Histamine fish poisoning in Australia, 2001 to 2013

Katrina E Knope, Timothy S Sloan-Gardner, Russell J Stafford

Abstract

We report on histamine fish poisoning outbreaks in Australia from 2001 to 2013. Histamine fish poisoning results from the ingestion of histamine contained within the flesh of certain fish species that naturally contain histidine, which has been converted to histamine by spoilage bacteria following poor handling or temperature control after harvesting. While symptoms vary, allergic symptoms such as facial flushing, headaches and rashes are frequently reported. Using the OzFoodNet outbreak register, published case reports and surveillance reports, we found data on 57 outbreaks of histamine fish poisoning, which affected 187 people, of whom 14% were hospitalised. There were no deaths reported. Outbreaks were generally small in size, with a median of 2 cases per outbreak (range 1 to 22 people), with 88% of outbreaks comprising less than 5 people. Tuna (in the family Scombridae) was the most frequently reported food vehicle, while 18 outbreaks involved non-scombridae fish. Median incubation periods among the outbreaks were short; being less than 1 hour for 22 outbreaks. The most frequently reported symptoms were diarrhoea and rash. Symptoms of facial/body flushing were reported for at least one case in 19 outbreaks and tingling, burning or swelling of the skin, especially around the lips for at least 1 case in 13 outbreaks. In 3 outbreaks, one or more cases were reported to have had respiratory distress or difficulty breathing. While the condition is often mild, improved recognition and appropriate treatment is important, as it will reduce the possibility of any severe health effects resulting from this condition. Key features of histamine fish poisoning outbreaks are the high attack rate, rapid onset, the typical symptoms and their short duration. *Commun Dis Intell* 2014;38(4):E285–E293.

Keywords: foodborne disease, histamine fish poisoning, OzFoodNet, scombroid, outbreaks

Introduction

Scombroid (or histamine fish) poisoning derives its name from the family of dark fleshed fish, or Scombridae (tuna and mackerel), with which it was first associated.[1] The illness is a chemical intoxication that occurs after the ingestion of bacterially contaminated fish that contain high levels of histamine.[2, 3] Non-scombroid fish with relatively high levels of naturally-occurring histidine in their flesh, including mahi-mahi (dolphinfish), swordfish, salmon, sardines and marlin have since been implicated, thus the disease is now more accurately described as histamine fish poisoning.[3, 4]

Symptom onset is rapid, usually within minutes to a few hours after consumption of the implicated fish.[5] Symptoms may vary for different individuals depending on underlying medical conditions and medications but can include flushing of the face, neck and upper arms, oral numbness and/or burning, metallic taste, headache, itchy rash, hives, nausea, vomiting, diarrhoea and difficulties swallowing. The illness is generally self-limiting and recovery usually occurs within 24 hours. When required, antihistamines are used to treat symptoms.[6] There have been reports of more severe presentations including hypotension, tachycardia, palpitations, respiratory distress and shock,[7,8,9] with a report of histamine fish poisoning leading to asthma exacerbation.[10]

There are 3 elements that are required for histamine fish poisoning to occur. Firstly, the fish must have high levels of free histidine present. Secondly, certain bacteria that produce the enzyme histidine decarboxylase, particularly *Morganella morganii*, *Klebsiella pneumoniae* or other Enterobacteriaceae must be present in the fish.[11] This enzyme is responsible for the conversion of histidine to histamine.[12] Lastly, there must be some form of inappropriate handling or temperate abuse that allows the multiplication of these bacteria and thus the production of histamine. As histamine is heat stable, cooking does not reduce the risk of illness.[12] The Food Standards Code states that the level of histamine in fish and fish products must not exceed 200 mg/kg.[13]

Diagnosis of histamine fish poisoning is usually based on the short onset time, clinical symptoms (including resolution of symptoms following appropriate treatment), and a history of consumption of fish. Occasionally, leftover fish can be collected and tested for high levels of histamine.

