consultation with PHUs about what changes to NCIMS would improve its usability.

The biggest weakness of the system was the poor data quality. As identified by many of the users, the structure of the database was almost solely responsible for this. Data entry of blood levels was problematic, with cleaning of these blood lead levels an extremely complex endeavour requiring strong software and a significant time commitment, a response unfeasible to most PHUs. As outlined in recommendations 11 and 12, urgent changes to be implemented should include introducing rules to improve data quality, including entry of blood lead levels as numerals only, and introduction a drop-down box to indicate the units used (either µg/dL or µmol/L). The exposure categories should also be reviewed. "Occupational lead exposure" should be introduced as an exposure category and the remaining categories reviewed for utility and to ensure they reflect current exposure trends, and reduced in number if possible. In addition, technological changes need to be considered, such as introduction of capillary testing into the case definition.

Although there was a perception among some members of the Public Health Unit network that lead is no longer an important public health issue, increasing evidence of public health effects even at lower levels mean that it is important that the system adapts to the changes and remains useful and fit for purpose into the future. The challenges in monitoring trends over time with the current system have meant that identification of how and in what direction the system should change have been based on anecdote and experience rather than evidence. Improvement of the system should allow ongoing evidence-based change to occur. Ideally the protocol should be updated so it is more proscriptive and there is greater uniformity in responses between PHUs. In addition, Safe Work NSW and NSW Health should continue to work together so that differences in response between the two groups (such as what constitutes a notifiable blood lead levels) are addressed formally and guidance can be provided to individuals and health providers in the community. Health also needs liaise closely with SafeWork NSW so that important information gathered about workplaces meeting or not meeting their legislative responsibilities is addressed, and so that workers are empowered within the workplace to protect themselves from the effects of exposure to lead. NSW Health, and particularly Environmental Health Branch, is in a unique position to advocate for these workers with the surveillance system as it currently stands, and this would be an opportunity to put health and disease prevention on the agenda of all agencies.

Finally, greater uniformity in response should occur across NSW. A clear and detailed protocol with clear delineation of responsibility for tasks would enable this. Information sharing among the public health network should also be encouraged, allowing practitioners to tap in to the wealth of experience across the state and allow the cultivation of corporate knowledge and a sense of ownership of lead surveillance at all levels of NSW Health.

Limitations

This evaluation was conducted internally within NSW Health to provide an overview of the system as it currently stands and review NSW Health practices. As such, key persons outside NSW Health who may have been able to provide key insights on lead surveillance and elevated blood lead as a public health problem were not consulted. These included general practitioners, occupational physicians, individuals notified with elevated blood lead (both those exposed in the community and those exposed occupationally), and SafeWork NSW. Once changes based on the findings of this evaluation are formalised and implemented, a wider review of lead exposure in NSW may lead to some interesting insights on how to prevent lead exposure in the community in the future. It would also be useful to gain the perspectives of members of the community who have had elevated blood lead levels notified to see whether the public health response was useful to them and ways in which it could be improved.

The complexity of the surveillance system, heterogeneity in responses to lead notifications on the part of different PHUs, and a lack of clarity of how the overall system functioned meant that this evaluation focused mainly on the gathering of qualitative information about how the system worked in practice (a process evaluation). The impact of the surveillance system on the outcome of blood lead levels in the community was beyond the scope of the evaluation. Cost-effectiveness of the surveillance system, including the cost in terms of resources, time and manpower in following up notifications of elevated blood lead, was also not considered. These could be areas for future evaluations to consider, ensuring that the NSW elevated blood lead surveillance system remains effective, cost-effective and fit for purpose.

Conclusion

This evaluation of the NSW elevated blood lead surveillance system identified several areas where it could be improved. These included problems with data quality, uniformity of response, concerns about data sharing including with other agencies), and the inability to analyse epidemiological data. Overall, with changes to data capture, greater standardisation of the response to lead notifications

across PHUs, and with an increasing focus on collaboration, the lead surveillance in NSW is well-positioned to continue to be effective into the future.

Recommendations

1. Review the lead response protocol to ensure the response required from PHUs is clear, both in terms of case follow-up and information collection and reporting requirements
2. State explicitly in the response protocol who has responsibility for specific actions, including clarification of the roles of PHUs and of Environmental Health Branch
3. Introduction of regular reporting requirements for lead (such as a quarterly or annual review of the epidemiology and of data completeness) would lead to timely identification of challenges with the dataset and provide information for ongoing improvements to the system
4. Continuing education for Environmental Health branch staff in the collection and analysis of surveillance system data and in the use of NCIMS and SAPHARI would lead to improved confidence of the staff in owning the lead surveillance system
5. Regular data review meetings between the Surveillance team and the Environmental Health team would enable both groups to have a greater understanding of the current state of lead surveillance in NSW
6. NSW Health and Safe Work NSW should collaborate to regularly communicate with laboratories (NSW health) and workplaces (Safe Work NSW) to provide education about blood lead and remind of them of their testing and notification obligations
7. Provide written clarity within the protocol about data sharing provisions with Safe Work NSW, including what information can be shared and when, and who to ask if they have uncertainty (e.g. Environmental Health Branch)
8. Clarify with Safe Work NSW what information is provided to employees and employers about blood lead testing and public health follow up, and if deficiencies are identified work with Safe Work NSW to ensure that information is provided that is clear and comprehensive (e.g. a brochure that outlines to workers that they should be having blood lead testing regularly if they are employed in a high-risk occupation, and that they can expect contact from the PHU if their level is high)
9. Implement regular reporting of surveillance data, both centrally and from PHUs, on a regular basis (e.g. quarterly or annually). This may require the development of a reporting template
10. Make the lead response protocol more explicit to promote a uniform response to elevated blood lead level notifications across PHUs

11. Identify key data fields in NCIMS that are challenging for data entry and extraction (such as blood lead level and exposure) and address these as a matter of urgency to improve the usability of the system for data analysis (discussed in more detail in recommendations 12-14, below)
12. Convert the entry field for blood lead level to a numerical field and create a drop-down box to record the units (or alternatively require all blood lead levels to be entered in a single type of units, e.g. µg/dL)
13. Create within NCIMS a standardised reporting form that is automatically generated and can be reviewed regularly (such as weekly or fortnightly) to allow ongoing monitoring of trends and identify problems with data quality or timeliness as they occur
14. Further explore with PHUs what parallel systems they use for data collection and what these offer that is missing from NCIMS to make NCIMS more acceptable to PHUs for the collection and recording of surveillance data
15. Work in partnership with Safe Work NSW to more closely align notification levels for occupationally exposed adults
16. Review the fields in NCIMS to ensure they are capturing information that is relevant and useful in a form that is easy to analyse – this could include changing some of the risk categories and making selection of options (such as hobbies) from a drop-down list
17. Develop targeted messaging towards populations of culturally and linguistically diverse backgrounds regarding risk factors for lead exposure, including those of particular relevance to specific groups (such as Ayurvedic medicines)
18. Make information and fact sheets about elevated blood lead levels available in a variety of languages
19. Provide training to Environmental Health staff in how to extract and analyse data from the system to build capacity within EHB and increase confidence in use and oversight of the system
20. Update the case definition to include capillary testing (perhaps as “probable” case) to reduce misclassification bias in the system, with clear requirements about when confirmatory testing is required. This may also increase testing among younger children and lead to increased sensitivity of the system as a whole
21. Develop a mechanism by which clusters could be more easily detected – this could include a requirement to record workplace in NCIMS or an automated mapping process that generates maps based on home or workplace address periodically.

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Elevated Blood Lead Levels - Response Protocol for

- **Public health priority: Routine**
- **Public Health Unit (PHU) response time: Respond to confirmed cases within 3 working days. Enter confirmed cases on Notifiable Conditions Information Management System (NCIMS) within 5 working days.**
- **Case management: Ascertain source where possible, and recommend risk reduction measures. Notify SafeWork NSW, where appropriate, of cases from occupational exposure.**
- **Contact management: Consider identification of other persons affected by the same source or the transfer of contaminant to other household members.**

NSW Public Health Units

1. Surveillance Objectives

- To identify cases and recommend appropriate risk reduction measures.
- To monitor the epidemiology to inform the development of better risk reduction strategies.

2. Case Definition

A confirmed case requires:

- A person with a venous blood lead level of ≥5 µg/dL (0.24µmol/L)

3. Notification Criteria and Procedure

Elevated blood lead level is to be notified by:

- Laboratories on diagnosis (electronically or by routine mail to the local Public Health Unit).
- Only confirmed cases should be entered onto NCIMS.

4. The Disease

Causative Agent

Lead is a naturally occurring metal found in the earth's crust. It has a wide variety of uses in manufacturing due to its properties of being soft, malleable and corrosion resistant. Australia is one of the world's major lead-producing countries.

Most people in Australia live in places where there are very small amounts of lead in food, drinking water, air, dust, soil and consumer products. Exposure to higher than background levels of lead may occur in areas where there are industrial sources of lead or through exposure to lead-containing paint. However, people's exposure to lead has substantially reduced in recent decades due to national initiatives which have restricted the addition of lead to paint and petrol, and the use of lead in consumer goods (e.g. toys, cosmetics and cans). In addition, lead management programs in endemic areas, such as Broken Hill, have resulted in a steady decline in blood lead levels in children.

