FOOD STANDARDS
Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

Consumer Literature Review for Proposal P1060 – Egg food safety & Primary production requirements

Consumers' egg-handling knowledge, risk perceptions, and behaviours

July 2024

Executive summary

Food Standards Australia New Zealand undertook a rapid systematic literature review to inform P1060 – Egg Food Safety & Primary Production Requirements by examining available evidence on Australian consumers' egg-related handling knowledge, risk perceptions, and behaviours. This report outlines the methodological approach to the literature review and summarises the available evidence.

Methodology

Searches of electronic databases and hand-searching were used to identify six unique studies. The literature review includes peer-reviewed articles published in academic journals as well as grey literature, such as government reports and additional data sourced from the authors of peer-reviewed articles. All studies were conducted within Australia. This is appropriate due to the different microbiological risk environments beyond Australia: while *Salmonella* Enteritidis has only recently emerged within Australia, it is regarded as endemic in many other countries. While New Zealand may offer a comparable microbiological environment, no studies were found that were conducted among New Zealand consumers.

Key messages

Overall, the review found that consumers generally have relatively low perceptions of risk in relation to eggs, engage in a range of unsafe egg-handling or cooking behaviours, and are resistant to attempts to change these. Knowledge of safe egg-handling practices does not always translate into actual practice (e.g. despite almost three-quarters of consumers believing that cracked eggs should be discarded, a substantial minority [40%] report using them if they can check them first), and increases in safe egg-handling knowledge have not been found to result in changes to actual behaviour.

On the more positive side, the vast majority of consumers report storing eggs and meals containing eggs in a safe manner (i.e. refrigeration).

It is important to note that consumers' risk perceptions and behaviours as reported in this review have been formed in the Australian microbiological risk environment, where *Salmonella* Enteriditis is not endemic. These findings are therefore specific to these conditions. There is the possibility that consumer risk perceptions and behaviour could change, potentially quite rapidly, if there was a perceived shift in this risk environment.

The key findings are summarised by research question below.

Research Question 1: What are consumers' perceptions of risk in relation to eggs?

- The majority of Australian consumers have low risk perceptions associated with consuming eggs that have runny yolks and/or whites. Two studies found that up to 94% of consumers believe they are safe to eat in at least some circumstances.
- There is evidence of a lack of consumer awareness of the risks posed by dirty eggs. Two studies found that only around 2-5% of consumers believe that dirty eggs should be thrown away. Most consumers believe they can be cleaned and consumed.

- A substantial proportion of consumers are unaware that eggs should never be washed. Three studies found that between 60-70% of consumers believe that there are at least some occasions in which eggs should be washed (e.g. when eggs are dirty). One study found that only 10-15% believed there was a risk of foodborne illness associated with washing eggs.
- Consumers may regard eggs as posing a lower relative food safety risk compared to raw meat or poultry. One study found that a substantially higher proportion of respondents said they didn't always wash their hands after handling raw eggs (43%) compared to raw meat or poultry (23%).

Research Question 2: How often do consumers eat eggs? In what setting? And how are they cooked, if at all?

- There is limited evidence available on the frequency of egg consumption. One study found that 89% of consumers reported eating eggs or meals containing eggs in a seven-day period.
- Two studies found that the majority of eggs are consumed with a runny yolk. Two studies also found that more than half of households report consuming raw egg batter.
- Consumers treat egg whites and egg yolks differently in their cooking behaviours. One study found that 85% of consumers reported that they cook eggs until the whites are firm, while only 2% reported that they cooked them until the yolks are firm.
- One study found that the vast majority of eggs were eaten at home, regardless of the type of meal/drink or the extent to which they were cooked.

Research Question 3: Where do consumers store eggs and/or leftover of eggs, and for how long?

- Two studies found that the vast majority (91-93%) of consumers report storing eggs in the refrigerator.
- There was very limited data available on the length of time for which eggs are stored.

Research Question 4: What are consumers' egg handling behaviours? Do egg handling behaviours differ between types of households?

- Three studies found that between 43-61% of consumers do not always wash their hands after handling eggs.
- One study found that 47% of consumers report washing dirty eggs before using them.
- One nationally representative study found that up to 40% of consumers consume cracked eggs after first checking them by breaking them into a separate bowl. This is despite 72% of consumers believing that cracked eggs should be discarded.
- One study found that 31% of households may sometimes, almost always, or always re-use egg cartons. This was most likely among households who had their own chickens or sourced their eggs from backyard producers.

- One study found that 31% of households reported that when they remove a broken egg from a carton they continue to use the same carton.
- One study found that 49% of households check whether eggs are still good to eat by using the best before date, 47% crack them into a separate bowl before using them, 31% put them in water to see if they float or turn upside down, and 17% smell them. Households in the highest income bracket were more likely to check the use-by date.
- No studies were found that examined how consumers separate egg yolks and whites.

Research Question 5: Are behaviour change techniques effective for improving safe egg handling behaviours among consumers? If so, what techniques are most effective?

- Two media campaigns undertaken in Western Australia were not found to improve consumers' egg-handling knowledge.
- One experimental study found that behavioural change techniques resulted in a significantly greater increase in food-handling knowledge compared to control groups.
- Neither the media campaigns or behavioural change techniques resulted in an improvement in consumers' egg-handling behaviours.

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Introduction

In February 2020, the Food Regulation Standing Committee (FRSC) requested FSANZ review Standard 4.2.5 – Primary Production and Processing Standard for Eggs and Egg Products to address the risk of *Salmonella* Enteritidis (SE) to human health. This Standard belongs to Chapter 4 of the Australia New Zealand Food Standards Code, and applies to Australia only. During 2021, FSANZ conducted a review of existing measures for risk management of egg food safety in Australia and concluded that current regulatory and non-regulatory measures are not adequate for safeguarding public health and safety from the risk of salmonellosis due to consumption of eggs and egg products in Australia.

Two issues were identified in the review:

a) Increasing and persistent high rates of foodborne illness due to *Salmonella* spp., with a significant proportion linked to consumption of eggs and egg products; and

b) Significant changes to the Australian food safety risk environment with the emergence of SE and new evidence that *Salmonella Typhimurium* (ST) has now been found on *and* within eggs at point of lay.

Risky food safety practices within domestic environments contribute to a significant proportion of foodborne illness around the world (Redmond and Griffith 2003). Within Australia, 28% of salmonellosis outbreaks occurred in private residences from January 2001 to January 2011 (Moffatt et al. 2016) and 26% from January 2011 to January 2014 (Chousalkar et al. 2017). Eggs and egg-containing foods were the most frequently identified food vehicle for *Salmonella* outbreaks in Australia between 2001 and 2016, being implicated in 30.6% (238/778) of outbreaks (Ford et al. 2018).

This literature review examines consumer risk perceptions, consumption, and handling behaviours that may increase the risk of foodborne illness due to *Salmonella*, as well as the effectiveness of behaviour change techniques for improving safe egg handling behaviours. It investigated the following research questions:

1. What are consumers' perceptions of risk in relation to eggs?
2. How often do consumers eat eggs? In what setting? And how are they cooked, if at all?
3. Where do consumers store eggs and/or leftovers of eggs, and for how long?
4. What are consumers' egg handling behaviours? Do egg handling behaviours differ between types of households?
    a. Do consumers wash their hands after handling eggs?
    b. Do consumers use or consume dirty or cracked eggs?
    c. Do consumers wash eggs?
    d. Do consumers reuse egg cartons?
    e. How do consumers typically separate egg yolks and whites?
    f. How do consumers check whether eggs are safe to eat?
5. Are behaviour change techniques effective for improving safe egg handling

behaviours among consumers? If so, what techniques are most effective?

Methods

Literature search strategy

FSANZ undertook a rapid systematic search for literature on Australian consumers' risk perceptions, consumption habits, and behaviours in regards to eggs, and the efficacy of behaviour change techniques for altering the latter. Literature was identified by searching six online databases for peer-reviewed studies published in English between January 2009 and September 2024, and hand-searching the reference lists and citing studies of obtained studies.

This literature review focuses on evidence relating to Australian consumers published since 2009, as a review of the literature was conducted at that time to inform Proposal P301 – Primary Production and Processing Standard for Eggs and Egg Products. International literature was excluded due to the different microbiological risk environments beyond Australia: while *Salmonella* Enteritidis has only recently emerged within Australia, it is regarded as endemic in many other countries, and consumers in those countries are likely to have different risk perceptions and handling behaviours regarding eggs. While New Zealand may offer a comparable microbiological environment, no studies were found that were conducted among New Zealand consumers.

Evidence synthesis

A total of six studies were included in the review. The evidence from each study was collated thematically under the research questions in order to present a narrative overview of the available evidence. The overall quality of the evidence that was available to answer each research question is described using a narrative approach. This is because there is currently no available tool that may be used to quantitatively synthesise the quality of evidence from studies that used diverse designs. However, considerations were given to the general principles of the GRADE approach (Guyatt et al., 2011) when narratively synthesising the quality of evidence. That is, consideration was given to the consistency of findings across studies, and the directness of the measures (e.g., relevance of the study's target sample).

Literature search, evidence synthesis and write-up was conducted by one FSANZ social scientist. The draft literature review was internally reviewed by FSANZ staff members.

More detail on the literature search strategy and research review process are available in Appendix A.

Findings

Research Question 1: Knowledge and risk perceptions

This section seeks to answer Research Question 1: What are consumers' perceptions of risk in relation to eggs? It reports on the findings of five Australian studies. Two of these studies were based in Western Australia, two were conducted entirely online, where location information was not reported, and one was a nationally representative sample of Australian consumers. The other four were based on non-representative convenience samples.

Summary

Uncooked eggs

- There is consistent evidence that consumers have low risk perceptions associated with consuming runny eggs. Two studies (Mullan et al. 2021, Charlesworth et al. 2023) found that up to 94% of consumers believe that eggs with runny yolks and/or whites are safe to eat in at least some circumstances (e.g. "only if eggs are bought from a supermarket"), and two studies found that only 56-65% of consumers believe that cooking eggs thoroughly (i.e. so both yolks and whites are firm) will reduce their risk of food poisoning (Charlesworth et al. 2021, 2023).
- In addition, there is some evidence that consumers may not perceive homemade batter as a raw-egg food, and may therefore not perceive it as having the same risks that they may associate with raw eggs (Whiley et al. 2018).
- There is also evidence of a lack of knowledge of risky egg cooking methods; one study found that 71% of respondents did not correctly identify the egg cooking methods that could increase their risk of food poisoning (Charlesworth et al. 2021).

Cracked or dirty eggs

- One study found that 27.8% of consumers believed that cracked eggs can be safely eaten in at least some circumstances (Charlesworth et al. 2023).
- There is evidence of a lack of consumer awareness of the risks posed by dirty eggs. In two studies that specifically asked about dirty eggs, only 2% and 5.4% of respondents believed that dirty eggs should be thrown away because they're not safe to eat (Mullan et al. 2021, Charlesworth et al. 2023). The vast majority incorrectly believed that dirty eggs should be washed, wiped with a damp sponge, or consumed without washing/wiping.

Washing eggs

- There is consistent evidence that a substantial proportion of consumers are unaware that eggs should never be washed. Across three studies, between 60-75% of consumers believed that there are least some occasions in which eggs should be washed (Charlesworth et al. 2021, Mullan et al. 2021, Charlesworth et al. 2023). In addition, one

of the studies found that only around 10-15% of consumers believed that there was a risk of foodborne illness associated with washing eggs (Charlesworth et al. 2023).

Relative perceptions of risk

- There is some evidence that consumers may regard eggs as posing a lower relative food safety risk compared to raw meat or poultry. In a nationally representative poll of Australians' handwashing habits, a substantially higher proportion of respondents said they didn't always wash their hands after handling raw eggs (43%) than after handling raw meat or poultry (23%) (Omnipoll 2022).

A more detailed description of the findings is provided below, grouped by different types of risk (raw/runny egg consumption, cracked eggs, dirty eggs, washing eggs, handwashing).

Raw or runny egg consumption

There is consistent evidence that consumers have low risk perceptions associated with consuming runny eggs. Two studies found that up to 94% of consumers believe that eggs with runny yolks and/or whites are safe to eat in at least some circumstances (Mullan et al. 2021, Charlesworth et al. 2023), and two studies found that only 56-65% of consumers believe that cooking eggs thoroughly will reduce their risk of food poisoning (Charlesworth et al. 2021, 2023). In addition, there is some evidence that consumers may not perceive homemade batter as a raw-egg food, and may therefore not perceive it as having the same risks that they may associate with raw eggs (Whiley et al. 2018).

There is also evidence of a lack of knowledge of risky egg cooking methods; one study found that 71% of respondents did not correctly identify the egg cooking methods that could increase their risk of food poisoning (Charlesworth et al. 2021).

Safety of raw or runny egg consumption

In Mullan et al.'s (2021) evaluation of the Western Australian Government's 2020-2021 'Play It Food Safe' media campaign, only 5.6% of 655 Perth residents correctly answered the question "Is it safe to eat eggs that have been soft poached or fried with a runny yolk?" by answering "No". Other response options were "Yes", "Only if the eggs are fresh", and "Only if the eggs have been bought from the supermarket". Proportions were not available for each incorrect answer.

Charlesworth et al. (2023) conducted an experimental study of 146 Australian participants designed to evaluate the use of behaviour change techniques for improving safe egg-handling behaviour. The authors provided additional data from this study upon request for this literature review. At baseline, 51.4% of respondents believed that "Eggs can be eaten raw or cooked", 30.4% believed that "Eggs can be eaten if they have runny yolk and whites just as long as they're not eaten raw", and just 17.6% believed that "Eggs need to be cooked until the yolk and whites are firm".

In the same study, 67.6% of people believed that it is "safe to eat eggs that have been soft poached or fried with a runny yolk", while 23.0% believed it was safe "only if the eggs are fresh", and 2.0% believed it was safe "only if the eggs have been bought from the supermarket. Only 6.8% of respondents believed that it was never safe.

Egg-cooking thoroughness and risk of food poisoning

In 2020, Charlesworth et al. (2021) carried out an evaluation of the Western Australian Government's 2019-2020 pilot 'Play It Food Safe' media campaign. In additional data the authors provided upon request for this literature review, a cross-sectional survey found that, at baseline, only a little more than half of 546 respondents (56.4%) agreed with the statement that "Cooking eggs until the yolks and whites are firm is something that will reduce my risk of suffering from food poisoning." 21.0% of respondents disagreed with this statement, while 16.9% neither agreed nor disagreed.

There also appeared to be a lack of knowledge of risky egg cooking methods. In the same study, 70.8% of respondents incorrectly answered the question "Which of the following ways in which eggs can be prepared INCREASE your risk of food poisoning." Only 29.2% of the sample answered correctly by selecting all of the correct response options and none of the incorrect ones. Correct response options were: "Soft boiled eggs", "raw egg mayonnaise", and "runny fried egg". Incorrect response options were: "Hard boiled eggs", "Scrambled egg", and "Omelette". The proportion who selected each response option was unavailable.

In Charlesworth et al.'s (2023) experimental study, 146 respondents were asked "How likely is it that you will get food poisoning if you…" and were provided with the behaviours of "Cook eggs until the yolks are firm" and "Cook eggs until the whites are firm". Respondents answered on a five-point scale ranging from "Extremely unlikely" to "Extremely likely". Approximately 80% of people believed that it was somewhat or extremely unlikely that they will get food poisoning if they cook eggs until either the yolks or whites are firm (see Table 1 below). This suggests that there is overall low perceived risk from at least partially cooked eggs, and no perceived difference in the level of risk between these cooking methods. That is, consumers appeared to perceive consuming eggs with runny yolks as having the same level of risk as consuming eggs with firm yolks.

Respondents were then asked "Compared to someone else of your age and gender, what is your chance of getting food poisoning if you…" with the same two behaviours. Similarly, approximately 75% of respondents believed that it was somewhat or extremely unlikely that they would get food poisoning compared to other people of their age or gender if they cook eggs until either the yolks or whites are firm (see Table 1 below).