In the United States of America (USA), histamine fish poisoning accounted for 7.6% of all foodborne illness outbreaks and 38% of those specifically seafood-related based on USA foodborne illness outbreak data from the Center for Science in the Public Interest from 1990 to 2003.[14] There were 223 outbreaks of histamine poisoning, affecting 865 people

in the US between 2000 and 2007.[15] Combining this with USA poison control centre data from the National Poisoning Data System for 2005 to 2009, and using a model to similar to Scallan et al.,[16] they estimated that there are 35,142 histamine fish poisoning cases annually in the USA.

Histamine poisoning is not notifiable in any state or territory in Australia; hence there is very limited data available on the incidence of this illness. Public health data collected on histamine poisoning is usually derived from outbreak investigations in those jurisdictions in which two or more cases of suspected foodborne illness is notifiable. Based on data circa 2000, OzFoodNet estimates that there are approximately 280 cases of histamine fish poisoning annually in Australia.[17]

Few outbreaks and cases of histamine fish poisoning occurring in Australia prior to 2001 have been reported in the literature. An outbreak related to tailor fish was reported in 1985,[18] an outbreak related to a tuna dish served at a restaurant with two cases was reported in 1993[19] and 2 separate outbreaks involving a total of 7 cases related to West Australian salmon cooked in 2 private homes were reported in 1992.[20] This study represents the first published analysis of national histamine fish poisoning cases. We aimed to describe the epidemiology of histamine fish poisoning cases between 2001 and 2013.

Methods

Study type

We conducted a retrospective descriptive case series analysis of outbreaks and single cases of histamine fish poisoning that occurred in Australia between 2001 and 2013.

Case definition

Outbreaks and single cases where histamine fish poisoning (or scombroid) was listed as the suspected or confirmed aetiology and where onset of the first case (or the single case) occurred during the period 2001 to 2013 were included in the analysis.

Data collection

Data were collected from 3 different sources: published literature, the OzFoodNet outbreak register and OzFoodNet fortnightly enteric surveillance reports. These latter 2 sources are not publically available.

The details of histamine fish poisoning cases or outbreaks identified through the literature or fortnightly enteric surveillance reports but not recorded in the outbreak register were confirmed with OzFoodNet epidemiologists in the state or territory where the outbreak occurred. A preliminary report was obtained for 1 outbreak that had not yet been entered into the outbreak register. A single outbreak that was reported in the literature but not included in the OzFoodNet outbreak register was also included.[21] For the purposes of the analysis, single cases of histamine fish poisoning were treated as outbreaks.

Data were summarised by the number of outbreaks, number affected, median incubation period, the range of reported symptoms and those most commonly reported, whether cases required hospitalisation or other medical treatment, the food vehicles involved and levels of contamination in the foods, the settings where the food was cooked and the factors contributing to the foods involved in the outbreaks becoming contaminated. For the purpose of the analysis, the setting was defined as the place where the food was cooked. Analyses were carried out in Microsoft Excel®.

The year and month of onset was calculated from the date of onset of symptoms for the first case in the outbreak, known as the onset date.

Human research ethics approval

Human research ethics committee approval was not sought or required because the information about outbreaks was collected under state and territory public health legislation, and this analysis is consistent with the purpose for which the data were collected.

Results

Epidemiological features

There were 57 outbreaks of histamine fish poisoning in Australia between 2001 and 2013 (Figure) (Appendix). Nine of these were incidents involving a single person. The OzFoodNet outbreak register contained information on 41 of these outbreaks, while a further 14 were identified through the fortnightly enteric disease surveillance reports, one through an OzFoodNet Epidemiologist sending in a preliminary outbreak summary and one through a published outbreak summary.[21] Clinically compatible illness was reported by 187 people, with 90 people requiring treatment from a medical practitioner, including 27 people (14%) in 13 outbreaks who required hospitalisation. There were no reported deaths.