Lead and lead compounds are not beneficial or necessary for human health, and can be harmful to the human body.

Mode of Absorption

Elevated blood lead levels usually derive from the ingestion of lead-containing substances, the inhalation of lead-containing dust and transfer from mother to foetus. Less commonly, some forms of the metal can be absorbed through the skin. Young children (under 5 years) and pregnant women are especially vulnerable to environmental exposure to lead, but adults engaged in particular occupations and hobbies are also at risk.

The average blood lead level among Australians is now estimated to be below 5 micrograms per decilitre (5 µg/dL or 0.24 µmol/L). A blood lead level greater than 5 µg/dL (0.24 µmol/L) suggests that a person has been, or continues to be, exposed to lead at a level that is above what is considered the average 'background' exposure in Australia.

Note that in communities that are at risk of known excess lead exposure due to industry (such as Broken Hill), Public Health Authorities run specific programs to monitor and reduce lead exposure.

Clinical Presentation

Health effects as a result of lead exposure differ substantially between individuals. Factors such as a person's age, the amount of lead, whether the exposure is over a short-term or a longer period, and the presence of other health conditions, will influence what symptoms or health effects are exhibited. Lead can be harmful to people of all ages, but the risk of health effects is highest for unborn babies, infants and children under 5 years.

It is well established that blood lead levels equal to or greater than 10 µg/dL (0.48 µmol/L) may have harmful effects on many organs and bodily functions. Effects such as increased blood pressure, abnormally low haemoglobin, abnormal kidney function, long-term kidney damage, behavioural problems, cognitive impairment and abnormal brain function have been observed at blood lead levels between 10µg/dL and 60 µg/dl (0.48-2.89 µmol/L) in adults and children.

Encephalopathy—which is characterised by irritability, agitation, poor attention span, headache, confusion, uncoordinated walking or movement, drowsiness, convulsions, seizures or coma—can occur at blood lead levels of 100–120 µg/dL (4.82-5.79 µmol/L) in adults and 70–100 µg/dL (3.37-4.82 µmol/L) in children. In extreme situations, irreversible brain damage or even death can occur at these blood lead levels.

A comprehensive review of the health effects of lead by the National Health and Medical Research Council (NHMRC) in 2015 found an association between blood lead levels below 10 µg/dl (0.48 µmol/L) and health effects in some population groups. However there was insufficient evidence to conclude that lead at this level caused any of the health effects observed.

5. Managing Single Notifications

Response Time

Investigation

Within 3 working days of notification of a confirmed case, begin follow-up investigation.

Data Entry

Within 5 working days of notification enter confirmed cases on NCIMS.

Response Procedure

The response to a notification should be carried out in collaboration with the case's health carers and/or SafeWork NSW. Regardless of who does the follow-up, PHU staff should ensure that action has been taken to:

- Confirm any symptoms associated with exposure, including onset date
- Confirm whether the case or relevant care-giver has been provided with the results before beginning the interview
- Seek the doctor's permission to contact the case or relevant care-giver
- Review case management
- Identify household contacts who may also be at risk of elevated blood lead levels

Response protocol for single elevated blood lead level notifications in non- endemic areas

[For endemic areas, refer to existing local protocols and programs for managing lead notifications in children].

The protocol outline below is for **new** notifications. If the notification relates to follow up from a previous notified blood lead level within the last 12 months (BLL), the PHU response can be modified according to the circumstances of the case.

Level	Blood lead level	Age	PHU Response
1	Greater or equal to 5 but less than 10 µg/dL (≥0.24 - <0.48 µmol/L)	Under 5 years	• ***Information:*** Consult treating doctor. Standard letter to case's parent/guardian and NSW Health's factsheet 'Lead exposure in children'. • ***Risk management:*** If requested by the doctor or the family offer counselling on risk reduction/contact management to case's parents/guardians. • ***Blood test:*** Household members may need to be tested particularly young children and pregnant women.
		5 years and above	• ***Information:*** Consult treating doctor. Standard letter to case's parent/guardian and NSW Health's factsheet 'Lead exposure in children'. • ***Risk management:*** Not routine. At the discretion of the PHU. • ***Blood test:*** Household members may need to be tested particularly young children and pregnant women.
2	Greater or equal to 10 but less than 25 µg/dL (≥0.48 - < 1.2µmol/L)	Under 5 years	• ***Information:*** Consult treating doctor. Standard letter to cases parent/guardian and NSW Health's factsheet 'Lead exposure in children'. • ***Risk management:*** Offer counselling/home risk assessment to case's parents/guardians as appropriate. • ***Blood test:*** Household members may need to be tested particularly young children and pregnant women. Retest BLL after 6 months or earlier if clinically indicated.
		5 years and above	• ***Information:*** Consult treating doctor. Standard letter to case. If non occupational exposure provide lead factsheet on risk identification and management to requesting doctor or case as appropriate. • ***Work related exposures:*** Suggest case or treating doctor advice patient to discuss BLL with employer in the case of occupational exposure. Inform SafeWork in case of a cluster of cases. • ***Risk management:*** Offer counselling/home risk assessment to case as appropriate. • ***Blood test:*** Household contacts may need to be tested particularly young children and pregnant women.
3	Greater or equal to 25 but less than 45 µg/dL (≥1.2- <2.2 µmol/L)	Under 5 years	• As for level 2, plus • ***Environmental assessment:*** Conduct preliminary environmental assessment, including home visit, exposure pathways and sampling if source not obvious. • ***Expert advice:*** Seek expert advice from clinical toxicologist for future BLL retesting.
		5 years and above	• As for Level 2,plus • ***Environmental assessment:*** Conduct preliminary environmental assessment, including home visit, exposure pathways and sampling if source not obvious. • ***Work related exposures:*** Strongly suggest case or treating doctor consult SafeWork NSW for further advice on occupational exposure, if appropriate.
4	Greater or equal to 45 µg/dL (≥ 2.2 µmol/L)	All ages	• As for level 3, plus • ***Medical treatment:*** If BLL of or above 45 µg/dL (2.17 µmol/L) in a **child** ensure treating doctor is aware of result when received as BLL at these levels may require urgent medical treatment (chelation). • ***Medical treatment:*** If BLL above 70 µg/dL (3.37µmol/L) requesting doctor is aware of the result as BLL at these levels in an **adult** may require urgent medical treatment (including chelation).

Management

a. Investigation and Treatment of Cases

The main treatment for adults and children involves:

- Reducing or preventing the case's exposure to lead sources
- Reducing the impact of exposure or eliminating it
- Ensuring that exposure to other sources does not occur.

Education

The case or relevant care-giver should be informed about the effect of the blood lead level and the likely causes. In particular, emphasis should be placed on minimising the exposure of young children and pregnant women to sources of lead.

Information for community members and health care professionals is available from PHUs.
http://www.health.nsw.gov.au/environment/factsheets/Pages/lead-exposure-children.aspx

The Office of Environment and Heritage Pollution Line, telephone 131555 or internet site
http://www.environment.nsw.gov.au/pollution/

Other information on lead is also available from
http://www.epa.nsw.gov.au/pesticides/lead.htm

Exposure Investigation

The case or relevant care-giver should be asked about sources of lead contamination such as:

- Lead paint on houses built before 1970 (including the case's and neighbouring houses), and in particular (i) any renovation or demolition of these houses and (ii) whether a young child is known to engage in eating soil and paint (pica).
- Involvement in high risk occupations, including lead mining and smelting, metal repair or foundry work, painting and decorating, automotive (including radiator) repairs or breaking down old car batteries
- Engaging in high risk hobbies involving lead or lead paint, including casting metal sinkers, antique furniture restoration, lead soldering, lead lighting and indoor shooting
- Living in an area associated with large and small lead industries or areas with historic high traffic flow
- Household pets which may provide an exposure pathway for lead dust
- Use of traditional medicines such as Ayurvedic or Burmese remedies.
- Infants who regularly chew or suck on painted toys, cots, window sills, paint chips, etc.
- Other potential sources such as sandpits, vegetable gardens or domestic poultry

Further information on occupational sources of lead can be obtained from SafeWork NSW on 13 10 50 or
http://www.safework.nsw.gov.au/

Isolation and Restriction

None

Environmental Evaluation

If the source of the exposure is not clear after the initial investigation has taken place, the PHU should arrange for an environmental assessment of the residential area if the case's blood lead level is in excess of 25 µg/dL (1.2 µmol/L) and/or the implicated source may affect the broader community.

Environmental Control measures

The Public Health unit response to any exposures identified will need to be tailored to the specific risks identified. General advice can be provided by telephone or the provision of information such as factsheets, or advice on managing lead paint in the home (for example refer to Lead Safe Blitz video) https://www.youtube.com/watch?v=q1zkvJGH1uA

In some instances an EHO may provide an assessment through a home visit. Householders (or the landlord of the property) may also be advised to engage the services of an independent assessor or remediator to advise or assist with exposure risk reduction.

b. **Contact Management:**

Identification of Contacts

Contacts can be defined as all persons exposed to the same source as the case (see case definition), or who have secondary exposures (e.g. children of persons who bring lead dust home on their clothes).