Table 1: Perceived risk of eggs according to different cooking methods (data provided by Charlesworth et al. 2023 upon request)

	Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely	Missing
How likely is it that you will get food poisoning if you...						
Cook eggs until the yolks are firm	52.0%	26.4%	18.9%	0.7%	0.7%	1.4%
Cook eggs until the whites are firm	52.7%	27.7%	14.9%	2.0%	0.0%	2.7%
Compared to someone else of your age and gender, what is your chance of getting food poisoning if you...						
Cook eggs until the yolks are firm	52.0%	23.6%	22.3%	0.7%	0.0%	1.4%
Cook eggs until the whites are firm	53.4%	23.0%	20.3%	2.0%	0.0%	1.4%

Homemade batter

There is also some evidence that consumers do not see homemade batter as a raw-egg food, and may therefore not perceive it as having the same risks as raw-egg foods. In an online survey of 282 adult Australians' egg-handling and cooking practices (Whiley et al. 2017), when asked "Do you consume raw eggs or raw egg products in the home?" 84% of participants responded "no". However, when participants were asked "Have you ever eaten raw mixture/batter containing eggs (or licked bowl, spoon, spatula, etc.)?", 86% of participants responded "yes".

This result could suggest that consumers do not perceive raw mixture/batter to be a raw-egg food. However, it could also potentially be due to the different tense in which these questions were asked. The first question (about raw eggs) was asked in present continuous tense, which may suggest that it is asking about ongoing behaviour, whereas the second (about raw mixture/batter) was asked in past tense and only required respondents to have engaged in the behaviour *once* to imply that they should respond "yes". Therefore, it is not clear from this single study whether consumers perceive raw mixture/batter to be a raw-egg food (with any associated perceived risks).

Cracked eggs

There is evidence of some consumer awareness of the risk associated with consuming cracked eggs. One study found that 27.8% of consumers believe that cracked eggs can be safely eaten in at least some circumstances (Charlesworth et al. 2023). In a separate study, only 38.6% of respondents correctly identified "Throw out any cracked or dirty eggs" as the best way to handle them (Charlesworth et al. 2021). However, due to the question wording, this is likely to reflect a lower perception of risk associated with dirty eggs (see Section 3.1.4 below).

In additional data sourced from Charlesworth et al.'s (2023) experimental study of 146 participants, at baseline 27.8% of people believed that it was safe to eat cracked eggs in some circumstances: 1.4% believed that cracked eggs are always safe to eat because it doesn't affect the egg contents, 12.2% believed that cracked eggs should only be eaten if they don't look or smell strange, and 14.2% believed that cracked eggs could be eaten if they only have a small crack. The remaining 72.3% believed that cracked eggs should be thrown away because they are not safe to eat.

However, in Charlesworth et al.'s (2021) article based on an evaluation of the Western Australian government's 2019-2020 pilot 'Play It Food Safe' media campaign, participants were asked "Which of the following BEST describes how to safely handle eggs?" Only 38.6% of the 332 respondents correctly answered "Throw out any cracked or dirty eggs" while 53.9% selected one of the incorrect responses, which were "Wash eggs under cool running water to clean them", "Use a damp sponge to remove any dirt from eggs", and "No need to remove dirt from shell as it won't affect the yolk or egg white." The proportion of respondents who selected each of the incorrect response options was not available.

Dirty eggs

There is evidence of a lack of consumer awareness of the risks posed by dirty eggs. In two studies that specifically asked about dirty eggs, only 2% and 5.4% of respondents believed that dirty eggs should be thrown away because they're not safe to eat (Mullan et al. 2021, Charlesworth et al. 2023). The vast majority believed that dirty eggs should be washed, wiped with a damp sponge, or consumed as-is.

In Mullan et al.'s (2021) evaluation of the Western Australian government's 2020-2021 'Play It Food Safe' media campaign, participants were asked three questions that assessed their understanding of safe egg-handling practices. Only 2% of respondents correctly answered the knowledge question "What should you do with eggs that are dirty" by responding "Throw them away because they are not safe to eat." The remaining percentage chose one of the other, incorrect responses, which were "Wash the eggs under cool running water to clean them", "Use a damp sponge to remove the dirty from the eggs", and "Cook them and eat them as usual; there is no need to remove the dirt from the egg shell." The proportion of people who selected each incorrect response was not available.

In additional data sourced from Charlesworth et al.'s (2023) study of 146 participants, at baseline 43.9% of respondents believed that eggs that are dirty should be washed under cool running water to clean them, 30.4% believed that you should use a damp sponge to remove the dirt from the eggs, 20.3% believed that there was no need to remove the dirt from the egg shell, and 5.4% believed they should be thrown away because they're not safe to eat.

As noted above, in Charlesworth et al.'s (2021) article based on their evaluation of the Western Australian government's 2019-2020 pilot 'Play It Food Safe' media campaign, only 38.6% of the 332 respondents correctly responded that "cracked or dirty eggs" should be thrown out, while 53.9% selected that they should be washed, cleaned with a damp sponge, or consumed as-is. The proportion of respondents who selected each of the incorrect response options was not available.

Washing eggs

There is consistent evidence that a substantial proportion of consumers are unaware that eggs should never be washed. Across three studies, between 60-75% of consumers believed that there are at least some occasions in which eggs should be washed (Charlesworth et al. 2021, Mullan et al. 2021, Charlesworth et al. 2023). In addition, one of the studies found that only around 10-15% of consumers believed that there was a risk of foodborne illness associated with washing eggs (Charlesworth et al. 2023).

In Charlesworth et al.'s (2021) article based on their evaluation of the Western Australian government's 2019-2020 pilot 'Play It Food Safe' media campaign, at baseline only 31.0% of respondents selected 'eggs' in response to "Which of the following foods should NEVER be washed before cooking?". Response options were "Apple", "Raw chicken", "Lettuce", "Feta cheese", "Eggs", and "Bean sprouts".

In Mullan et al.'s (2021) evaluation of the Western Australian government's 2020-2021 'Play It Food Safe' food-safety media campaign, participants were asked three questions that assessed their understanding of safe egg-handling practices. At baseline, around 25% of respondents correctly answered the knowledge question "Should you wash eggs before cooking with them?" with "No, never". The remaining 75% incorrectly answered by choosing one of the other response options: "Yes, always", "Only if they look dirty", or "Only if they were bought straight from the farm." The proportion of respondents that selected each incorrect response option was not available.

In the same study, participants were asked whether a range of behaviours would reduce their risk of getting food poisoning, by rating their response on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). For 'washing raw eggs', the mean baseline score was 3.26 (SD = 1.59), which is below the midpoint, suggesting that participants generally did not perceive washing eggs to be a behaviour that would reduce their risk of getting food poisoning. Note that, as this is an unsafe food behaviour, this is a positive result. However, the wording of this question does not allow for measurement of whether participants perceived washing eggs as a food safety risk.[1]

In the same study, participants were asked whether they agreed that a range of behaviours were something "That people who are important to me think I should do" on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). The mean baseline score for 'washing raw eggs' was 2.55 (SD 1.54), which is below the midpoint, suggesting that participants generally do not perceive this to be a behaviour that the people around them think they should do. Again, as this is an unsafe food behaviour, this is a positive result.

In additional data sourced from Charlesworth et al.'s (2023) study of 146 participants, at baseline 64.1% of respondents believed that there were occasions when eggs should be washed: 8.1% believed that eggs should always be washed, 43.2% believed that eggs should only be washed if they look dirty, 12.8% believed they should be washed only if they were bought straight from a farm, and 35.8% believed that they should never be washed.

[1] Similar questions were asked about cracked and dirty eggs, however due to the wording of the questions they did not provide measures suitable for assessing consumers' risk perceptions of cracked or dirty eggs.

In the same study, and as noted in the section on dirty eggs, 43.9% of respondents believed that eggs that are dirty should be washed under cool running water to clean them, 30.4% believed that you should use a damp sponge to remove the dirt from eggs, 20.3% believed that there was no need to remove the dirt from the egg shell, and 5.4% believed they should be thrown away because they're not safe to eat.

In the same study, 59.5% of people believed that it was unlikely that you would get food poisoning if you washed eggs before cooking them (34.5% extremely unlikely, 25.0% somewhat unlikely). 24.3% believed it was neither likely nor unlikely, and 14.8% believed that it was likely (12.8% somewhat likely, 2.0% extremely likely). 1.4% of responses were missing.

When asked "Compared to someone else of your age and gender, what is your chance of getting food poisoning if you wash eggs before cooking them", 64.8% of respondents said that it was unlikely (40.5% extremely unlikely; 24.3% somewhat unlikely), 24.3% said it was neither likely nor unlikely, and 10.2% said it was likely (8.8% somewhat likely; 1.4% extremely likely). 0.7% of responses were missing.

Handwashing

The Food Safety Information Council commissioned Omnipoll (2022) to investigate handwashing habits among a nationally representative sample of 1,254 adult Australians. The study found that a substantially higher proportion of respondents said they didn't always wash their hands after handling raw eggs (43%) compared to after handling raw meat or poultry (23%). This potentially indicates a different relative perception of risk between eggs and raw meat or poultry, with raw meat or poultry considered to carry a higher risk of foodborne illness than eggs.

Research Question 2: Consumption practices

This section seeks to answer Research Question 2: How often do consumers eat eggs? In what setting? And how are they cooked, if at all? It reports on the findings of six Australian studies. Two of the studies were based on nationally representative samples, two studies were online convenience samples from Australia, and two studies were based on conveniences samples without location data.

Summary

Frequency of egg consumption

- There is limited evidence available on the frequency of egg consumption. One study found that 89% of consumers reported eating eggs or meals containing eggs in the seven-day study period (FSANZ, 2009).

Extent of cooking before consumption

- Two studies found that the majority of egg consumption involved eggs with a runny yolk (FSANZ 2009, OmniPoll, 2019), and two studies found that over half of households report consuming raw egg batter (FSANZ 2009, Whiley et al. 2017).

- One study found that there were statistically significant differences (all $p < 0.05$) between individuals who consumed raw eggs (OmniPoll 2019). People who were aged between 25-49 years, who were married, had children, worked full-time, had a university-level education, and/or a household income greater than or equal to $90,000 were significantly more likely to have ever consumed raw eggs. There were no statistically significant differences in raw egg consumption between males and females.
- One study found that there were statistically significant ($p < 0.05$) differences between households that sampled homemade batter (FSANZ, 2009). Households with vulnerable members (that is, children aged 4 years and under, or an adult aged 75+) were more likely (62%) than other households to report that they always or almost always sample raw batter (53%).

Reported cooking behaviours

- There is evidence that consumers treat egg whites and egg yolks differently in their cooking behaviours. In one study, around 85% of consumers reported that they cook eggs until the whites are firm 'always' or 'most' of the time, while only 2% of consumers reported that they cooked eggs until the yolks are firm 'always' or 'most' of the time (Charlesworth et al. 2023).
- In contrast, in two studies that asked questions about cooking eggs until *both* the whites and yolks are firm, only around 53-60% of consumers reported that they do this as a current behaviour (Charlesworth et al. 2021, Mullan et al. 2021).

Location of egg consumption

- One food diary study found that the vast majority of eggs were eaten at home, regardless of the type of meal/drink or whether they contained firm or runny yolks, or well-cooked, raw, or lightly-cooked eggs (FSANZ 2009).

Egg Consumption

There is limited evidence available on the frequency of egg consumption. In 2008, FSANZ (2009) conducted a seven-day online food diary study with a nationally representative sample of 1,673 households consisting of 4,616 individuals to investigate consumers' egg consumption, storage, and food-safety behaviours. Over the course of the seven-day survey period, 89% of individuals reported consuming eggs or foods containing egg. Of the total number of occasions where an individual consumed egg or a food containing egg, 39% were categorised as being 'well cooked', 56% 'lightly cooked', and 5% 'raw'.

In the same food diary study, over half of households (54%) reported that they always or almost always have someone who samples the cake batter or licks the spoon when making cakes. 17% of households sometimes have someone sample the batter, 8% of households occasionally have someone sample the batter, 9.6% rarely, and 10% never have anyone sample the batter.

An online survey of a convenience sample of 282 adult Australians' egg-handling and cooking (Whiley et al. 2017) found that when asked "Do you consume raw eggs or raw egg products in the home?", 84% of participants responded "no". However, when participants

were asked “Have you ever eaten raw mixture/batter containing eggs (or licked bowl, spoon, spatula, etc.)?”, 86% of participants responded “yes”.

OmniPoll (2019) was commissioned by the Food Safety Information Council to survey a nationally representative sample of 1,229 adult Australians about their egg consumption habits. Participants were asked “How often do you personally eat the following?”, with the categories of “raw eggs (e.g. in a homemade mayonnaise or egg nog, or added to a smoothie)” and “eggs with a runny yolk (e.g. soft boiled, poached, fried)”. As shown in Table 2 below, 61% of respondents said that they “Never” consume raw eggs compared to only 14% of people who said that they “Never” consume eggs with a runny yolk. 39% of people said that they consume eggs with a runny yolk once a week or more often, and a further 22% once a month.

The finding that 61% of people “Never” consume raw eggs should be interpreted with caution given the finding extrapolated from Whiley at al. (2017) that consumers may not perceive raw mixture/batter to be a raw-egg food, and homemade batter/mixture was not listed as an example raw-egg food in the OmniPoll survey.

Table 2: Percentage of respondents (n = 1,229) who consumed raw eggs and/or eggs with a runny yolk. Adapted from OmniPoll (2019).

	Raw eggs (e.g. in a homemade mayonnaise or eggnog, or added to a smoothie)	**Eggs with a runny yolk (e.g. soft boiled, poached, fried)**
Once a week or more often	6%	39%
Once a month	6%	22%
Once every 3 months	5%	9%
Once every 6 months	4%	5%
Once a year	2%	2%
Less often	16%	8%
Never	61%	14%

Demographic differences

Significant demographic differences (all $p < 0.05$) were found among those who consumed raw eggs in both the FSANZ and OmniPoll studies. However, these studies are limited by their cross-sectional survey design, meaning that all analyses are purely correlational. They are also based on Chi-square analyses, so other factors were not controlled for and confounding variables cannot be ruled out. It is therefore not possible to infer causation from any of the analyses

In FSANZ’s (2009) seven-day online food diary study, approximately 11% of children aged 4 years and under were offered food containing raw eggs, compared with 24% of 25-34 year olds. Of the total eggs consumed by children aged 4 years and under, 1.4% were classified as raw, compared to 3.7% for 25-34 year olds. For individuals aged 75-84 years, 3% of all eggs consumed were classified as raw.

Statistically significant differences were also found between households that consumed cake batter. Households with vulnerable members (children aged 4 years and under, or an adult aged 75+) were more likely (62%) than other households to report that they always or almost

always sample raw batter (53%). A higher proportion of households with no vulnerable members reported that they never sample raw batter (11%) compared to households with vulnerable members (5%).

In the OmniPoll study, there were statistically significant differences among people of different age groups. People aged 25-34 years (56%) and 35-49 years (47%) were significantly more likely to have ever eaten raw eggs compared to people aged 50-64 (30%) and 65+ years (22%). People aged 25-34 years (14%) were significantly more likely to eat raw eggs once a week or more compared to those aged 50-64 years (2%) or 65+ years (0%).

People who were the main grocery buyer (41%) were significantly more likely to have ever eaten raw eggs than those who were not (25%), and significantly more likely to eat raw eggs at least once a month (13% vs 6%) and once every 3 months (6% vs 1%).

People with a child in the household (51%) were significantly more likely than those without a child in the household (34%) to have ever eaten raw eggs. Households with children were also significantly more likely than those without a child to have eaten raw eggs: once every 3 months (7% vs 4%), once a month (9% vs 5%), and once a week or more often (11% vs 4%).

People who were married were significantly more likely to have ever eaten raw eggs (42%) than those who were not (34%), and to eat them once a week or more often (7% married vs 4% unmarried).

People who worked full-time (51%) were significantly more likely to have ever eaten raw eggs compared to people who did not work at all (28%). People who worked full-time (9%) or part-time (10%) were significantly more likely to eat raw eggs once a week or more often compared to those who did not work (2%). People who worked full-time were significantly more likely to eat raw eggs once every six months (6%) compared to those who worked part-time (2%).