Outbreaks were generally small in size, with a median of 2 cases per outbreak (range 1 to 22 people), with 88% of outbreaks (50/57)

comprising less than 5 people. Attack rates were high, with 35% of people (105/299) who were known to have consumed the foods becoming ill. Attack rates were between 80% and 100% for the outbreaks for which an attack rate could be calculated (n=18).

All states and territories except Western Australia reported at least one outbreak. Outbreaks occurred in all years except 2002, and there was no clear seasonal trend, although February was the most frequent month of onset (11/57 outbreaks).

Median incubation periods for the outbreaks were short; being less than 1 hour for 39% (22/57) of outbreaks. In five of these, the median incubation period was reported to have been 15 minutes or less. In the remaining 35 outbreaks; 19 had a median incubation period of 1 hour and seven had a median incubation period of between 2 and 4 hours while the median incubation period was unknown or not provided for 9 outbreaks.

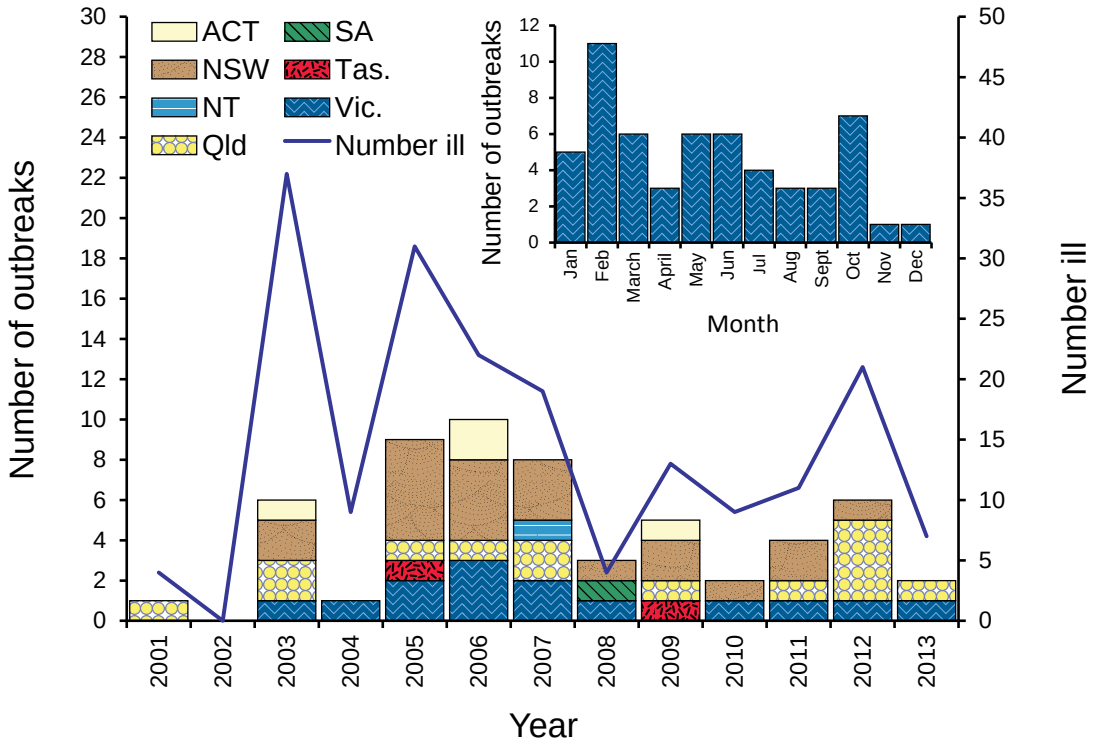
Frequency data for symptoms experienced by cases was not reported for all outbreaks, and the range of symptoms reported varied across outbreaks. For those cases where information of symptoms were available, the most frequently reported symptoms were diarrhoea (78%, 68/87) and rash (77%, 65/84), while nausea, vomiting, fever and abdominal pain were each reported for approximately half of the cases (between 43% and 56%) (Table 1).