Investigation and treatment of Contacts of Confirmed Cases

Blood lead testing should be recommended for:

- Children under 5 years and pregnant women if another household member has a blood lead level ≥5 µg/dL (0.24 µmol/L).
- Children aged 9 to 48 months who live in or visit older dilapidated housing with peeling paint
- Children aged 9 to 48 months who have been present during renovations of older housing painted before 1970
- Children who have siblings with elevated blood lead levels
- Children with pica, particularly if living in lead contaminated environments
- Children aged 9 to 48 months whose parents may be occupationally exposed or who are living near lead smelters, battery breaking yards, lead ore bodies or near highways or main roads with historic heavy traffic
- Children exposed to less common pathways such as lead hobbies or alternative medicines containing lead.

Education

Advise susceptible contacts (or parents/guardians) of the risk of elevated blood lead levels. In particular, emphasis should be placed on minimising the exposure of young children and pregnant women to sources of lead.

Isolation and restriction

None

6. Managing special situations: Cluster of notifications

Multiple notifications relating to individual workplaces should be referred to SafeWork NSW for further follow-up and management. Further advice can be sought from Environmental Health Branch, Health Protection NSW.

In circumstances where there appears to be geographical clustering of non-occupational cases, excluding known lead endemic areas (especially in children under 5), and the source is unknown, further investigation may be warranted. Further advice can be sought from Environmental Health Branch, Health Protection NSW.

7. Appendices

A. Fact sheet: Lead Exposure in Children

CONFIDENTIAL

LABORATORY NOTIFICATION FORM

NSW GOVERNMENT Health

NSW HEALTH USE ONLY

Date received: __ __ / __ __ / __ __ __ __ **PHU:** _____ **Record No:** _____

LABORATORY DETAILS

Lab Number: .....
Lab Name: .....
Lab Address: .....
Telephone: .....
Specimen Collection Date: __ __ / __ __ / __ __ __ __
Notification Date: __ __ / __ __ / __ __ __ __

PATIENT DETAILS

Last Name: *(first 2 letters only for HIV)* .....
Gender: ☐ Male ☐ Female ☐ Transgender
First Name: *(first 2 letters only for HIV)* .....
Language Spoken at Home: .....
Address: .....
Country of Birth: .....
State: ..... Postcode: .....
Occupation/School: *(Not for HIV)* .....
Date of Birth: __ __ / __ __ / __ __ __ __ Age: .....
Date of Death: *(if applicable)* .....
Date of Onset: __ __ / __ __ / __ __ __ __

Indigenous status:
☐ Aboriginal
☐ Torres Strait Islander
☐ Both Aboriginal and Torres Strait Islander
☐ Not Aboriginal or Torres Strait Islander
☐ Not stated

Reason for testing: .....
Risk factors for infection *(including possible exposure or underlying medical condition)*: .....
.....

CONDITION (please tick)

☐ Anthrax
☐ Arboviral infections, including:
- Barmah Forest virus
- Chikungunya virus
- Dengue virus
- Ross River virus
- Japanese encephalitis virus
- Kunjin virus
- Murray Valley encephalitis virus
- Yellow fever ☎
- Zika virus
- Other

☐ Avian Influenza ☎
☐ Botulism ☎
☐ Brucellosis
☐ Campylobacter infection
☐ Chancroid
☐ Chlamydia
☐ Cholera ☎
☐ Creutzfeldt-Jakob disease
☐ Variant Creutzfeldt-Jakob disease ☎
☐ Cryptosporidiosis
☐ Diphtheria ☎
☐ Donovanosis
☐ Giardiasis
☐ Gonorrhoea
☐ Haemophilus influenzae type b ☎
☐ Hendra virus infection ☎
☐ Hepatitis A ☎, B, C, D (delta), E ☎
☐ HIV – **SEE HIV NOTIFICATION FORM**
☐ Influenza
☐ Invasive pneumococcal infection
☐ Lead in blood ≥5 µg/dL (≥0.24 µmol/L)
☐ Legionellosis ☎
☐ Leptospirosis
☐ Listeriosis ☎
☐ Lymphogranuloma venereum
☐ Lyssavirus ☎
☐ Malaria
☐ Measles ☎
☐ Meningococcal infections ☎
☐ MERS-CoV ☎
☐ Mumps
☐ Paratyphoid ☎
☐ Pertussis
☐ Plague ☎
☐ Poliomyelitis ☎
☐ Psittacosis
☐ Q Fever
☐ Rabies ☎
☐ Rotavirus infection
☐ Rubella
☐ Samonellosis
☐ Severe acute respiratory syndrome ☎
☐ Shigellosis
☐ Smallpox ☎
☐ Syphilis
☐ Tuberculosis
☐ Tularaemia ☎
☐ Typhoid ☎
☐ Typhus (epidemic) ☎
☐ VTEC/STEC ☎
☐ Viral haemorrhagic fevers ☎

☎ Please notify these conditions by telephone to the Public Health Unit on 1300 066 055. See over for your local Public Health Unit contact details

Method of identificaton (please tick)

☐ Antigen ☐ Antibody ☐ Microscopy ☐ Culture ☐ NAT ☐ Other

Species/subtype *(if applicable)* ..... Specimen/site: ..... Comments: .....

Referring doctor details

Name: .....
Address: .....
Telephone: .....
State: ..... Postcode: .....

Public Health Unit	Mailing Address	Contact	After Hours/on call
Albury ***Murrumbidgee LHD***	PO Box 3095 Albury 2640	Ph: 02 6080 8900 Fax: 02 6080 8999	AH: 02 6080 8900
Bathurst ***Western NSW LHD***	PO Box 143 Bathurst, 2795	Ph: 02 6330 5880 Fax: 02 6332 3137 (s)	AH: 0428 400 526
Broken Hill ***Far West LHD***	PO Box 457 Broken Hill, 2880	Ph: 08 8080 1499 Fax: 08 8080 1196 (s)	AH: 0419 917 426
Camperdown ***Sydney LHD***	PO Box 374 Camperdown 1450	Ph: 02 9515 9420 Fax: 02 9515 9467 (s)	AH: 02 9515 6111
Dubbo ***Western NSW LHD***	PO Box 4061 Dubbo, 2830	Ph: 02 6809 8971 Fax: 02 6841 2261 (s)	AH: 0418 866 397
Central Cost PHU ***Central Coast LHD***	PO Box 361 Gosford, 2250	Ph: 02 4320 9730 Fax: 02 4320 9746 (s)	AH: 02 4320 2111
Goulburn ***Southern NSW LHD***	Locked Bag 11 Goulburn, 2580	Ph: 02 4824 1840 Fax: 02 4822 5038 (s)	AH: 02 6080 8900
Hornsby ***Northern Sydney LHD***	Hornsby Hospital Palmerston Rd Hornsby 2077	Ph: 02 9477 9400 Fax: 02 9482 1358 (s)	AH: 02 9477 9123
Lismore ***Northern NSW LHD***	PO Box 498 Lismore 2480	Ph: 02 6620 7585 Fax: 02 6620 2552 (s)	AH: 0439 882 752 If unanswered: 0417 244 966 or 0407 904 280
Liverpool ***South Western Sydney LHD***	PO Box 38 Liverpool 1871	Ph: 02 8778 0855 Fax: 02 8778 0838 (s)	AH: 02 8738 3000 (Liverpool Hospital Switch)
Newcastle ***Hunter New England LHD***	Locked Bag 10 Wallsend, 2287	Ph: 02 4924 6477 Fax: 02 4924 6048 (s)	AH: 02 4924 6477
Parramatta ***Western Sydney LHD***	Locked Bag 7118 Parramatta BC 2124	Ph: 02 9840 3603 Fax: 02 9840 3591 (s)	AH: 02 9845 5555
Penrith ***Nepean Blue Mountains LHD***	PO Box 63 Penrith 2751	Ph: 02 4734 2022 Fax: 02 4734 3444 (s)	AH: 02 4734 2000
Port Macquarie ***Mid North Coast LHD***	PO Box 126 Port Macquarie 2444	Ph: 02 6588 2750 Fax: 02 6588 2837 (s)	AH: 0439 882 752 If unanswered: 0417 244 966 or 0407 904 280
Randwick ***South Eastern Sydney LHD***	Locked Bag 88 Randwick 2031	Ph: 02 9382 8333 Fax: 02 9382 8314 (s)	AH: 02 9382 2222
Tamworth ***Hunter New England LHD***	Locked Mail Bag 9783 NEMSC 2348	Ph: 02 6764 8000 Fax: 02 6766 3890 (s)	AH: 02 6764 8000
Wollongong ***Illawarra Shoalhaven LHD***	Locked Bag 9 Wollongong 2500	Ph: 02 4221 6700 Fax: 02 4221 6759 (s)	AH: 02 4222 5000

NOTE: (s) = secure fax number

Appendix 3: Core questions for face-to-face interviews

Interviewee:

- Thank you for agreeing to speak with me today
- I am going to be asking a series of questions about your experiences of working with blood lead in NSW. This should take about 25-30 minutes.
- There are no right or wrong answers!
- We are conducting an evaluation of the NSW blood lead surveillance system to assess its performance, and make recommendations regarding its structure and function. It is hoped that this will result in improvements to the system so that it continues to be useful to the public health network and the wider community.
- When I refer to "system" I am talking about the system as a whole and not only the electronic information management system known as NCIMS
- First of all I want to show you a flow chart showing my understanding of how the blood lead surveillance system works in NSW. Can you look over it and tell me if you think it looks accurate? Is there any steps or information missing?