People who had a university level of education were significantly more likely to have ever eaten raw eggs (50%) compared to those with a primary/secondary school level of education (26%). People with a university level of education were more likely to eat eggs once a week or more often (9%) compared to those with a primary/secondary school level of education (3%).

People who had a household income of $90,000 or more were significantly more likely to have ever consumed raw eggs (46%).

There were minor but significant variations in raw egg consumption between states and territories. People in Queensland (18%) were more likely to eat raw eggs at least monthly than people in Western Australia (6%). People in Tasmania were less likely to consume raw eggs once a week or more often (1%) and more likely to consume them once a year (8%). People outside of capital cities were more likely to consume raw eggs once a year (3%) while those in capital cities were less likely (1%).

There were no statistically significant differences in raw egg consumption between males and females ($p > 0.05$).

There were no statistical comparisons available for runny egg consumption between demographic groups in the OmniPoll study.

Cooking Behaviours

There is evidence that consumers treat egg whites and egg yolks differently in their cooking behaviours. In one study, around 85% of consumers reported that they cook eggs until the whites are firm 'always' or 'most' of the time, while only 2% of consumers reported that they cooked eggs until the yolks are firm 'always' or 'most' of the time (Charlesworth et al. 2023). In comparison, in two studies that asked questions about cooking eggs until *both* the whites and yolks are firm, only around 53-60% of consumers reported that they do this as a current behaviour (Charlesworth et al. 2021, Mullan et al. 2021). These findings align with the low level of risk perceived in consuming runny yolks (see Section 3.1.2). However, the high percentage of consumers who report cooking eggs until the whites are firm does not reflect the relatively low level of risk perception associated with egg whites (which was equal to that of egg yolks), and may therefore simply be a matter of personal preference.

In additional data provided by Charlesworth et al. (2021) from their evaluation of the Western Australian Government's 2019-2020 pilot 'Play It Food Safe' media campaign, 53.1% of 546 respondents agreed at baseline that "Cooking eggs until the yolks and whites are firm is something I do currently", and 54.3% agreed that "Cooking eggs until the yolks and whites are firm is something I do without thinking". 27.6% disagreed that this was a behaviour they do currently, and 26.8% disagreed that this was a behaviour they do without thinking. 16.9% neither agreed nor disagreed that they do it currently, and 12.7% neither agreed nor disagreed that they do it without thinking.

In Mullan et al.'s (2021) evaluation of the Western Australian Government's 2020-2021 'Play It Food Safe' media campaign, 655 Perth residents were asked to indicate on a five-point rating scale (0 = never, 4 = always) the extent to which they engaged in a variety of food safety-related behaviours. The baseline score for the unsafe behaviour of 'cooking eggs so they have runny yolks or whites' was 1.85 (SD = 1.25), indicating that, on average, participants said that they 'sometimes' cook eggs so they have runny yolks or whites. Note, however, the relatively large standard deviation compared to the mean, suggesting a large degree of variance in the responses.

In the same evaluation, participants were asked whether they agreed that 'cooking eggs so that they have runny yolks or whites' was something "That people who are similar to me do" on a scale of 1 (strongly disagree) to 7 (strongly agree). The mean baseline score for 'cooking eggs so they have runny yolks or whites' was 4.24 (SD 1.45), which is above the midpoint, suggesting that most people believed that people similar to them cooked eggs so that they have runny yolks or whites. This indicates that people generally perceive this to be a normalised behaviour.

In the same evaluation, participants were asked whether they agreed that each behaviour was something that they "do without thinking" on a seven-point rating scale (1 = strongly disagree, 7 = strongly agree). The mean baseline score for 'cooking eggs so that they have runny yolks or whites' was 3.93 (SD 1.88), which is close to the midpoint, suggesting that people were generally neutral in their response. As noted above, this may be due to consumers treating whites and yolks differently in their cooking behaviours.

In data sourced from the authors for this literature review, in Charlesworth et al.'s (2023) experimental study of 146 participants, at baseline 9.5% of respondents said they "Never" cook eggs until the yolks are firm, 77.0% "Sometimes", 11.5% "About half the time", 2.0% "Most of the time", and 0.0% "Always". In the same data, 87.2% of respondents disagreed that "over the next week, I intend to cook eggs until the yolks are firm". 6.8% of respondents were neutral, 5.5% agreed, and 0.7% of responses were missing.

In the same data, at baseline 0.0% of respondents said that they "Never" cook eggs until the whites are firm, 8.8% "Sometimes", 6.1% "About half the time", 41.9% "Most of the time", and 43.2% "Always". In the same data, 9.5% of respondents disagreed that "over the next week, I intend to cook eggs until the whites are firm". 4.1% of respondents were neutral, and 86.5% agreed.

Consumption Locations

Table 3 below outlines results from FSANZ's (2009) food diary for the locations in which different kinds of egg dishes were eaten, with a focus on egg dishes that have runny and firm yolks or that are raw/lightly cooked vs well-cooked. The percentages do not always add up to 100% because multiple responses could be chosen.

As Table 3 shows, the majority of all meals containing eggs were consumed in the home, regardless of the type of meal/drink or whether they contained firm or runny yolks, or were well- or raw/lightly-cooked.

Table 3: Proportion of meals containing eggs consumed at home, at a cafe, or somewhere else. (FSANZ 2009)

	At Home	At Café	Somewhere Else
Egg dishes* – total	83.3%	15.1%	6.3%
Egg dishes with runny yolks	55.0%	5.6%	2.4%
Egg dishes with firm yolks	42.2%	8.0%	3.0%
Eggs as fillings^ - total	47.2%	17.2%	6.4%
Eggs as fillings with runny yolks	22.1%	2.2%	1.2%
Eggs as fillings with firm yolks	27.6%	13.2%	4.0%
Eggs as ingredients in meals# - total	70.2%	29.1%	17.5%
Raw/lightly cooked eggs used as ingredients in meals	68.1%	27.4%	15.9%
Well-cooked eggs when used as ingredients	15.9%	5.3%	2.7%
Eggs as ingredients in desserts& - total	59.9%	30.3%	29.2%
Raw/lightly cooked eggs eaten as ingredients in desserts	21.0%	11.2%	7.8%
Well-cooked eggs eaten as ingredients in desserts	18.9%	5.6%	3.8%
Eggs as ingredients in drinks and meal accompaniments% - total	13.5%	4.9%	3.1%
Raw/lightly cooked eggs in drinks and meal accompaniments	13.5%	4.9%	3.1%

* Egg dishes include boiled, fried, scrambled, poached, steamed, baked, microwaved and raw eggs, plus meals such as omelettes, eggs Benedict, Florentine, en cocotte, scotch eggs and stuffed or curried eggs
^ Eggs as fillings includes boiled, fried, scrambled, poached, steam, baked or microwaved eggs, plus omelettes. These eggs could be used as fillings in sandwiches, rolls, warps, burgers, breakfast muffins, etc.
# Eggs as ingredients in meals includes quiche/frittata ,salad with an egg with a runny yolk, salad with an egg with a firm yolk, soup, pasta carbonara, rice on noodle dishes with egg as an ingredient, and savoury souffle.
& Eggs as ingredients in desserts include mousse, baked cheesecake, tiramisu, dessert souffle, pavlova/meringue, egg custard, home-made sorbet, home-made ice cream, and pancakes/crepes/pikelets.
% Eggs as ingredients in drinks and meal accompaniments includes eggnog, energy or protein drinks with raw egg as an ingredient, home-made mayonnaise/aioli, home-made lemon curd/butter, Hollandaise/bearnaise sauce.

Research Question 3: Storage behaviours

This section seeks to answer Research Question 3: Where do consumers store eggs and/or leftovers of eggs, and for how long? The findings are based on two Australian studies; one nationally representative study and one study based on an online convenience sample.

Summary

Whole eggs

- Two studies found that the vast majority (91-93%) of consumers report storing eggs in the refrigerator (FSANZ 2009, Whiley et al. 2017).
- One study found that there were statistically significant differences between households (FSANZ 2009). Households in the lowest income bracket were more likely than other households to store eggs at room temperature (9% compared to 6% in the middle income bracket and 4% in the highest income bracket). However, the proportion of households storing eggs in the refrigerator was over 90% in all income brackets.

Meals containing eggs

- One study found that the vast majority of households stored meals containing eggs appropriately by keeping them in the fridge, freezer, or disposing of them (FSANZ 2009). Very few (1%) of households reported that they stored leftover meals at room temperature, and there were no significant differences between households.

Leftover egg yolks and whites

- One study found that around half of households (44%) dispose of leftover egg yolks and whites (FSANZ 2009). Those that do not dispose of leftover eggs, either use them in another dish the same day (31%), or store them in the fridge (22%). 17% of households reported they don't ever have leftover egg yolks or whites.

Length of storage

- There was very limited data available on the length of time for which eggs were stored. One study found that, over a seven-day period, more than half of consumers (56%) reported using more than or equal to the number of eggs with which they started that week (FSANZ 2009). However, it is unknown how long the eggs were stored prior to the week of the study.

Whole Eggs

The vast majority (91-93%) of consumers report storing whole eggs in the refrigerator.

In Whiley et al.'s (2017) survey of 282 adult Australians, 91% of participants reported that they stored their eggs in the refrigerator.

In FSANZ's (2009) seven day food diary survey of 1,673 households consisting of 4,616 individuals, 93% of households reported that they store eggs in the fridge, with only 8% reporting that they store them at room temperature (multiple response options were possible).

In FSANZ (2009), significant differences (all $p < 0.05$) were found between households of different income levels. A higher proportion of households in the highest income bracket store their eggs in the fridge (96%) compared to households in the lowest income bracket (91%). Households in the lowest income bracket were more likely than other households to store eggs at room temperature (9% compared to 6% in the middle income bracket and 4% in the highest income bracket). However, the proportion of household storing eggs in the fridge was over 90% in all income brackets.

Meals Containing Eggs

In FSANZ's (2009) seven day food diary study of 1,673 households, most households (71%) stored left-over meals containing eggs in the fridge, 12% stored them in the freezer, and 40% disposed of them – either by feeding them to pets/animals (21%), throwing them away (17%), or giving them to someone not living in the household (2%). Very few households (1%) reported that they stored leftover meals at room temperature. The percentages do not

add up to 100% because multiple response selections were possible. There were no significant differences (all $p > 0.05$) between households.

Leftover Egg Yolks and Egg Whites

FSANZ's (2009) seven day food diary study found that most households dispose of leftover egg yolks and egg whites, either by throwing them away (26%) or feeding them to pets (18%). 31% use them in another dish that same day, and 22% store them in the fridge. 17% reported they don't ever have leftover egg yolks or egg whites.

Significant differences (all $p < 0.05$) were found between households of different income levels. A higher proportion of households in the lowest income bracket reported they would either use the leftover egg yolks/whites in another dish the same day or would store them in the fridge/freezer (67%), compared to households in the highest income bracket (48%). Households in the highest income bracket were more likely than lower income households to throw away the eggs (52% compared to 33% for lower income households). Subsequent analysis identified significant differences between low and middle income households, and between low and high income households.

Significant differences (all $p < 0.05$) also existed between households with different sources of eggs. Households that obtain eggs from farmers or growers markets were more likely than other households to use leftover egg yolks or whites in another dish the same day, or to store them in the fridge/freezer for use later on (71%) compared to households that obtain their eggs from supermarkets and other retail stores (56%), or from backyard producers or their own chickens (56%). Households that obtain eggs from farmers/growers markets were also less likely than households that obtain their eggs from supermarkets/other retail stores and backyard producers/own chickens, to throw away leftover yolks and whites (29% compared to 44% for supermarket/other retail stores and backyard producers/own chickens).

Length of Storage

A reanalysis of the data from the FSANZ survey (2009) found that, on average, households began the survey week with 10 eggs, they bought or obtained a further 10 eggs during the survey week, and ended the week with 9 eggs.

When broken down by percentage, a little over half of households (55.8%) reported using more than or equal to the number of eggs than they started with during the week, suggesting that, if the older eggs were eaten first, these households did not store eggs in the home for longer than a week. The remaining 44.1% of households used less than the number of eggs they started with, suggesting that these eggs were stored longer than a week. No further detail was available on how long these eggs were stored.

Research Question 4: Egg-handling behaviours

This section seeks to answer Research Question 4: What are consumers' egg handling behaviours? Do egg handling behaviours differ between types of households? The findings are based on five Australian studies; two nationally representative, two with online convenience samples without location information, and one Western Australian study based on a convenience sample.

This section differs from that of 3.1 – Knowledge and Risk Perceptions because it addresses how consumers report actually handling eggs, which may differ from their risk perceptions of these egg handling behaviours.

Summary

Handwashing

- Three studies found that between 43-61% of consumers do not always wash their hands after handling eggs (FSANZ 2009, Omnipoll 2022, Whiley et al. 2017).
- One study found that people who were women, aged 35-49 years, had children in the household, or had a trade qualification were significantly more likely to answer that they "Always" wash their hands after handling raw eggs (Omnipoll 2022). Whereas people aged 65+ years, who did not have a child in the household, did not work, or had a household income of less than $50,000 were significantly more likely to answer "Never".
- A separate study found that there were no significant differences in handwashing habits between households with and without vulnerable members (that is, households with a child aged 4 years and under, or an adult aged 75+ years) (FSANZ 2009).
- However, there were inconsistent findings when comparing handwashing habits of households with different income levels. In two studies, the lowest income households (below $41,000 or $50,000) was found to either have significantly higher (FSANZ 2009) or significantly lower (OmniPoll 2022) levels of handwashing compared to middle and high income households. These inconsistent results may suggest that an unaccounted-for variable may be having an impact – such as, for example, experience or current employment in food service.

Dirty eggs

- Three studies found that a substantial proportion of consumers engage in unsafe behaviours when encountering dirty eggs (Charlesworth et al. 2023, FSANZ 2009, Whiley et al. 2017). One nationally representative study (FSANZ 2009) found that 47% of the general population report that they wash dirty eggs prior to using them, 39% wipe them before using, and 16% use them as-is without cleaning them. Only 3% report discarding the egg.

Washing eggs

- Consumers responses about washing eggs differ according to the context in which they were asked.
- Two studies that asked about 'washing eggs' found that only 27% of consumers reported that they wash raw eggs (Charlesworth et al. 2023, Mullan et al. 2021). However, in one nationally representative study that asked about washing eggs in the context of dirty eggs, 47% of households reported that they would wash dirty eggs before using them (FSANZ 2009). It is not clear how often consumers encounter dirty eggs, which may have some bearing on the different responses.

Cracked eggs

- There was mixed evidence about consumers' responses to finding cracked eggs across three studies.
- Two studies that asked consumers what they do with cracked eggs (that is, eggs found to be cracked within the carton) found that 10% and 12% of consumers use them as-is (FSANZ 2009, Whiley et al. 2018).
- FSANZ (2009), a nationally representative study, found that an additional 40% of consumers reported that they would check the eggs by breaking them into a bowl before using them, compared to 39% who reported that they discard cracked eggs. The other study, which was based on a small convenience sample of 30 poultry-keepers, did not provide the response option of "cracking into a bowl", found that 77% of respondents reported discarding them (Whiley et al. 2017).
- In comparison, a third study (Charlesworth et al. 2023) that asked how often consumers throw away cracked eggs on a five-point Likert frequency scale found that 72% of consumers reported discarding them "Always" or "Most of the time".
- Although Whiley et al. (2018) and Charlesworth et al. (2023) reported similar proportions that indicated they discard cracked eggs, both studies were based on small, unrepresentative samples, and neither study provide any alternative response options (such as 'crack[ing] egg into bowl before using'). This may limit the generalisability of these findings compared to the study by FSANZ (2009).