Additional information about symptoms were recorded for some outbreaks in a free text comments field. Symptoms reported in this field included facial/body flushing (19 outbreaks), skin-related symptoms (tingling or burning or swelling of skin especially around the lips, but also fingers) (13 outbreaks), headache (10 outbreaks) and cardiac symptoms (racing heart or palpitations or tachycardia or bradycardia) (10 outbreaks). Four cases were reported to have had respiratory distress or difficulty breathing.

Exposure settings

Outbreaks were most commonly associated with foods prepared in restaurants (47%, 27 outbreaks) and private residences (35%, 20 outbreaks). A small number of outbreaks were associated with foods that were commercially manufactured (5%, 3 outbreaks) (Table 2). The 3 commercially manufactured foods were tinned tuna (2 outbreaks) and anchovies (1 outbreak).

Figure: Outbreaks of histamine fish poisoning, Australia, 2001 to 2013, by year and state or territory,* and inset: outbreaks of histamine fish poisoning between 2001 and 2013, by month†



* There were no outbreaks reported from Western Australia.

† One outbreak in the Australian Capital Territory involving 4 cases is reported by year of publication because no onset dates are available. This outbreak is not included in the inset.

Table 1: Frequency data for symptoms reported for cases in outbreaks of histamine fish poisoning, Australia, 2001 to 2013

Symptom	Number of outbreaks with information	Number of cases with symptom	Number of cases with information available	Proportion of cases reporting symptom %
Diarrhoea	44	68	87	78
Rash	45	65	84	77
Nausea	41	35	62	56
Vomiting	42	14	28	50
Fever	41	23	49	47
Abdominal pain	41	20	47	43

Table 2: Food vehicles involved in outbreaks of histamine fish poisoning, Australia 2001 to 2013, by setting where the food was cooked

Food vehicle	Restaurant	Private residence	Commercially manufactured	Retail	Commercial caterer	School	Unknown	Total
Tuna	12	13	2	2	0	1	2	32
Mahi-mahi	7	1	0	0	0	0	0	8
Yellowtail kingfish/ kingfish	3	0	0	0	0	0	1	4
Fish-unknown species	2	1	0	0	0	0	1	4
Butterfish/ rudderfish	1	0	0	0	1	0	0	2
Seafood marinara	1	0	0	0	0	0	0	1
Seafood extender	0	1	0	0	0	0	0	1
Seafood – unknown	0	1	0	0	0	0	0	1
Sardines	0	1	0	0	0	0	0	1
Mullet	0	1	0	0	0	0	0	1
Marlin	1	0	0	0	0	0	0	1
Anchovies	0	1	0	0	0	0	0	1
Total	27	20	2	2	1	1	4	57

Suspected food vehicles

Tuna (in the family Scombridae) was the most frequently reported food vehicle (57%, 32 outbreaks) (Table 2), while 18 outbreaks involved nonScombridae fish, including mahi-mahi (14%, 8 outbreaks) and yellowtail kingfish, or kingfish (7%, 4 outbreaks). Levels of histamine in the foods associated with illness were reported for 24 outbreaks. Unacceptable levels of histamine (>200 mg/kg) were confirmed in the fish or seafood samples during 16 (28%) outbreak investigations, ranging between 270 mg/kg and 7,000 mg/kg (Appendix). In 6 outbreaks, the food was not considered to have been epidemiologically implicated. For 1 further outbreak, foods were stated to have been positive for histamine, but levels were not stated, and for another outbreak, histamine levels were reported to be high, but levels were not stated. For 4 outbreaks, results for multiple samples were available, and the levels of histamine in the seafood varied widely between samples, for example, ranging between 160 mg/kg and 5,100 mg/kg for samples taken during 1 outbreak investigation.

The source countries for the fish products involved in the outbreaks were rarely reported. In 6 outbreaks, the foods involved were thought to have been imported from overseas. Five of these involved foods imported from Indonesia (4 were tuna and 1 was mahi-mahi) and 1 outbreak involved tinned anchovies imported from Morocco. Two further outbreaks involved canned tuna, but the country of origin of the tuna was not specified.