<u>Core questions to be asked of all stakeholders</u>

1. Can you describe your role in working with blood lead notifications in NSW? How do you use/are you part of the lead surveillance system?
2. What do you think are the major strengths and weaknesses of the NSW blood lead surveillance system? Please elaborate
3. *Surveillance system attributes*
    a. *Simplicity and acceptability*
        i. What are your thoughts on the process for lead notifications in NSW?
        ii. Do you think the system is easy to use?
        iii. Do you have any concerns with patient privacy, data confidentiality and system security?
    b. *Flexibility*
        i. Have you seen any changes to the system over time?
        ii. Do you think the system is adaptable when changes (for example changes to the case definition) occur?
    c. *Data quality*
        i. Do you think the data captured is complete and of good quality?
        ii. Is the data produced by the system useful to you? Why or why not?
    d. *Sensitivity, representativeness, PPV*
        i. Do you think we are identifying most/all cases of elevated blood lead levels?
        ii. Is any particular group is missed?
        iii. Do you think the system is able to detect clusters?

e. Timeliness

i. Do you think the system is timely?

ii. (For users):

1. What time frame do you typically respond to a notification over? What factors might influence how the timeliness of a response?
2. Do you find the process of using the system time-consuming?

f. Stability

i. Do you think to system is reliable and able to provide information when needed?

4. How do you think the NSW blood lead surveillance system could be improved?

<u>Other potential questions to be asked (mainly for front-line users)</u>

1. Notifications and actions/processes:

a. What information do you seek when you speak to a patient?
b. Do you routinely contact the requesting doctor?
c. Do you feel able to advise patients on risk reduction measures and next steps?
d. Do you send any kind of letter out?
e. Do you recommend retesting?
f. Do you things differently depending on the age of the person being notified?
g. Who else do you speak to when you get a notification? (If anyone)
h. Who in your workplace looks at the lead data? (if anyone)
i. What happens if it is a workplace exposure? Do you do anything differently?
j. Do you feel confident in managing notifications where there are other agencies involved? (e.g. Safe Work)
k. What do you do when you have multiple notifications for the same individual?

2. The system in general:

a. Do you think the current system identifies people from disadvantaged or at-risk groups?
b. Do you think there is anything missing from the current system?
c. Do you think the lead surveillance system is well linked with other systems?
d. If you could change one thing about how lead is notified, what would it be?

Appendix 4: Questionnaire sent out to Public Health Units via email

Managing lead notifications in NSW Public Health Units

(Please tick the relevant box or provide a written response)		Yes	No
1.	Do you find the NCIMS application useful in managing notifications of elevated blood lead?		
	If no, please provide brief comment:		
2.	Do you use an additional database (separate to NCIMs) in your PHU to record information about notifications of elevated blood lead level?		
	If yes, can you please provide some details (e.g. access database, excel spreadsheet, custom database, other):		
3.	Do you have a dedicated questionnaire you use to collect information from cases when you interview them?		
	If yes, where did you get this questionnaire from? (e.g. developed locally, obtained from other PHU, obtained from NSW Health, other)		
4.	Who in your public health unit follows up notifications of elevated blood lead level? (Tick all that apply)		
	• Public health nurse		
	• Surveillance officer		
	• Environmental health officer		
	• Other (please provide details):		
5.	Does your public health unit routinely produce reports describing the epidemiology (e.g. rates, number) of elevated blood lead levels in your area?		
	If yes, are these for (please tick all that apply):		
	• Internal use		
	• External use		
	• Other		
	If yes, please give brief details (e.g. run SAS code weekly, annual report, other):		
6.	When you look at aggregate data for lead notifications, do you look at data from (please circle all relevant): NCIMS SAPHaRI Own database Other Don't look at aggregate data		
7.	Do you have any suggestions for improving the surveillance of elevated blood lead levels in NSW?		
8.	Do you have any other comments or observations on managing elevated blood lead in your PHU?		

Thank you for your time! For any other comments or concerns contact Dr Katherine Todd at katherine.todd@moh.health.nsw.gov.au

Chapter 6
Teaching

The MAE cohort of 2017 teach the MAE cohort of 2018 over afternoon drinks
Australian National University, Canberra, March 2017

"Who dares to teach must never cease to learn."

John Cotton Dana, 1912

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Prologue

My role and lessons learned

The Master of Applied Epidemiology has two teaching requirements for scholars:

1. To conduct a teaching session for the first-year MAE during course block
2. To design a Lesson from the Field (LFF), a teaching exercise based on a real-life problem encountered during the placement, delivered as a pre-tutorial exercise and with a follow up tutorial delivered via teleconference.

Myself and two colleagues, Julie Collins and Siobhan St Clair, who had both also spent time in the OzFoodNet network, collaborated to present a session on outbreaks entitled "What we wish we had known" (Appendix 1). In this session, we outlined some key topics that we felt we lacked clarity on when we investigated our outbreaks – on the development and use of questionnaires, on the legislation supporting outbreak investigation, and on the potential legal implications of your activities when investigating an outbreak. We developed the session using both our own experiences, and some well publicised outbreaks that had occurred both nationally and internationally. We found this a great experience as it allowed us to consolidate and reflect on what we had learned during our first year, and attempt to clarify the really important information.

The topic I chose for my LFF was "Risk Communication" (Appendix 2). I felt that this was an underappreciated topic in epidemiology and a great place to utilise the Environmental Health experience I was getting and share this with my colleagues. Risk Communication is an integral part of Environmental Health, and in watching my senior colleagues undertake risk communication activities including media interviews it seemed to be a real art. I enjoyed the process of developing learning objectives and identifying ways to meet them using the example of the White Bay data analysis I had done, as well as incorporating wider media messaging and encouraging my colleagues to reflect no what they knew based on the data, compared to the information the community would be getting based on mass media. I was initially concerned that my session would not be long enough, but it ended up running the full two hours allocated as my group engaged enthusiastically with the discussion. I gained a great appreciation of the value of learning objectives in guiding the development of a teaching activity and in clarifying what you want students to leave the session having achieved.

In addition to the formal teaching requirements, I also continued in my role as a Conjoint Associate Lecturer with the university of Sydney Population health and Medicine Program, teaching third and fourth year medical students about public health concepts. Although I had done this for a year prior

to commencing the MAE, I feel my abilities as a tutor, including guiding discussion rather than lecturing and in clarifying the objectives of the lessons, were significantly strengthened by my teaching experiences during the MAE.

Appendix 1 - Teaching first year cohort, MAE course block, March 2017 – "What we wish we knew before we did our outbreak investigation"

Outbreaks 2.0

What we wish we knew before we did our outbreak investigation!

Siobhan St George, Julie Collins and Katherine Todd

Let's talk about…

OZ FOOD NET

Learning objectives

- Be aware of practical considerations and resources for interviewing cases
- Recognise the legislative frameworks governing outbreak investigations
- Identify the type of information that may be disclosed during an outbreak investigation
- Recognise legal considerations during an outbreak investigation
- Explain the weight of evidence in making decisions about outbreaks

Interviewing Tips

- Know your questionnaire
  - Information will not always come chronologically
- Know the public health information available
  - Fact sheets
- Know some basic information about your case
  - Date of specimen collection
  - Have a calendar!!
  - Map

Interviewing Tips

- Don't assume that people know who you are or why you're calling
  - Multiple healthcare providers / results not always given
  - Notification delay
- Explain your line of questioning
  - "I'm now going to ask some questions about your illness…"
- Take the time to build rapport
  - May not be the last time you need to speak with that person

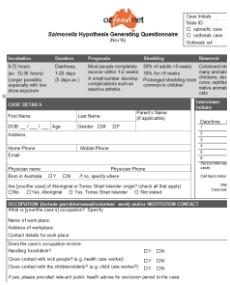
What information should you collect?

- Do you know the agent?
  - Specific questionnaires / guidelines
- Do you have a hypothesis?
  - *Salmonella* trawler vs. priority trawler
- What if you don't know what you're dealing with?
  - Be as systematic as possible to allow comparison
  - Draw on previously established questionnaires to capture information (demographics, travel, food)

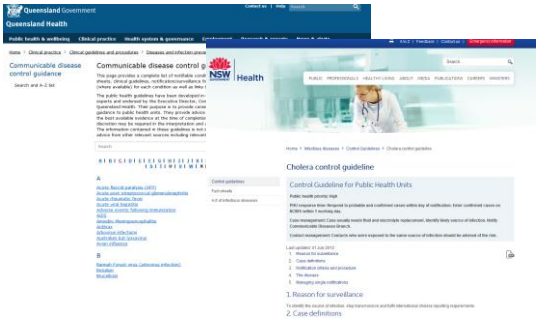
How should you organise information?