Behaviour around egg cartons

- One study investigated the reuse of egg cartons (FSANZ 2009), and found that 16% of households reported always or almost always reusing egg cartons. 15% of households sometimes re-used them, and 59% rarely or never did.
- Households that obtained their eggs from their own chickens or backyard producers were more likely to reuse egg cartons than those who obtained them from supermarket/other retail stores or farmers markets. Households in country areas were also more likely to reuse egg cartons.
- One study investigated what households do when they encountered broken and leaking eggs in an egg carton, and found that 31% of households reported that they remove the broken egg but keep the rest of the eggs in the same carton (FSANZ 2009).

Checking eggs

- One study investigated how households check that their eggs are still good to eat (FSANZ 2009). Around half of households reported that they do this by checking the best before date (49%) or cracking them into a separate bowl to check them before using (47%). 31% of households reported that they put them in water to see if they float or turn upside down, and 17% smell them.
- Households in the highest income bracket were more likely to report checking the use-by date (57%) compared to households in the lowest income bracket (47%).

Separating egg yolks and whites

- No studies were found that examined how consumers separate egg yolks and whites.

Handwashing

Three studies found that between 43-61% of consumers do not always wash their hands after handling eggs (FSANZ 2009, Omnipoll 2022, Whiley et al. 2017). There were inconsistent findings when comparing different income groups. In two studies that found significant differences between households of different income levels in Chi-square analyses, the lowest income households (below $41,000 or $50,000) were found to either have significantly higher (FSANZ 2009) or significantly lower (OmniPoll 2022) levels of handwashing compared to middle and high income households. These inconsistent results may suggest that an unaccounted-for variable may be having an impact – such as, for example, experience or current employment in food service.

In FSANZ's (2009) seven day food diary survey of 1,673 households, 54% of households reported that they always or almost always washed their hands after handling eggs. 21% of households sometimes washed their hands after handling eggs, 8% occasionally did, 11% rarely did, and 4% never did.

There were significant differences (all $p < 0.05$) in handwashing behaviour between different income levels. The proportion of households reporting that they always or almost always washed their hands after handling eggs decreased as the level of household income increased. Households in the lowest income bracket (≤ $40,999) were the most likely to report that they always or almost always wash their hands after handling eggs (57%) compared to middle income ($41,000-$80,999) households (53%), and high income (≥ $81,000) households (50%).

There were also significant differences (all $p < 0.05$) found between households with different sources of eggs. Households that sourced their eggs from backyard producers/own chickens, or from farmers/growers markets, were more likely to report that they always washed their hands after handling eggs compared to households that obtained their eggs from supermarkets or other retail stores (60% backyard/own chickens, 62% farmers markets, 53% supermarket). Conversely, a higher proportion of households that source their eggs from supermarkets or other retail stores reported that they rarely or never wash their hands (17%) compared to farmers/growers markets (13%) and backyard producers/own chickens (11%).

There were also significant differences between households in different locations: a higher proportion of households in country areas reported that they always or almost always wash their hands after handling eggs (59%) compared to capital city households (53%).

There were no significant differences ($p > 0.05$) between households with and without vulnerable members (that is, households with a child aged ≤ 4 years, or an adult aged ≥ 75 years).

In an OmniPoll (2022) survey of a nationally representative sample of 1,254 adult Australians commissioned by the Food Safety Information Council, participants were asked "How often do you wash your hands with running water and soap and dry thoroughly in the following

situations", of which one was "After handling raw eggs". 53% of people said that they "Always" wash their hands after handling raw eggs, 22% answered "Most of the time", 15% "Sometimes", 6% "Rarely", and 3% "Never".

There were significant differences between groups (all $p < .05$). Women were significantly more likely to answer "Always" (59%) compared with men (46%). Men, conversely, were more likely to answer "Most of the time" (27%) compared with women (18%).

People aged 35-49 years were significantly more likely to answer "Always" (60%), while people aged 65+ years were the least likely (39%). People aged 65+ years were most likely to answer "Sometimes" (21%), "Rarely" (10%), or "Never" (6%) compared to all other age groups.

People with children in the household were significantly more likely to answer "Always" (58%) compared to people without a child in the household (51%). People without a child in the household were more likely to answer "Never" (5%) compared to those with a child in the household (1%).

People who did not work were significantly more likely to answer "Never" (5%) compared to people who worked full-time (2%).

People whose highest level of education was 'College/Apprenticeship' were significantly more likely to answer "Always" (58%) compared to both 'Primary/Secondary School' (50%) and 'University-Educated' (50%).

People who had a household income of less than $50,000 were significantly more likely to answer "Never" (6%), while people who had an income of $50,000 - $89,000 were significantly less likely to answer "Never" (2%).

There were no significant differences between grocery buyers and non-grocery buyers.

In Whiley et al.'s (2017) survey of 282 adult Australians, participants were asked "How often would you wash your hands after handling eggs?" Response options were "Always", "Sometimes", "Only if yolk gets on my hand", and "Never". 38.7% of respondents answered that they would "Always" wash their hands after handling eggs. There was a statistically significant difference ($p < 0.05$) in responses according to profession, with Environmental Health Officers being more likely to respond "Always" than food handlers or other professions. There was no significant difference in response ($p > 0.05$) according to gender.

Cleaning

In Whiley et al.'s (2017) survey of 282 adult Australians, 34% of participants responded that they "Always" wipe down the bench after handling raw eggs. There was a statistically significant difference ($p < 0.05$) in responses according to profession, with food handlers and Environmental Health Officers being more likely to answer "Always" than other professions. There was no significant difference in response ($p > 0.05$) according to gender.

Dirty Eggs

There is evidence from three Australian studies that a substantial proportion of consumers engage in unsafe behaviours in response to dirty eggs.

Two of these studies, which asked comparable questions, found that 47-63% of consumers report the unsafe behaviours of washing dirty eggs prior to using them and/or using them without cleaning (see Table 4 below). It is important to note, however, that the two studies used very different samples of participants; FSANZ (2009) asked the question of 1,617 households while Whiley et al. (2017) asked it of a subset of 30 participants in their sample who kept poultry. The latter, which found that a lower percentage of consumers wash dirty eggs, may therefore be less representative of the general population.

Table 4: Consumer behaviours in response to dirty eggs

	Wash dirty eggs before using	Wipe dirty eggs before using	Use dirty eggs without cleaning	Don't have this problem	Discard the egg	Missing
FSANZ (2009) **1,617 households**	47%	39%	16%	7%	3%	-
Whiley et al. (2017) **30 poultry-keepers**	30%	43%	17%	-	3%	6%

In FSANZ (2009) there were statistically significant differences between households with different sources of eggs. Households that obtained eggs from a backyard producer or their own chickens, or from farmers/growers markets were more likely to report that they would wash, wipe, or use a dirty egg with the dirt still on it (99%) compared to those households that obtained their eggs from supermarket or other retail stores (95%). There were no significant differences found between different income levels, with or without vulnerable members, or in different locations.

No statistical analysis was conducted on Whiley et al. (2017), most likely due to the small sample size.

In data sourced from the authors of a study of 146 participants designed to evaluate the use of behaviour change techniques for improving safe egg handling behaviour (Charlesworth et al. 2023), at baseline 6.8% of respondents said that they "Always" throw away dirty eggs. 5.4% said "Most of the time, 3.4% "About half the time", 27.7% "Sometimes", and 56.8% "Never". In the same data, 22.4% of respondents agreed that "over the next week, I intend to throw away dirty eggs". 11.5% of respondents were neutral, and 66.3% disagreed. This study did not ask about wiping or otherwise cleaning dirty eggs.

Washing Eggs

Consumers responses about washing eggs differ according to the context in which they were asked. In two studies that asked merely about 'washing eggs', the majority of consumers reported that they did not wash eggs (Charlesworth et al. 2023, Mullan et al. 2021). However, in one study that asked about washing eggs in the context of dirty eggs, 47% of households reported that they would wash dirty eggs before using them (FSANZ 2009). It is not clear how often consumers encounter dirty eggs, which may have some bearing on the different responses.

In Mullan et al.'s (2021) evaluation of the Western Australian Government's 2020-2021 'Play It Food Safe' food-safety media campaign, participants were asked to indicate on a five-point rating scale (0 = never, 4 = always) the extent to which they engaged in a variety of food safety-related behaviours. The baseline score for 'washing raw eggs' was 0.40 (SD = 0.94), indicating that, on average, participants reported that they 'never' wash eggs.

In the same evaluation, participants were asked whether they agreed that 'washing raw eggs' was something "That people who are similar to me do" on a scale of 1 (strongly disagree) to 7 (strongly agree). The mean baseline score for 'washing raw eggs' was 2.82 (SD = 1.5), which is below the midpoint, suggesting that most people did not believe that people similar to them washed raw eggs.

In the same evaluation, participants were asked whether they agreed that each behaviour was something that they "do without thinking" on a seven-point rating scale (1 = strongly disagree, 7 = strongly agree). The mean baseline score for 'washing raw eggs' was 2.28 (SD = 1.71), which is below the midpoint, suggesting that most respondents indicated that they do not habitually wash raw eggs.

In additional data sourced from Charlesworth's (2023) study of 146 participants, at baseline 73.0% of respondents said that they "Never" wash eggs before cooking them. 20.3% answered "Sometimes", 2.0% "About half the time", 2.0% "Most of the time", and 2.7% "Always". In the same data, 9.5% of respondents agreed that "over the next week, I intend to wash eggs before cooking them". 6.1% of respondents were neutral, and 82.5% disagreed.

In contrast, in FSANZ's (2009) survey of seven day food diary survey of 1,673 households consisting of 4,616 individuals, 47% of households reported that they would wash eggs that had a "small amount of dirt on them" before using them.

Cracked Eggs

There was mixed evidence about consumers' responses to cracked eggs (that is, eggs found to be cracked within the carton) across three studies. Two studies that used similar response options (see Table 5 below) found that 10% and 12% of consumers reported using them as-is. However, FSANZ (2009) found that an additional 40% of consumers report that they would crack them into a bowl to check them before using them, compared to 39% who reported that they discard cracked eggs. Whiley et al. (2017) did not provide the response option of "cracking into a bowl".

Charlesworth et al. 2023, which asked about the frequency of discarding cracked eggs, found that 72% of respondents reported discarding cracked eggs "Always" (57.4%) or "Most of the time" (14.2%), while 2.7% reported that they did so "About half the time", 20.9% "Sometimes", and 4.7% "Never". In the same data, 82.4% of respondents agreed that "over the next week, I intend to throw away cracked eggs". 6.1% of respondents were neutral, and 11.5% disagreed.

Table 5: Consumer behaviours in response to cracked eggs

	Discard the egg	Crack egg into bowl before using	Use the egg	Feed egg to a pet	Don't have this problem	Can't say / Missing
FSANZ (2009) 1,617 households	39%	40%	12%	Not offered as a response option	12%	1%
Whiley et al. (2017) 30 poultry-keepers	77%	Not offered as a response option	10%	10%	Not offered as a response option	3%

The inconsistent results between the two studies that asked about behavioural responses to cracked eggs may be due to the different response options provided between studies as well as the different samples. The FSANZ (2009) study, which had the higher figure of unsafe behaviours, utilised a large, nationally representative sample and offered as a response option the unsafe behaviour of "crack[ing] egg into bowl before using". Whiley et al. (2017), which found a lower proportion of unsafe behaviours reported, was conducted among a subsample of 30 poultry-keepers, and did not offer the response option of "crack[ing] egg into bowl before using". While Charlesworth et al. (2023) found that a similar proportion (71.6%) of respondents reported discarding cracked eggs, the Likert frequency scale did not provide any alternative response options (such as 'crack[ing] egg into bowl before using'), and also utilised a small and unrepresentative sample that may limit its generalisability compared to the study by FSANZ (2009).

Given the findings in Research Question 1, that the majority (72%) of consumers believe that cracked eggs should be thrown away, these inconsistent findings may indicate a gap between egg-handling knowledge and behaviour. When provided with limited response options, consumers may have reported the behaviour that they know they should follow (i.e. discarding cracked eggs). However, when provided with a seemingly reasonable alternative option (i.e. checking the egg before using it), a substantial minority reported that they do this.

In FSANZ (2009), there were statistically significant differences in behaviour between households with different income levels. The proportion of households which reported they would not use the egg increased as household income increased. Households in the highest income bracket were the most likely to report that they would not use the egg (57%), and households in the lowest income bracket were the least likely (38%). Conversely, the likelihood that the household would check and/or use the egg increased as household income decreased. Households in the lowest income bracket were the most likely to report that they would check the egg first and/or use it as-is (62%), and households in the highest income bracket were the least likely to select these answers (43%).

There were also significant differences between households in different locations. A higher proportion of households in country areas reported that they wouldn't use a cracked egg (49%) compared to capital city households (43%). Capital city households were conversely more likely to check and/or use the egg (57%) compared to country households (51%).

There were no statistically significant differences between households with different sources of eggs or between households with or without vulnerable members.

There was no statistical analysis conducted on Whiley et al. (2017), likely due to the small sample size.

Reusing Egg Cartons

In FSANZ's (2009) survey of seven day food diary survey of 1,673 households consisting of 4,616 individuals, 16% of households reported always or almost always reusing egg cartons. 15% of households sometimes re-used them, and 59% rarely or never did.

There were statistically significant differences between households with different sources of eggs. Households that obtained their eggs from backyard producers or from their own chickens were more likely than households that obtained their eggs from supermarket/other retail stores or farmers/growers markets to always or almost always reuse egg cartons (55% compared to 7% for supermarket/other retail stores, and 22% for farmers/growers market). A higher proportion of households that obtain their eggs from supermarket/other retail stores report that they never reuse egg cartons (47%) compared to households that obtain their eggs from farmers/growers markets (30%) and backyard producers/own chickens (9%).

Statistically significant differences were also found in the reuse of egg cartons between households in different location areas. Households in country areas were more likely to always or almost always reuse egg cartons (23%) compared with households in capital cities (11%). A higher proportion of households from capital cities reported never reusing egg cartons (47%) compared to country households (29%).

Broken and Leaking Eggs

In FSANZ's (2009) survey, 35% of households reported that, when encountering a broken egg that has leaked into a carton, they moved all remaining eggs to another carton or container. 31% of respondents removed the egg but kept the rest of the eggs in the same carton, and 31% said they didn't have this problem because they check the eggs before they buy them. 7% of households reported that they disposed of all eggs that have been soaked in the broken egg, 1% disposed of all the eggs in the carton, and 1% "Can't say".

No significant differences were found between households with different levels of income, with or without vulnerable members, or houses in different locations. However, there were significant differences between households with different sources of eggs. A higher proportion of households that obtain their eggs from a backyard producer/own chickens report that they would remove the broken egg but continue to keep the eggs in the same carton (52%) compared to households which obtain their eggs from a supermarket/other retail store (45%), or from a farmers/growers market (35%).

Households that obtain their eggs from a farmers/growers market were more likely than other households to report that they would move the remaining eggs to another carton or dispose of the eggs (65%), compared to those who obtained their eggs from supermarket/other retail stores (55%) or from backyard producers/own chickens (48%).

Checking Eggs

In FSANZ's (2009) survey of 1,673 households, the most common way that households checked their eggs are still good to eat was checking the best before date (49%), followed by cracking them into a separate bowl to check them before using (47%). 31% of households put them in water to see if they float or turn upside down, and 17% smell them. Many households selected more than one response for this question.

Significant differences were found between households with different income levels; in the highest income bracket, 57% reported that they check the best before date, compared to 47% of the lowest income households. Households in the lowest income bracket were the most likely to use another method that didn't include the best before date to check eggs.

There were also significant differences between households with different sources of eggs in how they check whether they're still good to use. A higher proportion of households who obtained their eggs from supermarket/other retail stores reported checking the best before date (57%) compared to households that obtain their eggs from farmers markets (49%) or from backyard producers/own chickens (32%).

There were also significant differences found between households in different locations. A higher proportion of households in capital cities check the best before date (56%) compared to households in country areas (47%).

No significant differences were found between households with or without vulnerable members in how they check that eggs are still good to eat.

Separating Egg Yolks and Whites

No studies were found that examined how consumers separated egg yolks and whites.