Possible factors contributing to contamination

Possible factors contributing to the production of toxics levels of histamine in the food were collected systematically for the 41 outbreaks reported in the OzFoodNet outbreak register, while descriptions of possible process failures were also available for eight of these. No information on contributing factors was available for the 16 outbreaks (including the 9 incidents involving a single person) that were identified from sources other than the outbreak register. In two-thirds of the outbreaks (66%, 27/41), investigators reported that inadequate refrigeration, or foods being left at room temperature contributed to toxin production, but this was only confirmed by visual observation for one of the outbreaks.

Discussion

This study represents the first national analysis of histamine fish poisoning cases in Australia. Over the study period, there were 57 outbreaks affecting 187 people, of whom 14% required hospitalisation. The outbreaks reported here are similar to the number reported internationally. In the USA between 2000 and 2007, there were 223 outbreaks of histamine fish poisoning affecting 865 people.[15] In Europe, 34 outbreaks of histamine fish poisoning were reported in 2012, with a total of 241 cases, of which 14 were hospitalised.[22] France and Spain contributed 68% of the cases.[22]

The small size of the outbreaks precluded more detailed analysis of the association between food and illness. However, the descriptive epidemiology of the outbreaks did contribute to identifying linked cases with a common food exposure. The foods involved in the outbreaks reported here were most frequently Scombridae fish (tuna), but the consumption of other fish species (mahi-mahi) were shown to also be important causes of histamine fish poisoning.

Where histamine levels in the foods associated with illness were reported, two-thirds contained a concentration of histamine that exceeded the acceptable level under the Food Standards Code,[13] however, there were 7 outbreaks where the histamine concentrations were below the maximum acceptable levels. Bartholomew et al. noted that some people displayed clinically compatible symptoms of histamine fish poisoning after consuming fish with levels of <200 mg/kg.[23] The toxic dose threshold for histamine in food is unknown, though factors such as the part of the fish eaten and individual susceptibility may increase the toxic effect.[6]

The most frequent setting involved in the outbreaks was restaurants. This is similar to outbreaks reported for Europe in 2012, where 50% of outbreaks were from this setting. In contrast, only 12% of European outbreaks were reported from private homes.[22] The point at which the fish became contaminated, or at which histamine levels in the flesh began to increase cannot be determined from the data presented here, because data are presented by the place where the food was cooked. Once histamine is formed, appropriate handling, and even canning will not reduce the risk of health effects in consumers, as it is heat stable. This is demonstrated through the outbreaks reported here, with 3 outbreaks involving canned fish.

Hospitalisation information for histamine fish poisoning outbreaks is likely to underestimate the proportion of illnesses that might be considered serious. Investigators report that cases frequently present to emergency departments (Jennie Musto personal communication), but emergency department presentations are not counted within the number hospitalised. It is important to note that emergency department presentation is not always an indicator of severity, but may also reflect the time of day (when GP surgeries are closed) or economic reasons.

While the data presented here contained little detail on the possible factors leading to contamination, the most important contributing factor to histamine poisoning is known to be improper refrigeration of the harvested fish, which enables bacterial proliferation.[22] Rapid chilling of fish immediately after they are caught will reduce the risk of histamine formation. It is important that adequate temperature control is maintained from harvesting of fish throughout the wholesale and retail chain to the plate.