- Questionnaires often paper based / online word
- Enter into a database asap to allow for ongoing analysis
  - Epi Info
  - Excel or Access (if systematic) – Stata
- Keep all information until the investigation is over
  - Don't throw out your questionnaires!

Resources



Resources



Resources

Find the experts!

Legislation

- Each state and territory has legislation pertaining to the follow-up/investigation of cases of diseases of public health importance
- This legislation is different in each state
- Usually the Acts particularly relevant to investigating outbreaks are Food Acts and Public Health (and Wellbeing) Acts

Legislation

- It is important to know what legislation you are working under and what it says so that you can refer back to it
- People often want to know what right you have to collect information, and what right they have to give it

This commonly happens with:

- Receptionists at GP clinics*
- Nurses*
- Hospitals*
- Less familiar GPs*
- Businesses (e.g. booking information)

*Especially when seeking consent to contact

Legislation - examples

Victoria

Public Health and Wellbeing Act 2008, Part 9
Division 1

167 Power to request information

(1) An authorised officer may request a person to provide information to the authorised officer which the authorised officer believes is necessary to investigate whether there is a risk to public health or to manage or control a risk to public health.

(2) A person is authorised to provide the information requested under subsection (1).

Note

See section 227.

(3) A person may refuse to provide the information requested under subsection (1).

Public Health and Wellbeing Act 2008, Part 11
Division 4

227 Protection of person giving certain information

The giving of information that is authorised or required to be given under this Act in accordance with this Act—

(a) does not for any purpose constitute unprofessional conduct or a breach of professional ethics on the part of the person by whom it is given; or

(b) does not make the person by whom it is given subject to any liability in respect of it; or

(c) does not constitute a contravention of any other Act or law (including common

Legislation - examples

Queensland

Foodborne disease investigation lies under the *Food Act 2006*
Chapter 7, Part 2, Division 7
202 Power to require information

1) This section applies if an authorised person reasonably believes
(a) an offence against this Act has been committed; and
(b) a person may be able to give information about the offence.

(2) The authorised person may, by notice given to the person, require the person to give information about the offence to the authorised person at a stated reasonable time and place.

(3) The person must comply with a requirement under subsection (2), unless the person has a reasonable excuse.

(4) It is a reasonable excuse for an individual to fail to give information if giving the information might tend to incriminate the individual.

Other investigations fall under different acts including the *Public Health Act 2005*
Chapter 3, Part 3, Division 2
99 Power to require contact information

(1) This section applies if a contact tracing officer—
(a)reasonably suspects that a person—
(i)has a notifiable condition; or
(ii) has been in contact with a person who has, or may have, a notifiable condition; and
(b) has explained to the person that information is needed to attempt to prevent or minimise the spread of the notifiable condition.

(2) The contact tracing officer may ask the person to give the contact tracing officer all or any of the following information(the contact information) within a stated time—
(a)the person's name and residential address or another address where the person may be contacted;
(b) the name, address, whereabouts and telephone number of any other person—
(i) who may have transmitted the notifiable condition to the person; or
(ii) to whom the person may have transmitted the notifiable condition;
(c) information about the circumstances in which the person may have been exposed to the notifiable condition or may have exposed another person to the notifiable condition

Providing information

- At some point during your investigation you may be asked questions like What happened? How did I get sick? Are there others? What will happen now?
- It's sometimes hard to 'walk the line' between providing information and saying something you shouldn't (or even knowing what that is!)
- Some say 'it's safest to say nothing at all'
- I feel we have a duty, and a fantastic opportunity, to increase knowledge and awareness in people who are often our target audience!
- But we have to be aware of the possible legal implications of what we say (Katherine to speak more about this)

Things you usually can and can't say

(again, check with your PHOs, this may change depending on where you are)

Can (and arguably should!)

- Information about the person you are speaking to e.g. typing results
- Information about the pathogen e.g. where it originates and how contamination commonly occurs
- Potential sources of infection/risk factors depending on survey responses but only AFTER the interview (bias)
- Unspecific information about investigation processes*
- What will happen with their information and what action will be taken
- Education about other relevant risks and how to avoid them
- Official information request processes

*ALWAYS REMEMBER TO INCLUDE CAVEATS

Can't

- Any absolutes – we can almost never definitively say anything is the case, just that the evidence indicates it!
- Other people's personal and illness information
- Other people's specific test results
- Number of cases**
- Suspected sources of infection (when source not clear)**
- Results of the environmental investigation**
- Legal advice
- Anything to the media!

**Providing this information before the investigation is completed can be misleading or even incorrect!

Requests for Information

- If someone wants access to the full outbreak report and other relevant documents (e.g. for legal action) they often need to submit an official request for information, such as a Freedom of Information (FOI) request (VIC) or a request under the Government Information (Public Access) Act 2009 (NSW)
- There is usually a fee ($30-50) and requests are commonly submitted online
- Links to the appropriate forms should be available on your state health department's website

What are the legal implications of outbreak investigations?

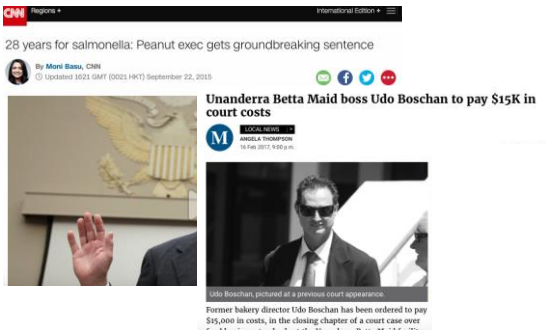
- You may become involved in civil, criminal or coronial proceedings
- Your investigation report, draft reports, copies of letters, emails and other communications may be subpoenaed and tendered in court.
- You may be required to be attend court as a witness
- Your investigation report or how you conducted the investigation may be under review

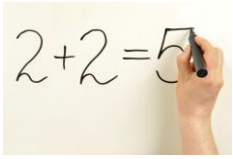
Example 1: Civil action

Example 2: Coronial inquest

- "[the lawyer for the family]… submitted that had the epidemiological investigation proceeded with greater haste during the previous week (had, for example, the questionnaire been developed within an hour or two, and the interviews with parents occurred on the 16 or 17 January instead of the 18th, 19th and 20th), the conclusion that Garibaldi garlic mettwurst was involved could have been reached at a much earlier stage and not later than Friday 20 January… I think that submission must be accepted".

Example 3: Criminal prosecution





What happens if we get it wrong?

Example 4: California strawberries and cyclosporiasis

- "Announcements by Texas and Ontario public health officials implicating California strawberries as the source of the cyclosporiasis outbreaks in May of 1996 had a devastating effect on the strawberry industry
- Supermarket chains took California strawberries off their shelves, in response to pressure from consumers. Consumers stopped buying strawberries from all sources. Truckloads of strawberries headed for market rotted as they were turned away by produce and grocery store managers
- Strawberry sales around the United States and Canada crashed, causing $40 million in losses for the industry and the loss of 5,000 jobs"

Heavy stuff!

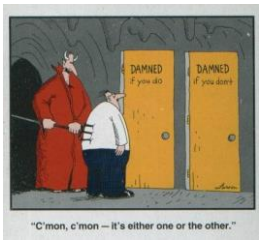
- So how do we make decisions when the evidence is unclear? When do we decide we have enough evidence?

So how do we decide?