Research Question 5: Behaviour change techniques

This section seeks to answer Research Question 5: "Are behaviour change techniques effective for improving safe egg handling behaviours among consumers? If so, what techniques are most effective?". The findings are based on three studies. Two studies were evaluations of a pilot and full food safety media campaign implemented by the Western Australian Government in 2019-20 and 2020-21 respectively. The third study was a prospective experimental study based on an online convenience sample.

Summary

Two media campaigns and one experimental study were undertaken that sought to change consumers' knowledge and behaviours around egg-handling.

Food-handling knowledge

- There is no evidence that the media campaigns improved consumers' food-handling knowledge. Increases in food-handling knowledge that were measured were consistent across participants who both did and did not recall the media campaign.

- The experimental study found that behavioural change techniques were associated with a significantly greater increase in food-handling knowledge compared to the control groups.

Egg-handling behaviour

- There is no evidence that the media campaigns improved consumers' egg-handling behaviours.
- There is no evidence that the behavioural techniques employed in the experimental study improved consumers' egg-handling behaviours. Although the group exposed to behavioural change techniques had an increased perceived risk around washing eggs, and a greater intention to throw away dirty eggs, these did not translate into actual behavioural change.

Pilot Food-Safety Media Campaign (2019-2020)

In 2019, the Western Australian Government piloted a food-safety media campaign in the city of Busselton that was designed to reduce the cases of foodborne illness that occur in the home. The campaign ran from November 2019 until February 2020, and involved fourteen key messages about food safety. Two messages specifically related to eggs:

- Make sure eggs aren't cracked, and don't wash them. Make sure they're cooked until whites and yolks are firm; and
- When buying eggs, it is important to check that they are not cracked or dirty.

The campaign involved 30-second television commercials, outdoor advertisements, 30-second radio advertisements, front-page print media advertisements, and social media advertisements involving video and images. More information on the campaign materials is available on the Play It Food Safe campaign page.

An evaluation of the pilot campaign was undertaken. Two weeks prior to the pilot campaign's launch, time-one surveys were distributed via social media, on both Busselton specific groups/pages as well as groups/pages in wider Western Australia. Face-to-face recruitment was also conducted in the city of Busselton. After the conclusion of the campaign, time-two surveys were distributed via social media, and participants who completed the time-one questionnaire were contacted via email to complete the time-two questionnaire. Face-to-face recruitment was also carried out in the city of Busselton. The overall sample included people residing in Busselton, where the media campaign was carried out, in Western Australia, wider Australia, and international.

Results from relevant measures undertaken in the evaluation are reported across three different research reports (Mullan and Charlesworth, 2020; Mullan et al. 2020; Charlesworth et al. 2021, 2022). Each of these reported slightly different findings from the same evaluation, and the number of participants reported differs between reports. It is not always clear what the extent of the overlap is between participants, however it is likely that the same participants were involved across all five reports.

It is also important to note that, where sufficient methodological detail was provided (Charlesworth et al. 2021), only 22% of the overall evaluation sample was surveyed at both time-one and time-two (see Table 7). The other 78% of the sample were different participants at time-one and time-two.

Table 6: Sample continuity between time-one and time-two for pilot media campaign evaluation (Source: Charlesworth et al. 2021).

<table>
<tr><th></th><th colspan="2">Time-one only</th><th colspan="2">Time-one and time-two</th><th colspan="2">Time-two only</th></tr>
<tr><td>Time-one (Pre-campaign)</td><td>Busselton residents (N = 66)</td><td>Control group (N = 148)</td><td rowspan="2">Busselton residents (N = 51)</td><td rowspan="2">Control group (N = 67)</td><td></td><td></td></tr>
<tr><td>Time-two (Post-campaign)</td><td></td><td></td><td>Busselton residents (N = 110)</td><td>Control group (N = 104)</td></tr>
</table>

Campaign recall

At time-two, participants were asked “Do you recall seeing, hearing and/or reading any advertisements relating to food-safety over the past 4 months?” Response options were ‘Yes’, ‘No’, and ‘Not sure’. ‘Not sure’ responses were coded as ‘No’.

In Mullan and Charlesworth (2020), it was reported that 97 (25.3%) participants out of 383 indicated they recalled seeing advertisements related to food-safety, and of these 69 indicated they lived in the city of Busselton.

In Charlesworth et al. (2021), it was reported that out of 329 respondents, 95 (17.4%) indicated that they recalled the advertisements. The remainder (82.6%) either did not recall any advertisements, were not sure if they saw any advertisements, or did not respond to the item. Of those who did recall the media campaign, television commercials were the most recalled type of advertisement (63.9%), followed by online advertisements (19.7%) and newspaper advertisements (14.8%). The proportion of these respondents who resided in the City of Busselton was not reported.

Safe food-handling knowledge

Twelve items were used to assess participants’ safe food-handling knowledge based on the key messages of the campaign. Of these twelve items, three were related to safe egg-handling knowledge (see Table 6 below).

The preliminary results from the evaluation found that, among 162 participants who resided in the city of Busselton, where the media campaign was undertaken, there was an apparent small increase in the three knowledge items related to safe egg-handling (Mullan and Charlesworth, 2020). However, no statistical analysis was undertaken on these findings, it is not clear what level of exposure participants had to the media campaign, and no similar analysis was undertaken with non-Busselton participants. It is therefore not possible to be confident that this increase was statistically significant or a result of the media campaign.

Table 7: Egg-related food safety knowledge, pre- and post- pilot campaign among Busselton residents.

	% answered correctly	
	Time-one (Pre-campaign)	**Time-two (Post-campaign)**
Discard cracked and dirty eggs	35.1%	42.5%
Never wash eggs	26.1%	38.9%
Cook eggs safely	27.0%	27.2%

In two separate reports, overall food handling knowledge scores among a sample of 546 participants, of whom 224 resided in the city of Busselton[2], were compared at time-one and time-two between those who did and did not recall seeing the campaign advertisements (Mullan et al. 2020, Charlesworth et al. 2021).

Out of a total possible score of 14, there was no significant difference in scores at either time point between those who resided in Busselton and those who resided outside of it. However, participants who indicated that they recalled the media campaign had significantly *lower* knowledge scores at time-two than at time-one, while those who did not indicate recalling the advertisements had significantly *higher* knowledge scores at time-two than at time-one (all $p < .01$; see Table 8 below). The results were not reported by specific knowledge item score, so it is not possible to ascertain whether this overall trend holds true for the egg-related food safety knowledge items in particular.

Table 8: Mean safe food-handling knowledge scores at Time One (pre-campaign) and Time Two (post-campaign) for different sample groups (Source: Charlesworth et al. 2021)

	Time One			**Time Two**		
Sample Group	***M***	***SD/SE***	**Range**	***M***	***SD/SE***	**Range**
Overall	6.21	2.74 SD	0-13	6.96	2.22	1-12
Recalled campaign	7.54	0.64 SE	Not reported	7.00	0.53 SE	Not reported
Did not recall campaign	5.92	0.47 SE	Not reported	6.73	0.47 SE	Not reported

The authors note the decrease in overall food safety knowledge was relatively small (around half a scale point) and may have little real-world impact. However, the authors suggest that the lack of an increase in knowledge may be due to the number of messages promoted in the campaign (eight, many of which contained sub-messages), which may have been too many for consumers to take in at one time (Charlesworth et al. 2021).

Egg-handling behaviours

Eight safe food handling behaviours were investigated in the pilot campaign evaluation. Of these, one was related to handling eggs: “cooking eggs until the yolks and whites are firm”. Participants were asked to indicate their level of agreement with the statement “Cooking

[2] The reason for the difference in Busselton resident numbers reported in Mullan and Charlesworth (2020) and those reported in Mullan et al. (2020) and Charlesworth et al. (2021) is not clear, although as it was only one study it is likely that there is at very least substantial overlap between participants.

eggs until the yolks and whites are firm is something I do currently" on a seven point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

In the preliminary results of the evaluation, participants who indicated they saw the food-safety advertisements were asked to what extent they had changed on a range of different behaviours related to the messages of the campaign. More than half of participants said that they had changed their behaviour in relation to "not washing raw eggs" (60.9%) and "cooking eggs until the yolks and whites are firm" (66.1%). However, among 162 Busselton residents, the proportion of participants who reported that they cook eggs until the yolks and whites are firm *decreased* from 60.0% at time-one to 54.8% at time-two. No other egg-related behaviours were measured. However, no statistical analysis was undertaken on these findings, it is not clear what level of exposure participants had to the media campaign, and no similar analysis was taken with non-Busselton participants. It is therefore not possible to be confident that these findings were as a result of the media campaign.

In subsequent reports (Mullan et al. 2020, Charlesworth et al. 2021), among the 224 Busselton residents who participated in the study, those who recalled the advertisements reported a significantly higher level of agreement that 'cooking eggs until the yolks and whites are firm is something I do currently' between time-one and time-two, while those who did not recall the advertisement reported a significantly lower level of agreement. Responses were collected on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The reverse was true for the 322 non-Busselton residents who made up the control group – those who recalled seeing the media campaign[3] reported a lower level of agreement between time-one and time-two, whereas those who did not recall seeing the campaign reported a higher level of agreement (all *p*'s < .01; see Table 9 below). There were no significant differences by gender, age, level of education or food-handling knowledge score.

Table 9: Mean score of responses to 'Cooking eggs until the yolks and whites are firm is something I do currently' at time-one (pre-campaign) and time-two (post-campaign). Responses were collected on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). (Source: Charlesworth et al. 2021).

	Time-one			**Time-two**		
Sample Group	***M***	***SD/SE***	**Range**	***M***	***SD/SE***	**Range**
Overall	4.65	1.84 SD	1-7	4.70	1.84 SD	1-7
Busselton residents who recalled the campaign	4.34	0.45 SE	Not reported	4.68	0.29 SE	Not reported
Busselton residents who did not recall the campaign	4.81	0.29 SE		4.51	0.32 SE	
Non-Busselton (control group) participants who recalled the campaign	6.00	0.42 SE		5.40	0.45 SE	
Non-Busselton (control group) participants who did not recall the campaign	4.83	0.29 SE		5.02	0.30 SE	

These findings of the pilot evaluation were further investigated to determine why or how

[3] It is not clear whether non-Busselton residents were accurately recalling the media campaign or not. As the campaign involved social media advertisements that are not location-bound, it is possible that non-Busselton residents were exposed to these.

some safe food-handling behaviours increased between time-one and time-two even though safe food-handling knowledge did not (Charlesworth et al. 2022). ‘Cooking eggs until the yolks and whites are firm’ was one of the behaviours that was investigated, as it significantly increased over the course of the campaign, albeit only slightly.

Mediation analyses were conducted on the responses of 117 participants who provided sufficient data around media campaign recall and other variables of interest to determine if media campaign recall predicted change in behaviour via change in perceived risk and habit.

Perceived risk was assessed at time-one and time-two through the question “Cooking eggs until the yolks and whites are firm is something… that will reduce my risk of suffering from food-poisoning.” Strength of participants’ agreement or disagreement was measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The average score at time-one and time-two was not reported. Instead, a change score was calculated by subtracting time-one from time-two scores. For ‘cooking eggs until the yolks and whites are firm’, the mean change score was 0.48. In other words, perceived risk increased by 0.48 of a scale point between time-one and time-two. No statistical analysis was carried out to determine the significance of this change.

The extent to which the target safe food handling behaviours were habitual among participants was assessed through the question “Cooking eggs until the yolks and whites are firm is something… I do without thinking.” Strength of participants’ agreement or disagreement was once again measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The average score at time-one and time-two was not reported. Instead, a change score was calculated by subtracting time-one from time-two scores. For ‘cooking eggs until the yolks and whites are firm’, the mean change score was .04. That is, participants’ reported habitual cooking of eggs until the yolks and whites are firm increased by .04 of a scale point between time-one and time-two. No statistical analysis was carried out to determine the significance of this change.

The mediation analysis found that change in perceived risk and habit associated with cooking eggs thoroughly directly predicted change in reported egg cooking behaviour, with the model accounting for 68% of the variance in the data ($p < .001$). In contrast, media campaign recall did not significantly influence behaviour change, perceived risk, or habit associated with cooking eggs thoroughly.

It is possible that the study did not have a sufficient power to detect the effect of the media campaign due to sample size (n = 117). However, the authors also suggest that participants may not have been exposed enough to the media campaign advertisements for them to have consolidated into an effect on perceived risk and habit. Instead, a possible explanation for the change in perceived risk and habit is the ‘mere measurement effect’ – that is, it was conducting the study itself, and asking people about their behaviours, risk perceptions, and habits, that led to the observed change, rather than the media campaign.

This explanation does not take into account the substantial difference in the samples at time-one and time-two. As noted above, only 22% of the sample was the same between time-one and time-two. That is, 78% of the sample answered either the time-one or the time-two survey, but not both. As the sampling method was not probabilistic, but was instead a convenience sample based on exposure to social media advertising and face-to-face

recruitment, the observed difference may be an artifact of the characteristics of the different samples recruited at time-one and time-two.

Conclusion

Overall, the evaluation found there was no increase in participants' food safety knowledge as a result of the pilot media campaign, and there may have actually been a small decrease. Although there was some apparent improvement in participants' knowledge about not washing eggs between pre- and post-campaign, the improvement was found among all groups – including those who were not exposed to, or did not recall the media campaign.

There was some evidence of positive behaviour change in respect to the one egg-related food safety behaviour that was assessed, "cooking eggs until the yolks and whites are firm". Among Busselton residents (where the campaign was piloted) who recalled the advertisement there was an increase in the reporting of this behaviour compared to those who did not recall the advertisements. However, a mediation analysis found that the drivers of this positive behavioural change were changes in perceived risk and habit. The media campaign was not found to have a significant effect on either the behaviour change or on respondents' perceived risk or habit. This may be a result of the study having insufficient power to detect the effect of the media campaign due to small sample size. It is also possible that the measured increase in this behaviour was due to a 'mere measurement' effect, where asking participants about this behaviour led to an increase in its performance. However, it could also be due to the substantial difference in participants between time-one and time-two, as 78% of participants did not complete the survey at both time points.

Full Food-Safety Media Campaign (2020-2021)

Following the pilot food-safety media campaign described above, the Western Australian Government launched its full 'Play It Food Safe' food-safety media campaign in the Perth metropolitan area in January 2021. The campaign ran until April 2021, and involved nine key messages about food safety. This was a smaller number of messages than was run in the pilot media campaign. The messages that were specifically related to eggs were:

- Never wash raw eggs. Avoid bacteria getting inside the egg through the porous shell.
- Always cook eggs until the yolk and whites are firm. If you use raw eggs in foods such as desserts and mayonnaise, refrigerate immediately.

The campaign involved 30-second television commercials, outdoor advertisements, 30-second radio advertisements, front-page print media advertisements, and social media advertisements involving video and images. More information on the campaign materials is available on the Play It Food Safe campaign page.

In Mullan et al.'s (2021) evaluation of the 'Play It Food Safe' media campaign, a sample of 655 participants sufficiently completed two surveys (one at time-one and one at time-two, of which both occurred post-campaign) to assess their recall and impressions of the campaign, and their food-handling knowledge and behaviours. These surveys were conducted at two time-points: 1) following the conclusion of the media campaign, and 2) approximately eight weeks later. This evaluation therefore assessed behaviour maintenance over time post-campaign, rather than any changes between pre- and post-campaign knowledge and

behaviours. This is different to the evaluation of the pilot campaign, which measured immediate pre- and post-campaign knowledge and behaviours, and was designed to determine if there were any changes over time or if behaviour was maintained. It is therefore not possible to assess if the media campaign resulted in behaviour change between pre- and post-campaign. Unlike the previous evaluation, the sample was restricted to the city in which the media campaign was undertaken (Perth) and the same participants completed surveys at time-one and time-two.

Campaign recall

Participants were asked about their recall of the media campaign advertisements at time-one, following the conclusion of the campaign (exact question wording not provided). Only 11.5% of participants indicated that they recalled seeing food-safety advertisements during the campaign period, and a further 12.3% were unsure. The majority of participants (76.2%) did not recall seeing any advertisements related to food safety during the campaign period. This is slightly less than the proportion of participants in the pilot evaluation who did not recall the campaign advertisements (82.6%).