A comparison between the number of people affected per year as reported here (14.4 cases per year) and OzFoodNet estimates of annual case numbers (280 cases),[17] suggests that the cases reported in this study represent only 5% of cases occurring in the community each year. The outbreaks reported here were small in size, but it is possible that other cases associated with consumption of the same foods were not reported. A range of factors may contribute to the small size of reported outbreaks, or to outbreaks not being reported. Symptoms of histamine fish poisoning may often be mild, non-specific, and may resolve quickly and without treatment, and therefore the symptoms may be misdiagnosed or missed altogether, and medical attention may not be sought. The lack of a laboratory test to confirm current or recent histamine fish poisoning further reduces case ascertainment. Histamine fish poisoning is not a separately notifiable condition in Australia, and thus cases may only be reported when an outbreak is known to have

occurred. In the USA, where it is estimated that for every histamine fish poisoning case reported within an outbreak there are 317 cases in the community, underreporting of histamine fish poisoning cases still occurs, even in states where reporting of single cases is required.[15]

The increasing importance of international trade in food products can lead to increased risks of foodborne illness. OzFoodNet reports 2–3 outbreaks each year involving foods imported into Australia.[24] Six of the outbreaks in this study involved imported foods, five of them associated with tuna from Indonesia.

Conclusion

This is the first published national analysis of cases of histamine fish poisoning in Australia. Although typically a mild manifestation, histamine fish poisoning can result in more severe outcomes, including hospitalisation. A combination of factors including people not seeking medical care, misdiagnosis, and underreporting results in the true burden of this disease remaining unknown.

Acknowledgements

We thank the many individuals and organisations who investigate and report on these outbreaks, in particular, OzFoodNet epidemiologists, public health unit and communicable disease control branch staff, public health laboratories and food safety units. OzFoodNet is funded by the Australian Government Department of Health.

Author details

Katrina Knope[1]
Timothy Sloan-Gardner[1,2]
Russell Stafford[3]

1. Zoonoses, Foodborne and Emerging Infectious Diseases Section, Health Emergency Policy Branch, Office of Health Protection, Australian Government Department of Health, Woden, Australian Capital Territory
2. Master of Philosophy in Applied Epidemiology (MAE) Scholar, National Centre for Epidemiology and Population Health, Research School of Population Health, ANU College of Medicine, Biology and Environment, Australian National University, Acton, Australian Capital Territory.
3. OzFoodNet, Communicable Diseases Unit, Chief Health Officer Branch, Department of Health, Herston, Queensland

Corresponding author: Ms Katrina Knope, Zoonoses, Foodborne and Emerging Infectious Diseases Section, Health Emergency Policy Branch, Office of Health Protection, Australian Government Department of Health, MDP 14, GPO Box 9848, CANBERRA ACT 2601. Telephone: +61 2 6289 2751. Email: Katrina.Knope@health.gov.au