- You must balance the potential public health impact of a problem with the known quality of available data and the potential damage to business or industry
- Information that might lead officials into taking action when data are suggestive of the source but insufficient to make a definitive call include:
  - The severity of the disease
  - The population at risk
  - Whether exposure is suspected to still be occurring
  - The quality of available data
  - Potential impact on business/industry

Key take-home points

1. Remember that sometimes action is taken on epidemiological evidence alone
2. You will constantly be balancing the need to take public health action with creating a critical level of evidence to support taking that action
3. In an outbreak setting the pressure to take action can be intense
4. Document, document, document!
5. Keep your documents organised
6. When decisions are being made, share your opinion – it is ok to have a robust discussion!
7. Your best protection is good teamwork



Risk communication

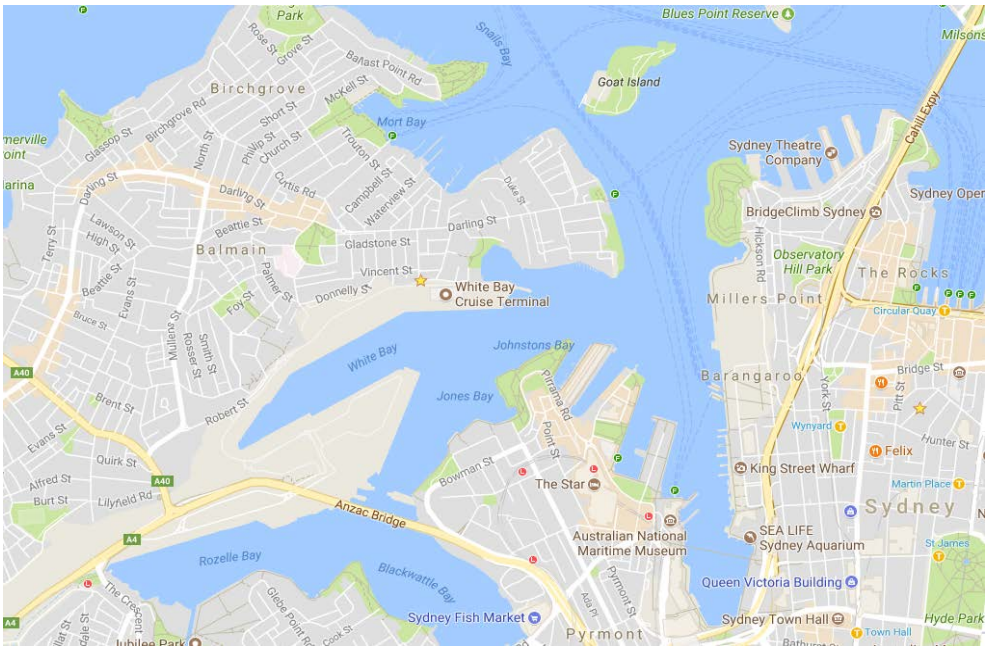
Learning objectives

By the end of this LFF students should be able to:

1. *Interpret and communicate epidemiological information to a non-scientific audience*
2. *Understand basic principles of risk communication*
3. *Formulate a risk communication strategy*
4. *Understand what factors affect risk perception*
5. *Identify common pitfalls of risk communication strategies*

Background

White Bay is located in Balmain, in the local government area of Leichhardt in Sydney. White Bay has been a working port in Sydney since the mid-1800s. Until the port was first opened to cruise ships in 2008, it had for many years been less frequently used by large ships. In April 2008, the NSW Government temporarily relocated the Cruise Passenger Terminal from Darling Harbour to White Bay for a period of five years. In 2009, the NSW Government decided to permanently relocate the Darling Harbour terminal to White Bay.



The Port Authority prepared an environmental assessment, including preparation of air quality and noise impact assessment studies from cruise ships and terminal operations. In 2011, the Port Authority Ports received approval from the NSW Department of Planning and Environment to demolish an assortment of buildings and structures on the site and construct the White Bay Cruise Terminal (WBCT), with berthing facilities for up to two cruise ships and a new purpose-built cruise

passenger terminal. Following approval, the WBCT was constructed by Ports and opened on 15 April 2013.

Since that time, the local community has expressed concerns about the health impacts of noise, air quality and odour from ships and have questioned whether air quality in the area poses any risks to those living, working or at school in the area. Some homes are in very close proximity to the terminal, and due to the topography of the land, cruise ships funnels are close to these homes.

Exercise 1

Read documents in the Resources folder 1-6 and answer the following questions:

1. What are the specific concerns of the community?
2. What has been the response from government and other agencies?
3. What are some additional concerns or considerations that may be influencing involved parties and how might this affect their response?

    (These parties could include community members, local government, local politicians, the Health department, the Environmental Protection Authority, Cruise ship companies and other players).

Exercise 2

You as the epidemiologist at the health department have been asked to conduct some analysis of publicly available air quality data for White Bay as part of the response to the community's concerns – the product of this analysis is included in the appendix as "Air Quality in White Bay".

1. Read document 7, "***What is air pollution?"*** from the Office of Environment and Heritage. Then review the graphs in the appendix and prepare a draft initial response interpreting this information for the community and addressing what this means for them.

You may feel you want more information before you give your response; if so outline what this information might be and how you would go about obtaining it.

(You may want to look up what the maximum acceptable levels of $PM_{2.5}$ and sulphur dioxide (SO2) levels are – I will leave this as a challenge for you!)

Exercise 3

Read document 8, "***Risk communication strategies".***

1. Develop a risk communication strategy outlining how you will communicate your findings and your recommendations to the community (*dot points are fine)*. Consider the following points in your strategy:
    - How would you communicate your findings?
    - Who might you communicate to?
    - In what forum would you communicate your results?
    - Who else might you include in your communication strategy?
    - What is your key message?
2. Write a sentence or two justifying your choice of risk communication strategy.

Exercise 4

Read document 9, ***"The psychology of risk perception"***.

1. What factors do you think might influence risk perception?
2. How they may be at play in this situation?

Appendix 1:

White Bay Cruise Terminal – Air quality monitoring

Air quality monitoring

In response to ongoing community concerns regarding air quality adjacent to the White Bay Cruise Terminal, a single air quality monitoring station was commissioned at the corner of Adolphus street and Grafton Street Balmain, approximately 14m above sea level (at street level – see Figures 1 and 2). As far as practicable this complies with the requirements of the relevant Australian Standard; it represents the best available location, but does not fully comply as there are trees within 20m of the site. The non-compliance is not expected to significantly affect the results.

Measurements were recorded of $PM_{2.5}$ and sulphur dioxide (SO2) levels, as well as wind speed and direction. A monthly reported was issued publically on the Sydney ports website describing the air quality for the preceding month (results available at http://www.sydneyports.com.au/community/white_bay/sub_page_4/monitoring_results_noise_and_air_quality/air_quality_monitoring_201516) . It was commissioned to monitor for 12 months from September 2015 to September 2016, and has now ceased monitoring.

The results for the White Bay air quality monitoring station were for SO2 and PM2.5 were compiled for the year based on publicly available data, and compared with other air quality monitoring sites in Sydney (Figures 3-6).

Location of the White Bay air quality monitoring station

Figure 1 - Location of air quality monitoring station (AQMS) at the corner of Grafton and Adolphus Streets, Balmain

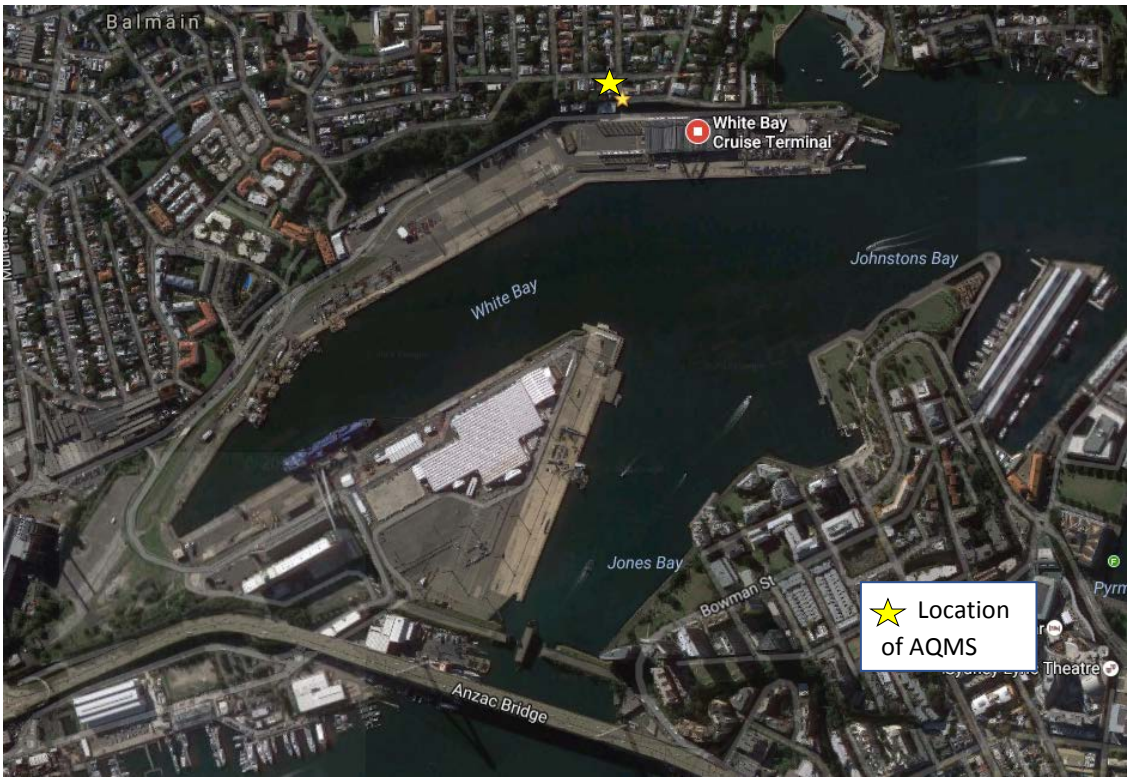


Figure 2 - Approximate location of AQMS

Approximate location of air quality monitoring station (Google street view)

What the monitoring has shown:

Sulphur dioxide (SO2)

Figure 3 - Comparison of monthly maximum 1-hour average SO2 levels across Sydney regional AQM sites, September 2015-September 2016