Safe food-handling knowledge

Safe food-handling knowledge was measured using 13 questions that assessed participants' understanding of safe food-handling practices. The behaviours related to eggs were: "Do not wash eggs", "Throw away dirty eggs", and "It is unsafe to eat eggs with runny yolks and whites". The evaluation showed that knowledge of these behaviours between Time One (immediately post-campaign) to Time Two (8 weeks post-campaign) slightly increased for "Do not wash eggs" and "It is unsafe to eat eggs with runny yolks and whites", but decreased for "Throw away dirty eggs" (see Table 9 below). As noted above, knowledge was not assessed pre-campaign, and thus cannot be compared.

Table 10: Percentage of correct and incorrect responses for three egg-related food-handling knowledge questions between time-one (immediately post-campaign) and time-two (8 weeks post-campaign) across total sample. (Adapted from Mullan et al. 2021).

Knowledge Item and Responses	Time-one	Time-two
Should you wash eggs before cooking them?		
Correct response: "No, never"	26.3%	27.2%
Incorrect response: "Yes, always", "Only if they look dirty" or "Only if they were bought straight from farm"	73.4%	69.5%
Missing	0.3%	3.4%
What should you do with eggs that are dirty?		
Correct response: "Throw them away because they are not safe to eat"	2.0%	1.5%
Incorrect response: "Cook them and eat them as usual; there is no need to remove the dirt from the egg shell", "Use a damp sponge to remove the dirt from the eggs", or "Wash the eggs under cool running water to clean them."	97.7%	95.1%
Missing	0.3%	3.4%
Is it safe to eat eggs that have been soft poached or fried with a runny yolk?		
Correct response: "No."	5.6%	6.6%
Incorrect response: "Yes", "Only if the eggs are fresh", or "Only if the eggs have been bought from a supermarket."	94.0%	89.5%

Missing	0.3%	4.0%

The overall food-handling knowledge results were compared between those who did and did not recall seeing campaign advertisements. Across the total sample, there was a significant ($p < .05$) increase in mean safe food-handling knowledge between time-one and time-two. However, although participants who recalled the media campaign had significantly ($p < .01$) higher knowledge scores at both time one and time-two compared to those that did not recall the media campaign, there was no significant difference ($p = .757$) in the change in knowledge over time among participants who saw the campaign compared to those who did not. That is, the analysis found that safe food-handling knowledge improved over time among participants who both did and did not recall the media campaign (see Table 11 below).

Table 11: Mean safe food-handling knowledge score for all participants and (separately) participants who did and did not recall the media campaign, out of a total possible score of 13 (adapted from Mullan et al. 2021).

	Time-one		**Time-two**	
	Mean	SD	Mean	SD
All participants	6.41*	1.88	6.60*	2.03
Participants who recalled media campaign	7.04	2.00	7.28	2.14
Participants who did not recall media campaign	6.30	1.87	6.51	2.00

* There was a statistically significant difference overall ($p < .05$). However, there was no statistically significant difference in the change in knowledge between participants who recalled and did not recall the media campaign.

Egg-handling behaviour

Eight behaviours were assessed in the evaluation, with four behaviours being randomly assigned to participants for assessment at time one and the same behaviours being reassessed at time two. The behaviours that specifically related to eggs were “Washing raw eggs” and “Cooking eggs so they have runny yolks or whites”. Participants used a five-point rating scale to indicate the extent to which they engage in the above behaviours (0 = never, 1 = sometimes, 2 = about half the time, 3 = most of the time, 4 = always). Note these are both unsafe food-handling behaviours, so a low engagement score is a positive result.

There was a low mean score for engaging in the behaviour of “washing raw eggs” at both time one and time two (see Table 10 below), indicating that, on average, participants ‘never’ engaged in this behaviour. As this is an unsafe food behaviour, this is a positive result. There was no statistically significant difference ($p< .05$) between time-one and time-two, either overall or separately for those who did or did not recall the media campaign, suggesting that this behaviour remained stable for both groups and there was no effect from the media campaign over the study period.

The mean score for “cooking eggs so they have runny yolks or whites” was just below the midpoint at both time one and time two, indicating that participants, on average, ‘sometimes’ engaged in this behaviour at both time points. Similar to the previous behaviour, there was no statistically significant difference ($p< .05$) between time-one and time-two, either overall or separately for those who did or did not recall the media campaign, suggesting that this behaviour remained stable for both groups and there was no effect from the media campaign over the study period.

As this evaluation did not collect baseline data before the media campaign started, it is not possible to assess if the media campaign resulted in behaviour change between pre- and post-campaign.

Table 12: Food-handling behaviours at time-one (immediately post-campaign) and time-two (8 weeks post-campaign). (Adapted from Mullan et al. 2021.)

		Time-one			Time-two		
Sample Group	**Food-handling habit**	***M***	***SD***	**Range**	***M***	***SD***	**Range**
Overall	Washing raw eggs	0.40	0.94	0-4	0.51	1	0-4
	Cooking eggs so that they have runny yolks or whites	1.85	1.25	0-4	1.86	1.25	0-4
Recalled campaign	Washing raw eggs	0.40	0.98	0-4	0.50	1.02	0-4
	Cooking eggs so that they have runny yolks or whites	1.74	1.31	0-4	2.00	1.37	0-4
Did not recall campaign	Washing raw eggs	0.40	0.93	0-4	0.50	1.03	0-4
	Cooking eggs so that they have runny yolks or whites	1.87	1.25	0-4	1.85	1.25	0-4

Note: There were no statistically significant changes in egg-related behaviours over time for any group ($p > .05$).

Egg-handling habits

Participants were asked whether the same behaviours described above were something that they "do without thinking". They indicated their agreement on a seven-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree). As above, the two behaviours assessed in relation to eggs ("Washing raw eggs" and "Cooking eggs so they have runny yolks or whites") were both unsafe food-handling behaviours, so lower agreement is a positive result.

Both washing raw eggs and cooking eggs so that they have runny yolks or whites were below the midpoint, suggesting that participants had weak habits for these unsafe food behaviours. However, there was a statistically significant ($p < .05$) increase in the habit of washing raw eggs campaign over time for both those who recalled and did not recall the media (see Table 11 below). As this increase occurred for both groups, it was not caused by the media campaign. Instead, this adverse result may be an effect of 'mere measurement' combined with social desirability bias – as washing eggs was a behaviour that was being measured in this survey, and there is a common-sense association between 'washing' and 'cleanliness', participants may have assumed that this was a safe or protective behaviour rather than an unsafe food-handling behaviour.

There was also a slight increase in the habit of cooking eggs so that they have runny yolks or whites over time for all groups. However, this was not a statistically significant result ($p > .05$), suggesting that this habit remained stable over the study period and there was no effect from the media campaign.

Table 13: Food-handling habits at Time One and Time Two (adapted from Mullan et al. 2021).

		Time One			Time Two		
Sample Group	**Food-handling habit**	***M***	***SD***	**Range**	***M***	***SD***	**Range**
Overall	Washing raw eggs	2.28*	1.71	1-7	2.53*	1.67	1-7
	Cooking eggs so that they have runny yolks or whites	3.93	1.88	1-7	4.02	1.82	1-7
Recalled campaign	Washing raw eggs	2.20*	1.69	1-7	2.65*	1.72	1-7
	Cooking eggs so that they have runny yolks or whites	3.89	1.95	1-7	4.16	2.18	1-7
Did not recall campaign	Washing raw eggs	2.30*	1.72	1-7	2.52*	1.67	1-7
	Cooking eggs so that they have runny yolks or whites	3.95	1.87	1-7	4.00	1.83	1-7

* There was a statistically significant increase in the habit of washing raw eggs for all groups ($p < .05$).

Perceived risk

Participants were asked whether they agreed that each food-handling behaviour would reduce their risk of getting food poisoning, using a seven-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). Although the egg-related behaviours were unsafe food-handling behaviours, this question did not assess participants' perceived risk of engaging in the behaviour, but instead assessed whether they thought the behaviours would *reduce* their risk of food poisoning.

Overall, participants did not believe that 'washing raw eggs' or 'cooking eggs so they have runny yolks or whites' would reduce their risk of food poisoning, with all mean scores below the midpoint. However, there was a slight but statistically significant ($p < .05$) increase in the mean score for washing raw eggs between time-one and time-two for both those who did and did not see the campaign. This indicates that participants increased their belief that washing raw eggs would reduce their risk of food poisoning over the course of the study period. As this increase occurred for both groups, it was not caused by the media campaign. Instead, as noted above, this adverse result may be an effect of 'mere measurement' combined with social desirability bias – as washing eggs was a behaviour that was being measured in this survey, and there is a common-sense association between 'washing' and 'cleanliness', participants may have assumed that this was a safe or protective behaviour rather than an unsafe food-handling behaviour.

Table 14: Perceived risk for food handling behaviours overall and for those who did or did not recall the media campaign (adapted from Mullan et al. 2021)

		Time-one			Time-two		
Sample Group	**Food-handling habit**	***M***	***SD***	**Range**	***M***	***SD***	**Range**
Overall	Washing raw eggs	3.26*	1.59	1-7	3.51*	1.66	1-7
	Cooking eggs so that they have runny yolks or whites	2.81	1.44	1-7	3.04	1.54	1-7
Recalled campaign	Washing raw eggs	3.29*	1.73	1-6	3.52*	1.71	1-7
	Cooking eggs so that they have runny yolks or whites	2.83	1.67	1-7	2.84	1.55	1-7
Did not recall campaign	Washing raw eggs	3.25*	1.58	1-7	3.51*	1.66	1-7
	Cooking eggs so that they have runny yolks or whites	2.82	1.42	1-7	3.06	1.54	1-7

* There was a statistically significant increase in agreement that washing raw eggs would reduce risk of food poisoning for all groups ($p < .05$).

Conclusion

As the evaluation did not collect baseline data before the media campaign started, it is not possible to assess if the media campaign resulted in behaviour change between pre- and post-campaign. However, there was no evidence that the media campaign had any effect on participants' longer-term safe food-handling knowledge, egg-handling behaviour, habits, or risk perceptions across the two time points measured.

There was no evidence that participants' safe food-handling knowledge improved as a result of the media campaign. While there was an overall increase in participants' safe food-handling knowledge between time-one (immediately post-campaign) and time-two (8 weeks' post-campaign), there was no significant difference found in the change in knowledge between those who did and did not see the campaign. That means the media campaign itself did not cause an improvement in safe food-handling knowledge.

There was also no evidence that egg-handling behaviour improved as a result of the media campaign over the course of the study period (eight weeks post-campaign). There was no statistically significant difference in reported behaviour for the two egg-related behaviours of "washing raw eggs" or "cooking eggs so they have runny yolks or whites". However, as the evaluation did not collect baseline data before the campaign started, it is not possible to assess if the media campaign resulted in change between pre- and post-campaign.

Additionally, there was evidence of a deterioration in people's habitual food-handling habits regarding washing raw eggs, with a small but statistically significant increase in reports of habitually washing eggs among both those who did and did not see the media campaign. As washing eggs is an unsafe food-handling behaviour, this is an adverse result. There was a similar statistically significant increase in participants' perception that washing raw eggs would reduce their risk of food poisoning. As these increases occurred among both those who did and did not recall the media campaign, the media campaign did not cause these effects. The effects detected were consistent across both those who did and did not recall the media campaign. This means that they were not caused by the media campaign, and may instead be a result of 'mere measurement' – that is, simply asking participants about these knowledge and/or behaviours may itself effect a change.

Safe Egg Handling Experimental Study

Subsequent to the previous studies, Charlesworth et al. (2023) conducted a prospective experimental study to evaluate the use of behaviour change techniques for improving safe egg handling behaviours in addition to media campaign advertising materials. This study included provisions to account for the 'mere measurement' effect that was potentially observed in Charlesworth et al. (2022b).

The study involved a convenience sample recruited via social media of 148 participants (88% female) between 20 and 78 years of age (*M* = 48.15 years, *SD* = 15.67 years), who were randomly allocated to one of three groups. One group ('video only') was shown a 30 second educational video advertisement from the 'Play It Food Safe' campaign, one group ('behaviour change techniques') was shown the same video and engaged in four behaviour change techniques, and one group ('mere measurement') was not shown any campaign material nor engaged in any behaviour change techniques. The four behaviour change techniques that were used in the behaviour change techniques group were:

1) Providing information from a credible source regarding safe egg handling practices;
2) Providing information about the potential consequences when not practicing safe egg handling behaviours (i.e. getting food poisoning, not being able to work/study while unwell);
3) Providing a text asking participants to consider whether there were any discrepancies between their current behaviours and the goals of the target behaviour; and
4) Providing a text outlining the pros and cons of engaging in safe egg handling behaviours.

Five safe egg-handling behaviours were assessed among each of the groups: washing eggs, throwing away cracked eggs, throwing away dirty eggs, cooking eggs until the yolks are firm, and cooking eggs until the whites are firm. Participants were assessed in their knowledge, intention, attitudes, self-efficacy, perceived risk, and engagement for each of these behaviours. This review will look at knowledge, intention, perceived risk, and engagement. Participants were assessed through questionnaires at two time points: at baseline and two weeks post-intervention.

Safe egg-handling knowledge

Participants were asked five multiple-choice questions to assess safe egg-handling knowledge (e.g. "Is it safe to eat eggs that have been soft poached or fried with a runny yolk?"). Answers were scored dichotomously (1 = correct, 0 = incorrect), and participants could achieve a score between 0 – 5 after totalling the number of correct answers across the five different questions. Higher scores indicate higher knowledge.

All groups showed an increase in safe egg-handling knowledge from time-one (baseline) to time-two (two weeks post-intervention) ($p < .001$), however the behaviour change technique group experienced a significantly greater increase in safe egg-handling knowledge over time compared to the video only and mere measurement groups ($p < .001$) (see Table 13 below).

Table 15: Safe-food-handling knowledge scores at time-one (baseline) and time-two (two weeks post-intervention), by group. (Adapted from Charlesworth et al. 2023)

	Time-one (Baseline)		Time-two (2 weeks post-intervention)	
Sample Group	***M***	***SD***	***M***	***SD***
Video only	1.55*	1.15	2.24*	1.25
Behaviour change technique	1.48**	1.09	3.12**	1.52
Mere measurement	1.23*	0.99	1.58*	1.28
Overall	1.38*	1.06	2.12*	1.45

* All groups had a significant improvement in safe food-handling knowledge scores.
** Behaviour change technique group experienced a significantly greater increase in safe food-handling knowledge compared to the other groups.

Safe egg-handling intentions

Participants were asked to indicate their agreeance with a statement specific to each of the five egg-handling behaviours ("Over the next week, I intend to [wash eggs before cooking them/throw away cracked eggs/etc]") using a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Higher scores indicated a stronger intention to engage in the behaviour (see Table 14 below).

Table 16: Intention scores at time-one (baseline) and time-two (two weeks' post-intervention) for egg-handling behaviours, by group. (Adapted from Charlesworth et al. 2023)

		Time-one		Time-two	
Behaviour	**Sample Group**	***M***	***SD***	***M***	***SD***
Washing eggs	Video only	1.98	1.67	1.98	1.64
	Behaviour change technique	1.70	1.26	1.48	1.03
	Mere measurement	2.16	1.65	1.99	1.49
	Overall	2.00	1.58	1.87	1.45
Throwing away cracked eggs	Video only	5.66	1.77	5.68	1.87
	Behaviour change technique	5.73	1.66	6.15	1.03
	Mere measurement	5.89	1.51	5.59	1.59
	Overall	5.78	1.62	5.74	1.58
Throwing away dirty eggs	Video only	3.02	1.96	3.20	2.00
	Behaviour change technique	2.73*	1.51	3.76*	1.95
	Mere measurement	3.15	1.88	2.80	1.60
	Overall	3.02	1.82	3.14	1.83
Cooking eggs until yolks are firm	Video only	2.25	1.10	2.73	1.59
	Behaviour change technique	2.27	1.26	3.48	1.81
	Mere measurement	2.14	1.11	2.63	1.42
	Overall	2.20	1.13	2.85	1.59
Cooking eggs until whites are firm	Video only	5.61	1.67	5.95	1.36
	Behaviour change technique	5.61	1.60	6.06	1.44
	Mere measurement	5.97	.99	5.85	1.37
	Overall	5.78	1.37	5.93	1.38

* Significant effect ($p < .01$).