References

1. Hungerford JM. Scombroid poisoning: a review. *Toxicon* 2010;56(2):231–243.
2. Attaran RR, Probst F. Histamine fish poisoning: a common but frequently misdiagnosed condition. *Emerg Med J* 2002;19(5):474–475.
3. Lehane L, Olley J. Histamine fish poisoning revisited. *Int J Food Microbiol* 2000;58(1–2):1–37.
4. Hwang DF, Chang SH, Shiua CY, Chai T. High-performance liquid chromatographic determination of biogenic amines in fish implicated in food poisoning. *J Chromatogr B Biomed Sci Appl* 1997;693(1):23–29.
5. Heymann DL editor. *Control of Communicable Disease Manual*. 18th edn: American Public Health Association; 2004.
6. Lehane L, Olley, June. Histamine (Scombroid) Fish Poisoning. In: *National Office of Animal and Plant Health*. Canberra: Department of Agriculture Fisheries and Forestries, 1999.
7. Johnson EA, Schantz EJ. Chapter 17. Miscellaneous natural intoxicants. In: Riemann HP, Cliver DO Editors. *Foodborne infections and intoxications*. 3rd edn. Elsevier Inc. 2006: 687–688.
8. D'Aloia A, Vizzardi E, Della Pina P, Bugatti S, Del Magro F, Raddino R, et al. A scombroid poisoning causing a life-threatening acute pulmonary edema and coronary syndrome in a young healthy patient. *Cardiovasc Toxicol* 2011;11(3):280–283.
9. Iannuzzi M, D'Ignazio N, Bressy L, De Sio A. Severe scombroid fish poisoning syndrome requiring aggressive fluid resuscitation in the emergency department: two case reports. *Minerva Anestesiol* 2007;73(9):481–483.
10. Wilson BJ, Musto RJ, Ghali WA. A case of histamine fish poisoning in a young atopic woman. *J Gen Intern Med* 2012;27(7):878–881.
11. Bjornsdottir K, Bolton GE, McClellan-Green PD, Jaykus LA, Green DP. Detection of gram-negative histamine-producing bacteria in fish: a comparative study. *J Food Prot* 2009;72(9):1987–1991.
12. Smolinska S, Jutel M, Crameri R, O'Mahony L. Histamine and gut mucosal immune regulation. *Allergy* 2014;69(3):273–281.
13. Australia New Zealand Food Standards Code – Standard 2.2.3 – Fish and Fish Products. [online] Accessed on 14 February 2014. Available from: http://www.comlaw.gov.au/Details/F2011C00569
14. Smith Dewall C, Hicks G, Barlow K, Alderton L, Vegosen L. Foods Associated with Foodborne Illness Outbreaks from 1990 through 2003. *Food Protection Trends* 2006;26(7):446–473.
15. Pennotti R, Scallan E, Backer L, Thomas J, Angulo FJ. Ciguatera and scombroid fish poisoning in the United States. *Foodborne Pathog Dis* 2013;10(12):1059–1066.
16. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, et al. Foodborne illness acquired in the United States—major pathogens. *Emerg Infect Dis* 2011;17(1):7–15.
17. Hall G, Kirk M. *Foodborne illness in Australia: annual incidence circa 2000*. Canberra: Department of Health and Ageing; 2005.

18. Taylor S. Histamine poisoning associated with fish, cheese, and other foods. Geneva: World Health Organization; 1985.

19. Brown C. Scombroid poisoning. *Med J Aust* 1993;158(6):435–436.

20. Smart DR. Scombroid poisoning. A report of seven cases involving the Western Australian salmon, *Arripis truttaceus*. *Med J Aust* 1992;157(11–12):748–751.

21. Hall M. Something fishy: six patients with an unusual cause of food poisoning! *Emerg Med (Fremantle)* 2003;15(3):293–295.

22. European Food Safety Authority and European Centre for Disease Prevention and Control. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2012. *EFSA Journal* 2014;12(2):3547, 312 pp. doi:10.2903/

23. Bartholomew BA, Berry PR, Rodhouse JC, Gilbert RJ, Murray CK. Scombrotoxic fish poisoning in Britain: features of over 250 suspected incidents from 1976 to 1986. *Epidemiol Infect* 1987;99(3):775–782.

24. Kirk M, Musto J, Gregory J, Fullerton K. Obligations to report outbreaks of foodborne disease under the International Health Regulations (2005). *Emerg Infect Dis* 2008;14(9):1440–1442.