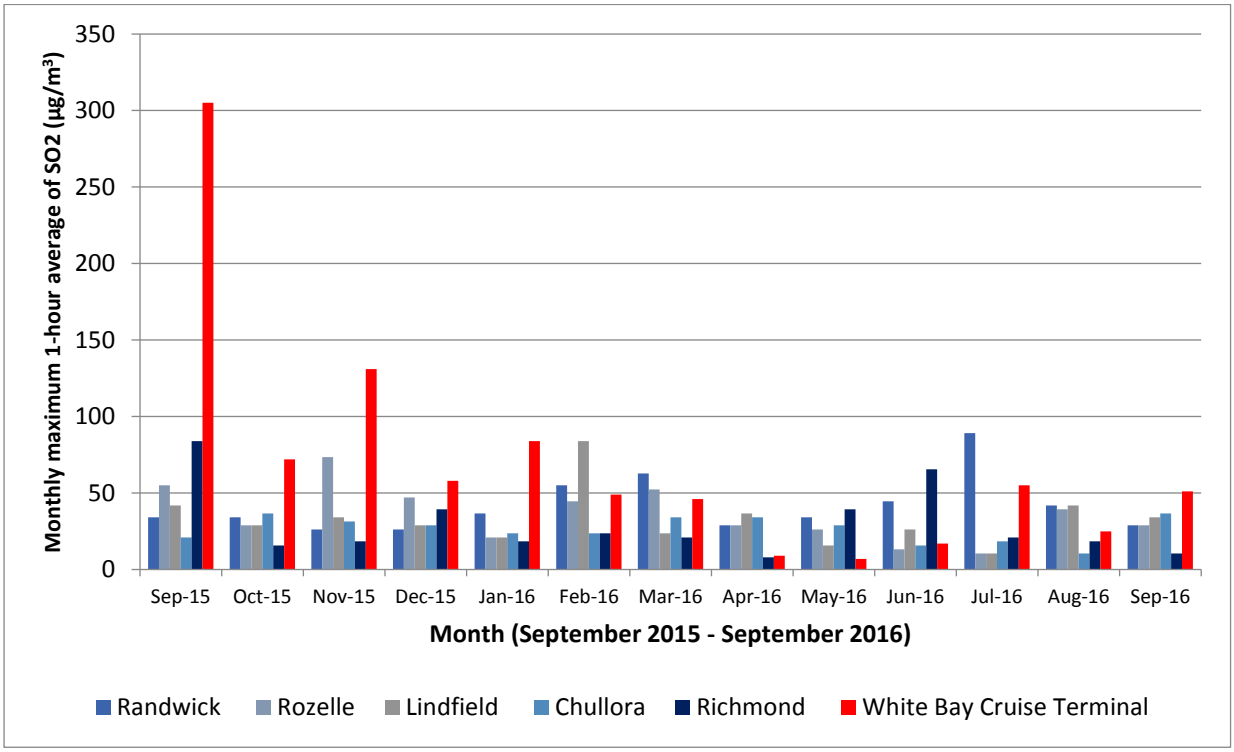
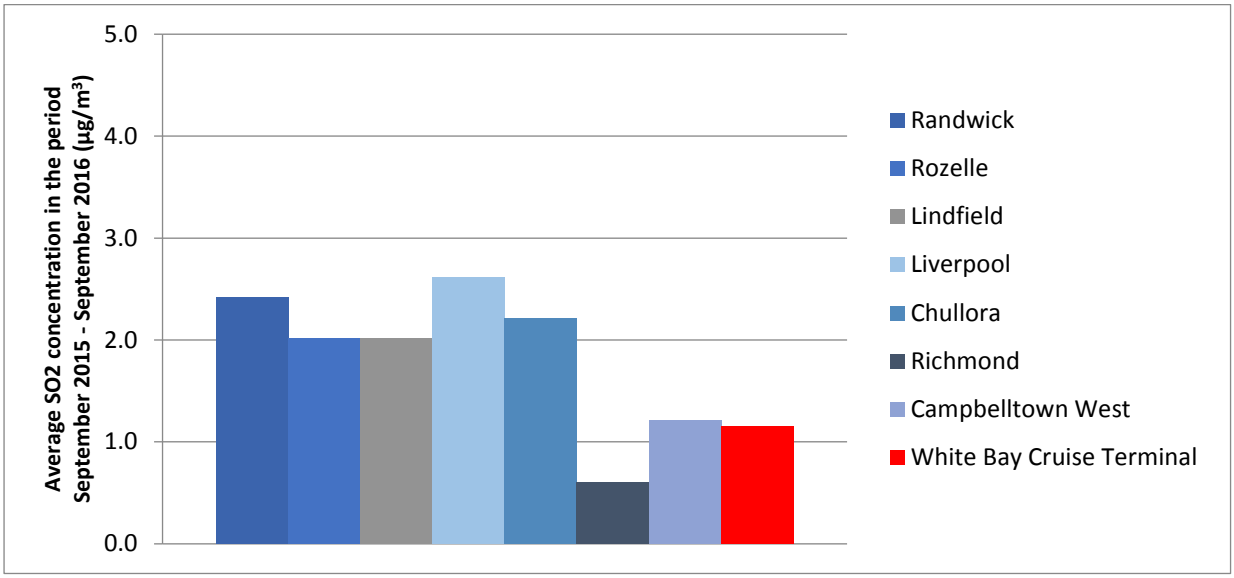


Figure 4 - Overall average SO2 concentration (µg/m³) in the period September 2015 - September 2016 at AQMS across the Sydney region



Particulate matter (PM2.5)

Figure 5 - Comparison of monthly maximum 24-hour average $PM_{2.5}$ levels across Sydney regional AQM sites, September 2015-September 2016

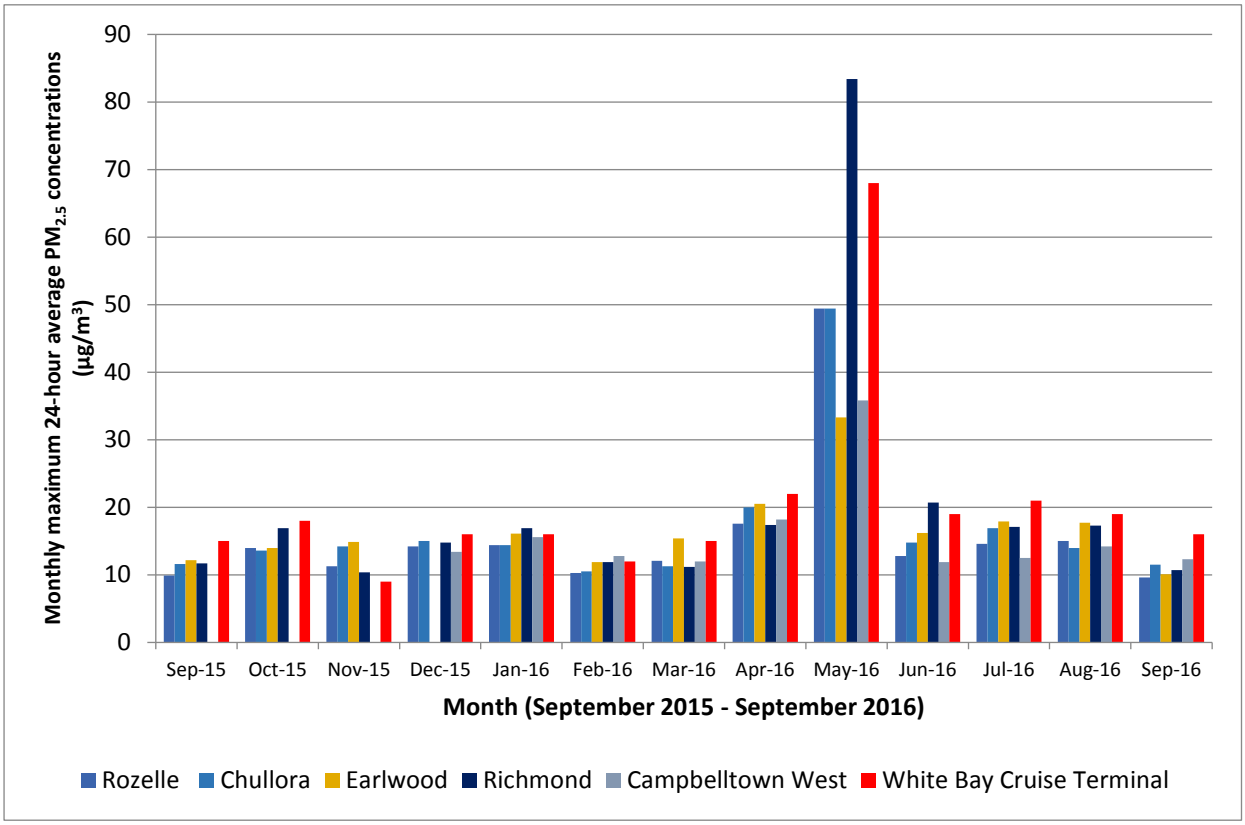
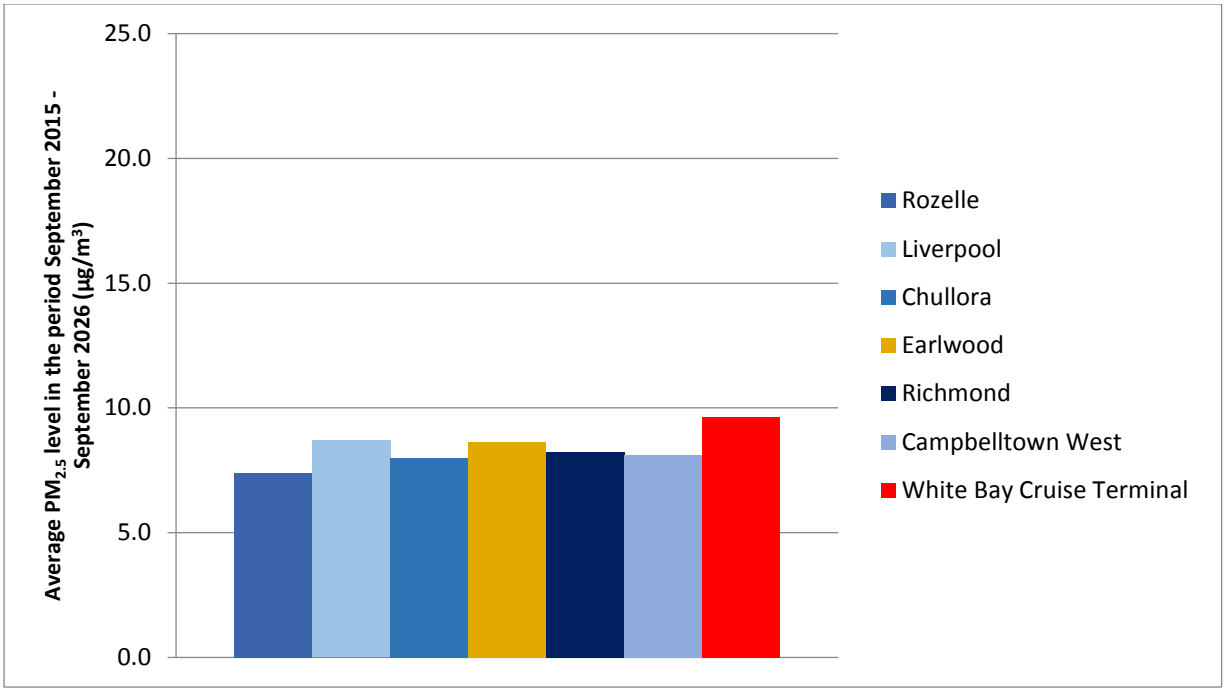