The only significant change in intentions for safe egg-handling at time-two compared to baseline was found in respect of throwing away dirty eggs ($p < .01$). The behaviour change technique group experienced an increase in intention at two weeks' post-intervention compared to the video only group (who did not see an improvement compared to baseline) and the mere measurement group (who saw a decrease in intention compared to baseline). No other significant effects were observed in intentions for the other safe egg-handling behaviours.

Perceived risk

Participants were asked two questions for each egg-handling behaviour, with one question assessing perceived susceptibility ("How likely is it that you will get food poisoning if you… [egg-handling behaviour]") and one question assessing perceived vulnerability ("Compared to someone else of your age and gender, what is your chance of getting food poisoning if you… [egg-handling behaviour]"). Participants rated their likelihood of getting food poisoning for each of the behaviours using a five-point scale ranging from 1 (extremely unlikely) to 5 (extremely likely). A mean of the two items was calculated for each of the behaviours, with higher scores indicating higher perceived risk of getting food poisoning from the behaviour.

Table 17: Mean perceived risk scores at time-one (baseline) and time-two (two weeks' post-intervention), by group. (Adapted from Charlesworth et al. 2023).

		Time-one		**Time-two**	
Egg-Handling Behaviour	**Sample Group**	***M***	***SD***	***M***	***SD***
Washing eggs	Video only	2.18*	.98	2.82*	1.21
	Behaviour change technique	2.25**	1.09	3.45**	.98
	Mere measurement	2.04*	1.00	2.36*	1.12
	Overall	2.13*	1.01	2.74*	1.19
Throwing away cracked eggs	Video only	1.44#	.63	1.67#	.85
	Behaviour change technique	1.48#	.69	1.58#	.86
	Mere measurement	1.46#	.67	1.62#	.80
	Overall	1.46#	.66	1.63#	.82
Throwing away dirty eggs	Video only	1.65	.74	1.80	.89
	Behaviour change technique	1.56	.76	1.69	.89
	Mere measurement	1.58	.73	1.63	.72
	Overall	1.60	.73	1.69	.81
Cooking eggs until yolks are firm	Video only	1.65	.71	1.80	.87
	Behaviour change technique	1.61	.68	1.75	.87
	Mere measurement	1.81	.78	1.84	.73
	Overall	1.72	.74	1.80	.80
Cooking eggs until whites are firm	Video only	1.57	.68	1.78	.86
	Behaviour change technique	1.66	.68	1.73	.91
	Mere measurement	1.78	.81	1.76	.70
	Overall	1.69	.75	1.76	.79

* Significant effect ($p < .001$), ** Significant effect ($p < .01$), # Significant effect ($p < .05$).

As shown in Table 15 above, all groups experienced a significant increase in perceived risk for washing eggs between baseline and two weeks' post-intervention ($p < .001$), however the behaviour change technique group experienced a significantly greater increase ($p < .01$). All groups also experienced a significant increase in perceived risk for throwing away cracked eggs ($p < .05$). This was an adverse result. No significant effects were found for the other three egg-handling behaviours.

Safe egg-handling behaviours

At baseline, participants were asked how often they engaged in each of the behaviours (e.g. "Do you wash eggs before cooking them?" using a five-point Likert scale ranging from 0 (never) to 4 (always). At time-two, participants used the same scale to indicate how often in the past two weeks they had engaged in the behaviour ("Over the past two weeks, how often did you wash eggs before cooking them?) (see Table 18 below).

Table 18: Mean scores for engagement in egg-handling behaviours, at time-one (baseline) and time-two (two weeks' post-intervention), by groups. (Adapted from Charlesworth et al. 2023).

		Time-one		Time-two	
Behaviour	**Sample Group**	***M***	***SD***	***M***	***SD***
Washing eggs	Video only	.48	1.05	.20	.70
	Behaviour change technique	.39	.93	.12	.55
	Mere measurement	.39	.69	.23	.69
	Overall	.41	.86	.20	.66
Throwing away cracked eggs	Video only	3.14	1.32	2.19	1.88
	Behaviour change technique	3.09	1.28	2.24	1.94
	Mere measurement	2.86	1.44	1.80	1.89
	Overall	2.99	1.37	2.01	1.89
Throwing away dirty eggs	Video only	.95	1.40	.77	1.46
	Behaviour change technique	.58	1.06	.79	1.36
	Mere measurement	.76	1.09	.46	1.14
	Overall	.78	1.18	.63	1.29
Cooking eggs until yolks are firm	Video only	1.18	.45	1.45	1.25
	Behaviour change technique	1.06	.66	1.42	1.39
	Mere measurement	.99	.52	1.15	1.10
	Overall	1.06	.54	1.30	1.22
Cooking eggs until whites are firm	Video only	3.14	1.05	3.48	1.02
	Behaviour change technique	3.27	.91	3.55	1.03
	Mere measurement	3.20	.90	3.48	.88
	Overall	3.20	.90	3.49	.95

All groups decreased their engagement in washing eggs ($p < .001$) and throwing away cracked eggs ($p < .001$) between baseline and follow-up. All groups increased their engagement in cooking eggs until the yolks are firm ($p < .01$) and cooking eggs until the whites are firm ($p < .001$). No significant effects were found for throwing away dirty eggs, or between groups.

Conclusion

Overall, the study found that behaviour change techniques were effective for improving safe egg-handling knowledge, the intention to throw away dirty eggs, and the perceived risk of washing eggs. However, behaviour change techniques were not effective for improving actual egg-handling behaviours. However, it is important to note that this study was limited to an assessment two weeks post-intervention, and there may potentially be differences in behaviour maintenance over time between groups that have not been assessed in this study.

Although all participants' safe egg-handling knowledge increased over time, there is evidence that the behaviour change techniques employed in this study resulted in a significantly greater level of improvement.

The group exposed to behaviour change techniques also saw a significant increase in intention to throw away dirty eggs, and a significantly greater increase in risk perception around washing eggs than did the other two groups.

However, there was no significant differences in reported behaviour between the different groups. All groups decreased their engagement in washing in eggs (which is a positive result) and throwing away cracked eggs (which is a negative result). All groups also increased their engagement in cooking eggs until the yolks are firm and cooking eggs until the whites are firm. No significant effects were found for throwing away dirty eggs among any groups. This result suggests that the behaviour change techniques did not impact on participants' reported egg-handling behaviours, despite the significantly greater increase in safe egg-handling knowledge among those in the behaviour change group.

Strengths and Limitations

It is a strength of this literature review that there has been recent work conducted on egg-handling behaviours in Australia. However, there was a relatively small number of studies, a substantial proportion of which involved convenience samples sourced from social media and/or were conducted only in single cities in Western Australia. This is particularly the case for Research Questions 1 and 5, where evidence was sourced from three studies that all used non-nationally representative samples. The findings from these research questions therefore may not be generalisable to the whole Australian population.

The way in which questions were worded in some studies did not always lend themselves to providing an understanding of consumers' risk perceptions around eggs or particular egg-handling behaviours due to the reverse-wording of some of the behaviours under consideration (e.g. framing questions in terms of the perceived risk associated with "throwing away dirty eggs" or "cooking eggs until the yolks and whites are firm"). Unfortunately, this means that the studies in question do not always provide comparative data on each behaviour of interest.

All analyses that have been undertaken for the studies reported in this literature review are correlational, and can't account for third variables that have not been measured. For example, the discrepancy evident in the handwashing behaviours associated with household income level – it is likely that there is another variable that may account for the difference

that has not been included in the studies – such as, for example, food service experience. It is not possible to investigate this in the context of this literature review.

Finally, the studies that have been incorporated in this literature review are subject to the usual social desirability and reporting biases that are associated with survey-based research. However, the findings of this literature review suggest that, regardless of these biases, people are reporting engaging in behaviours that are unsafe. This may further suggest a lack of knowledge as to what 'correct' behaviours should be reported.

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Appendices

Appendix A: Literature review methods

All decisions regarding inclusion/exclusion criteria were made prior to the literature search commencing, except where otherwise stated. An initial search was conducted in September 2022 according to the protocol outlined below. A supplementary search was then conducted in July 2024 that covered any literature published in the period between September 2022 and July 2024.

Inclusion criteria

The review included studies that examined:

- Australian consumers' risk perceptions, consumption habits, and handling behaviours regarding eggs.
- The efficacy of behavioural change techniques for improving Australian consumers' risk perceptions, consumption habits and handling behaviours regarding eggs.

No restrictions were placed with respect to study type (e.g experiments, surveys, focus groups, interviews, observational studies), participant characteristics (e.g. age, geographic location, dietary pattern), or specific outcome measures. Rather, this information was coded for each study (see 'Table of included studies' in Appendix B). Grey literature was also included.

Exclusion criteria

Searches were limited to papers available in English published between January 2009 and July 2024, and where the studies were conducted in Australia. The decision was made to exclude international literature due to the different microbiological risk environments beyond Australia: while *Salmonella* Enteritidis has only recently emerged within Australia, it is regarded as endemic in many other countries, and consumers in those countries are likely to have different risk perceptions and handling behaviours regarding eggs.

Online database searches

Six online databases were searched via EBSCO Discovery:

- Science Direct
- Food Science Source
- FSTA – Food Science and Technology Abstracts
- MEDLINE with Full Text
- SocINDEX with Full Text
- EconLit with Full Text

Online databases searches were undertaken using simple Boolean search term combinations.

Search string:

(egg OR eggs) AND (consum* OR domestic*) AND (percep* OR behavi* OR knowl* OR attitud* OR prefer* OR handl* OR safe* OR stor* OR eat OR raw OR salmonell*) AND (Australia* OR New Zealand*)

Other sources/Grey literature

To ensure the literature review incorporated a suitably broad range of references, further literature was sought by:

- Searching the FSANZ Behavioural and Regulatory Analysis section reference database;
- Contacting jurisdictions who have undertaken work on egg-handling behaviours;
- Contacting authors of included studies for additional data;
- Searching the websites of known relevant agencies, including the Food Safety Information Council;
- Searching the reference lists of all included studies; and
- Searching for studies that have cited any of the included studies (using Google Scholar).

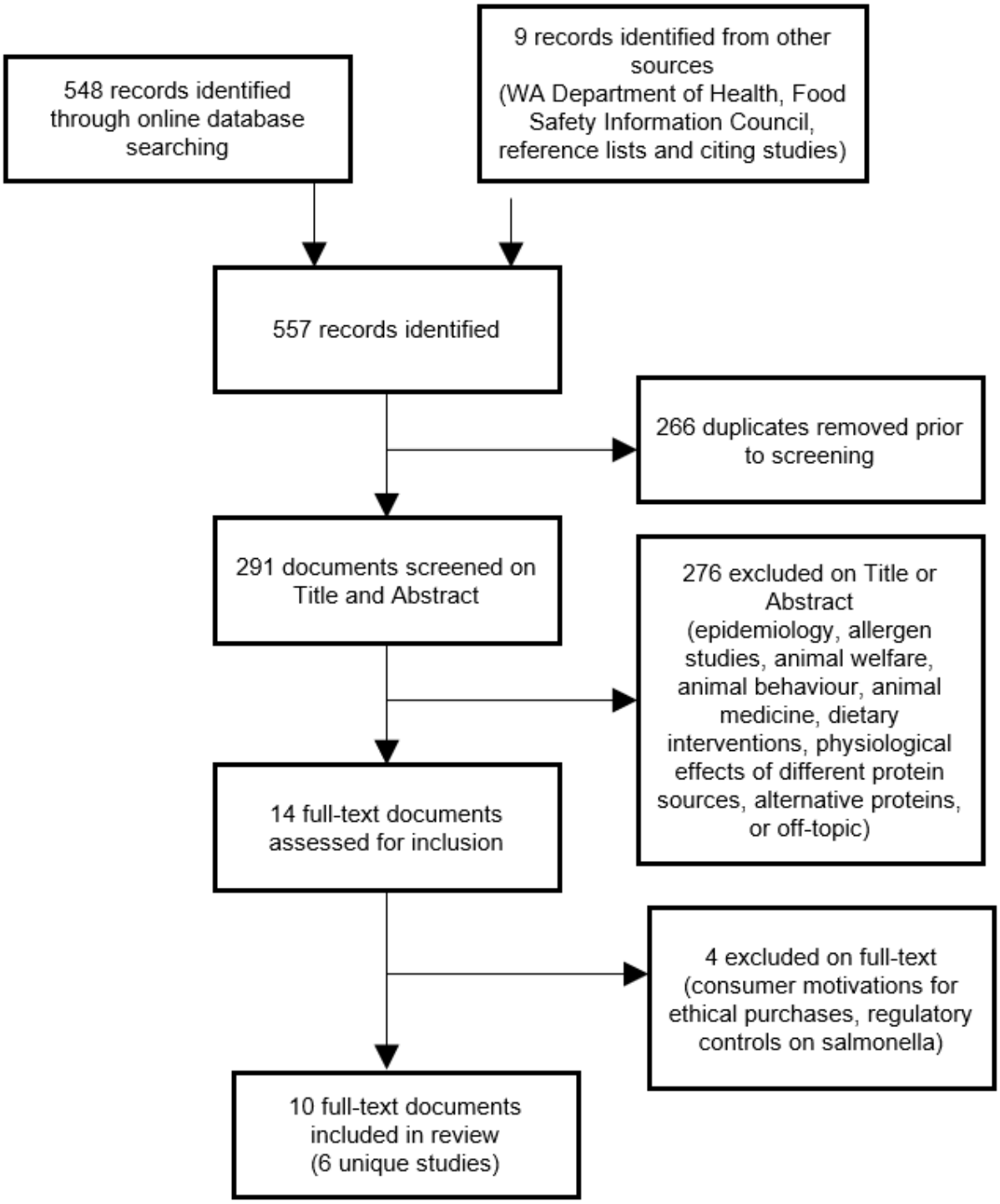
Research review process

The search process initially identified 557 references. References were exported to EPPI-Reviewer 4, a web-based software program for managing and analysing data for literature reviews. Duplicates were removed using EPPI-Reviewer 4 duplicate management tools; references allocated a similarity score of at least 0.95 by the software were automatically excluded, and remaining potential duplicates identified by the software were manually screened and excluded by one officer.

Following removal of duplicates, out of scope papers were removed based on title and/or abstract. Finally, documents identified as out-of-scope on the basis of full-text review were excluded. This resulted in ten documents (reporting on six unique studies) being included. All stages of the screening process were conducted by one officer.

Figure A1 shows the number of documents retrieved at various stages of the review process. The information depicted in Figure A1 is based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Moher et al., 2010).