Appendix: Outbreaks of histamine fish poisoning, Australia, 2001 to 2013*

Year	Setting	Number affected	Number required medical treatment	Number hospitalised	Food vehicle	Imported food	Histamine level reported mg/kg
2001	Restaurant	4	Unknown	0	Mahi-mahi fillets		Unknown
2003	Restaurant	6	4	1	Yellowfin tuna		470 and 490
2003	Private residence	2	2	0	Tuna patties		No samples available/taken
2003	Private residence	2	2	2	Sardines		2,961
2003	Restaurant	22	2	0	Butterfish (rudderfish) medallions		270
2003	Restaurant	3	2	0	Mahi-mahi		Unknown
2003	Restaurant	2	2	0	Thai fish cakes		Positive, level not stated
2004	Commercial caterer	9	0	0	Rudderfish		Unknown
2005	Private residence	2	0	0	Fish (unknown species)		60
2005	Private residence	4	4	0	Tuna steak		No samples available/taken
2005	Restaurant	2	1	0	Yellowfin tuna		No samples available/taken
2005	Restaurant	2	2	0	Yellowfin tuna		1,700
2005	Restaurant	2	2	0	Tuna component of nicoise salad		No samples available/taken
2005	Restaurant	1	Unknown	Unknown	Fish-unknown species		No samples available/taken
2005	Unknown	1	Unknown	Unknown	Kingfish		Unknown
2005	Unknown	3	Unknown	Unknown	Tuna		Negative
2005	Unknown	14	Unknown	Unknown	Fish dish		‘High levels’, but no number stated
2006	Private residence	2	0	0	Bluefin tuna steaks		5,100 or 160 cooked/raw
2006	Private residence	2	1	0	Tuna steak		Unknown
2006	Private residence	1	Unknown	Unknown	Tuna		Unknown
2006	Private residence	2	Unknown	Unknown	Tuna		No samples available/taken
2006	Restaurant	2	2	0	Kingfish		3,450
2006	Restaurant	2	2	1	Tuna steaks		Unknown
2006	Restaurant	1	Unknown	1	Mahi-mahi		Negative
2006	Restaurant	1	Unknown	Unknown	Tuna		<10
2006	Restaurant	3	Unknown	Unknown	Marlin		Unknown
2006	Restaurant	6	0	6	Yellowtail kingfish fillets		362
2007	Commercially manufactured	2	2	0	Suspect tinned tuna		Negative
2007	Private residence	3	2	2	Tuna kebab steaks	Indonesia	Unknown

Appendix continued: Outbreaks of histamine fish poisoning, Australia, 2001 to 2013*

Year	Setting	Number affected	Number required medical treatment	Number hospitalised	Food vehicle	Imported food	Histamine level reported mg/kg
2007	Restaurant	2	1	0	Tuna		No samples available/taken
2007	Restaurant	2	2	0	Mahi-mahi	Indonesia	No samples available/taken
2007	Restaurant	2	2	2	Tuna steak	Indonesia	Unknown
2007	Restaurant	2	2	2	Grilled tuna		Unknown
2007	Retail	2	Unknown	0	Tuna	Indonesia	No sample
2007	Retail	4	Unknown	0	Tuna kebabs		3,600
2008	Commercially manufactured	1	1	1	Tuna from can		Unknown
2008	Private residence	1	Unknown	Unknown	Tuna steaks		Unknown
2008	Private residence	2	Unknown	Unknown	Tuna steaks	Indonesia	2,200 and 5,200
2009	Private residence	2	2	1	Tuna steak		Unknown
2009	Private residence	6	Unknown	0	Tuna		5,000
2009	Restaurant	1	Unknown	Unknown	Seafood marinara		Unknown
2009	Restaurant	2	1	1	Tinned anchovies	Morocco	>360
2009	Unknown	2	Unknown	Unknown	Tuna	Indonesia	Negative
2010	Private residence	4	2	0	Tuna		7,000
2010	Restaurant	5	5	0	Mahi-mahi fillets		Unknown
2011	Private residence	1	Unknown	Unknown	Seafood extender		Negative
2011	Restaurant	3	3	3	Yellowtail kingfish		4,800 and 5,100
2011	Restaurant	3	2	0	Tuna		5500
2011	Restaurant	4	4	4	Tuna		Unknown
2012	Private residence	4	1	0	Seafood - unknown		Unknown
2012	Private residence	4	0	0	Fresh mullet fillets		650
2012	Private residence	3	2	0	Mahi-mahi		>1,600 to 2,050
2012	Private residence	3	3	0	Tuna		No samples available/taken
2012	Restaurant	3	3	0	Mahi-mahi		No samples available/taken
2012	School	4	4	0	Tuna		25
2013	Restaurant	3	2	0	Tuna		Unknown
2013	Restaurant	4	Unknown	Unknown	Mahi-mahi		Unknown

* One outbreak in the Australian Capital Territory involving four cases is reported by year of publication because no onset dates are available.