Figure 6 - Overall average $PM_{2.5}$ level (µg/m³) in the period September 2015 - September 2016 at AQMS across the Sydney region



Risk communication

A lesson from the field

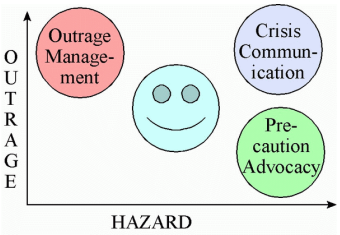
What is risk communication?

What is risk communication?

- An evidence-based approach to communicating effectively with the public
- A strategy to providing clear, credible information that is accessible to the public

- Three main types of risk communication:
  - **Precaution advocacy**
  - **Outrage management**
  - (Crisis communication)

Risk = Hazard + Outrage



Why is risk communication important?

- It helps people understand risk
- It helps people make informed decisions

Precaution advocacy

- https://www.youtube.com/watch?v=6zPoOOvUmNI

Outrage management

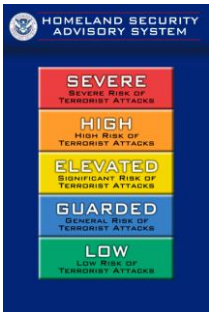
- https://www.youtube.com/watch?v=SuGogll75dU

Principles of risk communication

- Be truthful
  - Base your statements on evidence
  - This includes not making statements that are not cannot be substantiated and being prepared to admit what is known
- Be helpful
  - Respond directly to audience concerns
  - Respond using words or other information appropriate to the audience
- Be clear
- Be proactive
  - Build credibility over time
- Be available
  - Otherwise your audience may go to a less reliable source first!

"Good" vs. "bad" risk communication

Helpful risk communication	Non-helpful risk communication
Helps people to understand risk	Addresses the controversy without addressing the concerns of the public
Addresses knowledge gaps and misconceptions	Does not address knowledge gaps or misconceptions
Gives behaviourally realistic advice	Does not provide strategies
Is based on evidence	Appears to be based on a "party line" or agenda rather than the science/evidence
Uses wording that people understand	Uses jargon



- No clear objective criteria for what defines the risk levels
- No examples of what the risk level might mean
- No advice on what to do!
- Considered "vulnerable to manipulation by government officials"

Risk communication – Mad Cow Disease

- https://www.youtube.com/watch?v=QobuvWX_Grc

Developing a risk communication strategy

1. Understand your audience	2. Analyse your information
- Demographics - Current knowledge - Main sources of information - Perceptions, priorities and values - "Credibility influencers" - Barriers to effective communication	- Audience's concerns - History of the issue - Information sources - Misperceptions and urban myths - Confusing information - Opposing views
3. Organise your information	**4. Engage the public**
- Spokesperson - Holding statements - Key message development - Information repository - Spokesperson training and preparation	- Communication vehicles (news media, internet, public of individual meetings, phone calls, letters, radio interviews) - Verbal and non-verbal communication - Account for different learning styles - Obtain and respond to feedback - Respond to concerns - Track interactions, issues and resolutions

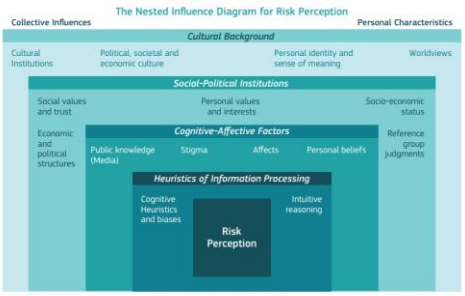
Characteristics of effective communicators

- Knowledgeable
- Well prepared
- Defined communication goals
- Forthcoming, honest, at ease
- On time, co-operative and helpful
- Empathetic, non-judgmental and able to validate concerns
- Stays within area of expertise
- Understands that everything is "on the record"
- Manages non-verbal cues that could undermine credibility
- Knows when to stop talking (and listen)

(non-verbal communication…)

Risk communication – Ebola

- https://www.youtube.com/watch?v=nfcnIXbcofs



OUTRAGE!!!

1. Is it voluntary or coerced?
2. Is it natural or industrial?
3. Is it familiar or exotic?
4. Is it memorable?
5. Is it dreaded?
6. Is it chronic or catastrophic?
7. Is it knowable or unknowable?
8. Is it controlled by me or by others?
9. Is it fair or unfair?
10. Is it morally irrelevant or morally relevant?
11. Can I trust you or not?
12. Is the process responsive or unresponsive?

From Sandman's *"Risk Communication"*

Risk communication – Hendra virus

- https://www.youtube.com/watch?v=rF_whOkypjY

Risk communication in the 21st century

- 24 hour news cycle
  - Increasing demand for news
  - Outrage sells!
- Social media
  - Rapid dissemination of information
- The internet
  - A wealth of credible and no credible information sources
  - Accessible 24/7
  - Often difficult to identify who is/is not credible or who has an agenda

Final tips

- Have the community trust you BEFORE the crisis happens
- Planning
  - Risk communication is a process, not an event
  - Establish goals
  - Tailor your message
  - Use sources the audience finds credible
- Preparation
  - Understand your audience and the issues
- Practice
  - Look polished
  - Look calm and collected
  - Speak clearly, simply and concisely
  - Be as helpful as possible

LFF pre-reading documents:

1. https://www.smh.com.au/national/nsw/balmain-cruise-terminal-health-fears-spark-dispute-between-industry-and-regulators-20141011-10rwn6.html
2. https://www.dailytelegraph.com.au/newslocal/inner-west/homeowners-are-leaving-white-bay-over-cruise-terminal-pollution/news-story/c3f42f32d2fddee708ae5b0264a97b5a
3. https://www.slhd.nsw.gov.au/populationhealth/pdf/Q&ACruiseShips.pdf
4. http://www.abc.net.au/news/2015-05-28/nsw-port-authority-suspends-overnight-ship-berthing/6502302
5. https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/whitebaycruiseterminalcommunityimpacts.pdf?la=en&hash=C86F5035230D721537FD4B63A4815BCE850C24C1
6. https://www.theguardian.com/environment/2015/mar/10/alan-jones-backs-balmain-residents-battle-against-cruise-ship-pollution
7. http://www.environment.nsw.gov.au/topics/air/air-pollution
8. http://www.who.int/risk-communication/training/module-b/en/index2.html
9. https://www.health.harvard.edu/newsletter_article/the-psychology-of-risk-perception