Figure A1: Number of documents retrieved at various stages of the review process



Appendix B: Table of study characteristics

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
Charlesworth et al. (2021) NB: Additional data was sourced from the authors of this study.	546 participants. Recruited through social media and face-to-face field recruitment in the City of Busselton.	70.5% female. Aged 13-84 years (M = 43.98, SD = 16.69) 27.8% Bachelor's degree 79.7% resided in Western Australia 41.1% lived in the City of Busselton.	RQs 1, 2, 5	Evaluation of the 2019-2020 Western Australian pilot safe food-handling media campaign in the City of Busselton. Two quantitative survey questionnaires were used to assess consumers' campaign recall, safe food-handling knowledge, and behaviour at two time points, four months apart: prior to the campaign launch in Nov 2019, and two weeks after the conclusion of the campaign in Feb 2020.	Only around half of respondents (56.4%) agreed that cooking eggs thoroughly will reduce risk of food poisoning. 70.8% of respondents incorrectly identified which types of egg preparation increase risk of food poisoning. Only 38.6% of respondents correctly identified that cracked or dirty eggs should be thrown out. Only 31.0% of respondents correctly answered that eggs should never be washed before cooking. Only around half (53.1%) of respondents reported cooking eggs until the yolks and whites are firm. Food safety knowledge did not increase as a result of the pilot 'Play It Food Safe' media campaign. However, those Busselton residents who recalled the campaign advertisements reported an increase in cooking eggs thoroughly from pre-campaign to post-campaign, whereas those Busselton residents who did not recall the advertisements experienced a decrease in this behaviour over the same time period. For the control group, this

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
					effect was reversed, with those who recalled the advertisements experiencing a decrease in engagement in cooking eggs thoroughly from pre-campaign to post-campaign, and those who did not recall the advertisements experiencing an increase over the same time period. There were no significant differences among demographic variables.
Charlesworth et al. (2022)	117 participants who had complete data for the variables of interest and who indicated whether they had seen the campaign advertisements.	78.6% female Aged 19-73 years (M = 45.85, SD = 14.61) 67.5% born in Australia 53.9% university-educated 42.7% resident in the City of Busselton	RQ 5	Evaluation of the 2019-2020 Western Australian pilot safe food-handling media campaign in the City of Busselton. Two quantitative survey questionnaires were used to assess consumers' campaign recall, safe food-handling knowledge and behaviour at two time points, four months apart: prior to the campaign launch in Nov 2019, and two weeks after the conclusion of the campaign in Feb 2020.	Respondents' perceived risk, habitual behaviour, and behaviour engagement scores slightly increased from pre-campaign to post-campaign. Increase in perceived risk was significantly associated with an increase in habit and behaviour. Increase in habit was also significantly associated with an increase in behaviour. A mediation model accounted for 68% of the variation in the data ($p < .001$). The model showed that change in perceived risk directly predicted change in behaviour for cooking eggs until the yolks and whites are firm. Change in habit also directly predicted change in this behaviour. However, media campaign recall did not directly predict change and changes in perceived risk and habit were not found to be a result of engagement with the media campaign advertisements.

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Charlesworth et al. (2023) NB: Additional data was sourced from the authors of this study.	148 participants. Recruited via paid advertisements on Facebook and via researchers sharing advertisement materials on personal social media accounts. Participants were incentivised to participate through the option to enter a prize drawer to win one of ten $50 shopping vouchers.	To be eligible, participants had to prepare eggs at home and shop for eggs for their household. 88.4% female Aged 20-78 years (M = 48.15, SD = 15.67) 70.5% university-educated 45.3% has worked in food service 26.4% had prior food-safety training	RQs 1, 2, 4, 5	Randomised prospective experiment. At baseline, participants completed measures of intention, behaviour, attitudes, self-efficacy, perceived risk, and knowledge relating to safe egg handling, as well as demographic questions. Participants were then randomly assigned to one of three groups where they either (1) watched a 30-second video advertisement designed to promote safe egg handling (video only group), (2) watched the 30-s video and completed behaviour change technique tasks (video plus behaviour change technique group, or (3) did not watch the video or complete the behaviour change technique tasks (mere measurement group). Two weeks later, participants completed the initial measures again, excluding the video and intervention tasks.	At baseline, 81.8% of respondents believed that eggs can be safely eaten with runny yolk and whites, and 92.6% believed it was safe to eat eggs with a runny yolk in at least some circumstances. Approximately 80% of people believed it was unlikely they would get food poisoning if they cooked eggs until the whites are firm. 27.8% of people believed that it was safe to eat cracked eggs in some circumstances. 94.6% of respondents believed you should engage in unsafe food practices (such as washing, wet wiping, or eating anyway) in response to dirty eggs. 64% of respondents believed that there were occasions when eggs should be washed, and around 60% of people believed that it was unlikely that you would get food poisoning if you washed eggs before cooking them. 86.5% of respondents said they “Never” or “Sometimes” (less than half the time) cook eggs until the yolks are firm. 87.2% of respondents indicated that they did not intend to cook eggs until the yolks are firm over the next week.

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					85.1% of respondents said they “Always” or “Most of the time” cook eggs until the whites are firm, and 86.5% indicated that they intended to do so over the next week. 84.5% of respondents said they “Never” or “Sometimes” (less than half the time) throw away dirty eggs, and 66.3% indicated they did not intend to throw them away over the next week. 57.4% of respondents said that they “Always” throw away cracked eggs, and 82.4% of respondents indicated that they intended to over the next week. 73.0% of respondents said that they “Never” wash eggs before cooking them, and 82.5% indicated that they did not intend to wash eggs over the next week. The study found that behaviour change techniques were effective for improving safe egg-handling knowledge, intention to throw away dirty eggs, and perceived risk for washing eggs. However, exposure to behaviour change techniques and/or the media campaign video resulted in no significant increase in egg-handling behaviours compared to the control group.

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FSANZ (2009)	1,673 Australian households consisting of 4,616 individuals Main grocery buyers were recruited using an online research panel. Nationally representative sample achieved through quotas. Young adults (18-34 years) and males were over-sampled to account for lower response rates from these groups.	49.8% female 7.6% 0-4 years 5.9% 5-9 years 5.7% 10-14 years 3.6% 15-17 years 8.5% 18-24 years 14.9% 25-34 years 13.5% 35-44 years 12.8% 45-54 years 13.0% 55-64 years 12.1% 65-74 years 2.2% 75-84 years 0.2% 85+ years 1.8% Aboriginal or Torres Strait Islander 32.7% 0 - $40k/yr household income 33.3% $41k-90k/yr household income 21.2% $91k+/yr household income 12.7% not stated 72% capital cities 28% country 15.4% households with child ≤ 4 yrs 5.3% households	RQs 2, 3, 4	Seven day online diary that collected data on egg consumption and storage and handling behaviours. One respondent (the Main Grocery Buyer of the household) filled out information on their own egg consumption and for other members of the household. Respondents were given drop down lists of egg dishes and foods that might contain eggs, and for each person in the household the respondent recorded which of the listed dishes and foods they had eaten that day and the number of portions eaten. Eggs and egg dishes were categorised as well cooked, lightly cooked, or raw.	89% of individuals reported consuming eggs or foods containing egg, the majority of which were 'lightly cooked'. Approximately 11% of children aged ≤ 4 years were exposed to raw eggs over the course of the survey period, compared to 24% of 25-34 year olds. Of the total eggs consumed by children aged ≤ 4 years, 1.4% were raw, compared to 3.7% for 25-34 year olds. Over half of households (54%) reported that they always or almost always have someone who samples cake batter. Households with children ≤ 4 years or an adult ≥ 75 yrs were more likely (62%) to have someone who samples the batter than those without (53%). The majority of all meals containing eggs were consumed in the home, regardless of the type of meal/drink or whether they contained firm or runny yolks, or were well- or raw/lightly-cooked. The vast majority (93%) of households report storing eggs in the fridge. 8% report storing them at room temperature. A higher proportion of households in the lowest income bracket store eggs at room temperature compared to the middle or highest income brackets.

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
		with adult ≥ 75 yrs 0.1% both			The vast majority of households store meals containing eggs in the fridge or freezer, or dispose of them. Very few (1%) reported storing leftover meals at room temperature. Slightly more than half of households (55.8%) appear to use eggs within the week. 54% of households reported always or almost always washing their hands after handling eggs. Households in the lowest income bracket were the most likely to report always or almost always washing their hands (57%), compared to middle income (53%) and high income (50%) households. 63% of households reported washing dirty eggs or using them without cleaning. 40% of households reported that they would check cracked eggs by cracking them into a bowl before using. 12% would use the egg as-is, and 39% would discard the egg. Households in the lowest income brackets were more likely to report using cracked eggs. 47% of households report washing eggs if they are dirty. 16% of households always or almost always reused egg cartons. Households

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
					that obtained their eggs from their own chickens or backyard chickens were more likely to reuse egg cartons. Around half (49%) of households checked eggs were still good to eat using the best before date. A similar proportion (47%) checked by cracking eggs into a separate bowl before using them. Households in the highest income bracket were more likely to check the best before date (57%) compared to households in the lowest income bracket (47%).
Mullan et al. (2020a)	336 participants with sufficient data. No recruitment details provided.	74% female 15-82 years (M = 46) 63% born in Australia 39% university-educated 84% resided in Western Australia 48% resided in City of Busselton	RQs 1, 4, 5	Evaluation of the 2019-2020 Western Australian pilot safe food-handling media campaign in the City of Busselton. Two quantitative survey questionnaires were used to assess consumers' campaign recall, safe food-handling knowledge, and behaviour at two time points, four months apart: prior to the campaign launch in Nov 2019, and two weeks after the conclusion of the campaign in Feb 2020.	65.2% of respondents believed that cooking eggs thoroughly would reduce their risk of food poisoning. 43.8% of respondents correctly responded to questions testing their knowledge of the importance of discarding cracked and dirty eggs. 39.9% of respondents correctly responded to questions testing their knowledge about the risk associated with washing eggs. 59.6% of respondents reported "cooking eggs until yolks and whites are firm" as a current behaviour. The proportion of participants who correctly answered that they "should never wash eggs" increased from 26.1%

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					to 38.9% from pre- to post-campaign. The proportion of participants who correctly answered how to cook eggs safely (i.e. 'until the yolks and whites are firm') increased marginally from 27.0% to 27.2%.
Mullan et al. (2020b)	546 participants No recruitment details provided	42% Busselton residents 48% resided outside Busselton	RQs 2, 5	Evaluation of the 2019-2020 Western Australian pilot safe food-handling media campaign in the City of Busselton. Two quantitative survey questionnaires were used to assess consumers' campaign recall, safe food-handling knowledge, and behaviour at two time points, four months apart: prior to the campaign launch in Nov 2019, and two weeks after the conclusion of the campaign in Feb 2020.	There were no significant demographic differences in people's endorsement of 'cooking eggs until the yolks and whites are firm'. Food safety knowledge did not increase as a result of the pilot media campaign. However, those Busselton residents who recalled the campaign advertisements reported an increase in cooking eggs thoroughly from pre-campaign to post-campaign, whereas those Busselton residents who did not recall the advertisements experienced a decrease in this behaviour over the same time period. For the control group, this effect was reversed, with those who recalled the advertisements experiencing a decrease in engagement in cooking eggs thoroughly from pre-campaign to post-campaign, and those who did not recall the advertisements experiencing an increase over the same time period. There were no significant differences among demographic variables.

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
Mullan et al. (2021)	Perth residents. 655 participants sufficiently completed the survey at both time points. Survey advertised on Facebook in May and June 2021.	71% female Aged 17-81 years (M = 49, SD = 12.79) 64% born in Australia 57% university-educated 65% reported ever having had food poisoning, and a further 9% were uncertain	RQs 1, 4, 5	Two quantitative post-campaign surveys were deployed to assess participants' recall and impressions of the campaign, and their food-handling knowledge and behaviours. These surveys were conducted at two time-points: 1) following the conclusion of the media campaign, and 2) approximately eight weeks later. This evaluation therefore assessed behaviour maintenance over time post-campaign, rather than any changes between pre- and post-campaign knowledge and behaviours.	5.6% of respondents correctly answered "Is it safe to eat eggs with runny yolks and whites" by answering "No". 2% of respondents correctly answered "What should you do with eggs that are dirty" by answering "Throw them away because they are not safe to eat." 26.3% of respondents correctly answered "Should you wash eggs before cooking with them?" by answering "No, never." On a five-point rating scale (0 = never, 4 = always) the mean baseline score for "cooking eggs so they have runny yolks or whites" was 1.85 (SD 1.25), suggesting that, on average, participants "Sometimes" cook eggs so they have runny yolks or whites. On a five-point rating scale (0 = never, 4 = always) the mean baseline score for "washing raw eggs" was 0.40 (SD 0.94), suggesting that, on average, participants "Never" wash eggs. Food safety knowledge around "do not wash eggs" and "it is unsafe to eat eggs with runny yolks and whites" increased between Time One and Time Two. However, it decreased for "Throw away dirty eggs". There was no significant difference between participants who did

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
					and did not see the campaign; knowledge improved in both groups. The behaviours of washing raw eggs and cooking eggs so they have runny yolks or whites remained stable between Time One and Time Two. There was a slight but significant ($p < .05$) increase in habitually washing raw eggs between Time One and Time Two (by 0.40). This is a negative result.
OmniPoll (2019)	1,229 Australians Recruited through online panel.	50.53% female 12.6% 18-24 years 19.6% 25-34 years 25.7% 35-49 years 25.8% 50-64 years 16.3% 65+ years 37.9% university-educated 34.9% <$50k household income 26.4% $50k-89k household income 29.1% $90k+ household income 91.1% grocery buyer	RQ 1	Online quantitative survey	6% ate raw eggs at least once a week 5% ate raw eggs once a month 5% ate raw eggs once every 3 months 4% ate raw eggs once every 6 months 2% ate raw eggs once a year 16% ate raw eggs less than once a year 61% never ate raw eggs 39% ate runny eggs once a week or more 22% ate runny eggs once a month 9% ate runny eggs once every 3 months 5% ate runny eggs every six months 2% ate runny eggs once a year 8% ate runny eggs less than once a year 14% never ate runny eggs People were significantly ($p < .05$) more likely to have ever eaten raw eggs if they: - were aged 25-34 or 35-49 yrs - had a child in the household - were married

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
		30.2% child in household 37.5% works full-time 24.1% works part-time 38.4% does not work			- worked full time - were university-educated.
OmniPoll (2022)	1,254 Australians Recruited through online panel. Sample quotas set for each state, city, and regional area, along with sex and age.	49.4% female 12.2% 18-24 yrs 18.5% 25-34 yrs 25.8% 35-49 yrs 26.7% 50-64 yrs 16.8% 65+ yrs 37.8% university-educated 30.5% < $50k household income 24.8% $50k-89k household income 36.1% $90k+ household income 88.3% grocery buyer 31.4% child in household	RQs 1, 3	Online quantitative survey	People were asked "How often do you wash your hands with running water and soap and dry thoroughly in the following situations... " Of which one was "After handling raw eggs" 53% “Always” 22% "Most of the time" 15% "Sometimes" 6% "Rarely" 3% "Never" Far fewer respondents (23%) said they didn't always wash their hands after handling raw meat or poultry. This may indicate different perceptions of risk association with eggs vs raw meat or poultry. People were more likely to answer “Always” who: - Were female - Were aged 35-49 yrs

Study	Sampling Approach	Participant characteristics	Relevant research question/s	Design/measures	Key findings
		39.5% works full-time 22.2% works part-time 40.4% does not work			- Had a child in the household - Had a college/apprenticeship education People were more likely to answer "Never" who: - Were aged 65+ yrs - Had no child in the household - Did not work - Had a household income < $50k There were no significant differences between grocery buyers and non-grocery buyers.
Whiley et al. (2017)	282 Australians Survey was promoted on a number of Facebook pages, including: Environmental Health Australia, the Adelaide showground Farmers Market and community Facebook pages. This resulted in a snowball sample, where individuals shared the survey link with their friends.	76.6% female 17% 18-25 yrs 23.8% 36-25 yrs 19.5% 36-45 yrs 27.7% 46-55 yrs 10.6% 56-65 yrs 1.4% 65+ yrs 66.6% university-educated 10.3% Environmental Health Officer 3.2% Food Handler	RQs 1, 2, 3, 4	Online quantitative survey.	84% of consumers said they did not consume "raw eggs or raw egg products in the home". However, when asked about whether they had eaten raw mixture/batter containing eggs, 86% of participants responded "yes". There was no difference in food safety knowledge (hand washing or bench wiping) between males and females. EHOs and Food handlers reported significantly safer food handling practices compared to other professions. 91% of participants reported they stored their eggs in the refrigerator. 38.7% of respondents said that they "Always" wash their hands after handling eggs. There was a significant difference

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					among professions, with Environmental Health Officers significantly more likely to answer "Always". Gender did not have a significant difference. 34% said they always "wipe down the bench after handling raw eggs". Food handlers were the most likely to respond always, followed by Environmental Health Officers. Gender did not have a significant impact on the response. Of those who kept poultry, 47% were currently using unsafe practices with regards to handling dirty eggs: 17% would use it as-is; 30% would wash it: 43% would wipe it; 3% would discard it. 10% would use a cracked egg 10% would feed it to a pet; and 77% would discard a cracked egg.