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Shell Egg Handling Practices and Microbiological Safety in Food Premises in the Australian State of Victoria

ABSTRACT

In Australia, salmonellosis is the second most frequently reported foodborne infection. Raw or undercooked shell eggs have been implicated as the vehicle for numerous outbreaks of salmonellosis that are often associated with businesses that prepare and serve food. Egg handling practices at food businesses can affect the microbiological risks associated with egg products. In order to assess the egg handling practices across food businesses in the Australian State of Victoria, 668 shell egg samples, each consisting of six whole eggs, were collected, and the internal contents were examined for *Salmonella* spp. and *Escherichia coli.* In addition, a questionnaire was completed at each food business to evaluate egg handling practices, including the condition of the shell eggs at the premises, food safety programs used by the business to mitigate risk, and storage and use of eggs within the business. One sample was found to contain *E. coli*, while no *Salmonella* spp. were found in any of the samples. A small proportion of businesses had cracked or dirty eggs or eggs past their "best before" date on the premises. In addition, just over 20% of businesses stored their eggs at room temperature, rather than under refrigeration as recommended.

INTRODUCTION

Foodborne illness places a substantial burden on the Australian community, with one estimate suggesting that it costs $AU1.2 billion annually *(1)*. In Australia, salmonellosis is the second most frequently reported foodborne infection *(29)*. In 2013, the National Notifiable Diseases Surveillance System *(7)* reported a notification rate for salmonellosis of 55.3 and 51.5 per 100,000 population nationally and in the State of Victoria, respectively. There are two species, several subspecies and numerous serotypes (serovars) within the genus. Shell eggs, usually raw or undercooked, have been implicated as the vehicle for outbreaks of salmonellosis *(9, 10, 15, 17, 20, 21, 23, 27, 28)*.

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Globally, *S. enterica* Enteritidis and Typhimurium serotypes are most commonly associated with foodborne salmonellosis *(31)*, with *S.* Enteritidis more likely to infect internal egg contents through vertical transmission from the infected reproductive tissue of the hen *(32)*. As *S.* Enteritidis is not endemic in chicken flocks in Australia, *S.* Typhimurium is the most commonly notified serotype in Australia, and bacterial contamination of internal egg contents occurs less frequently than with *S.* Enteritidis *(29, 31)*. *S.* Typhimurium is more likely to contaminate the egg shell surface and occasionally, through horizontal transmission, penetrate the egg shell and then the vitelline membrane surrounding the yolk *(32)*. Egg yolk supports exponential growth of *Salmonella* spp. As eggs have a number of natural defences against bacterial penetration, including the shell cuticle, inhibitory and bactericidal components in the albumen, and a number of membranes, maintaining the integrity of these defences through appropriate egg handling practices is critical to maintaining the safety of shell eggs for consumers.

Several surveys have been performed in Australia to determine the prevalence of *Salmonella* spp. associated with shell eggs, including in the internal egg contents and on the shell. In these studies, *Salmonella* spp. was not found in egg internal contents and was found infrequently on egg shells *(5, 6, 11, 13)*. In addition, some surveys have also screened for other microorganisms, such as *Enterobacteriaceae* (which includes *Salmonella* spp. and *Escherichia coli*, among many other species) as an indication of egg hygiene *(13)*.

It should be noted that even low levels of microbiological contamination of eggs must be considered in relation to egg consumption patterns in the Australian population. In the 2013 calendar year, the volume of grocery sales of eggs in Australia was 181.8 million dozen *(3)* for a national population of approximately 23 million people *(2)*.

While the consumption of raw or undercooked eggs has been implicated in outbreaks of salmonellosis, to put this in an Australian context, in 2011 (the most recent year for which comprehensive annual national outbreak data are publicly available) there were 12,271 salmonellosis notifications nationally *(30)*. During that year, 151 suspected or confirmed outbreaks of foodborne illness were investigated and reported. Of these, 29 (of 151 total outbreaks, and of 61 foodborne salmonellosis outbreaks) were associated, with varying degrees of evidential stringency, with the consumption of egg or egg-based dishes. Microbiological confirmation of *Salmonella* spp. in eggs was substantiated in 11 of 29 of these outbreaks. An analytical epidemiological association between the illness and eggs was found in 3 of these outbreaks (one of these was also confirmed microbiologically). In the remaining 16 outbreaks, the association between illness and egg consumption was based on purely descriptive epidemiological evidence. Thus, microbiological confirmation of *Salmonella* spp. in egg or egg-based dishes was substantiated in 18.0% (11/61) of foodborne salmonellosis outbreaks during 2011 *(30)*.

Given the frequency of salmonellosis notifications in Australia, the detection (albeit infrequently) of potentially pathogenic microorganisms on egg shell surfaces, the high consumption of eggs in Australia, and the potential for contaminating bacteria to grow at exponential rates under conducive conditions, safe egg handling practices should be promoted in food businesses. For these reasons, a microbiological analysis combined with a survey of egg handling practices in food businesses across the Australian State of Victoria was undertaken in order to assess microbiological contamination in the internal contents of shell eggs and to examine egg handling practices.

MATERIALS AND METHODS

Sample collection

Environmental Health Officers (EHOs) in Victoria are statutorily obligated to collect a minimum number of food samples from registered food businesses for analyses to monitor food safety across the state. Between March and May 2013, EHOs were invited to voluntarily submit shell egg samples as part of this survey and in line with their statutory food sampling obligations. Samples were collected during routine inspections of the food businesses or as part of an EHO's food sampling surveillance activities. In total, 668 shell egg samples were collected from food businesses in 43 of 79 local council areas across the Australian State of Victoria. The contributing municipalities included a mixture of metropolitan, regional and rural councils. Each sample consisted of six whole eggs that were being stored and were ready for use at the premises. EHOs were instructed to specifically sample cracked or dirty eggs, if present; otherwise, eggs were collected at the EHOs discretion. All samples were placed in insulated boxes for transport to the laboratory. At the time of sample collection, EHOs also obtained information from the food business relating to the type of premises and the food handling practices at that business, using a questionnaire comprised of 13 questions. Complete business and handling practice information was available for 662 of the 668 samples. Packaged eggs from supermarkets, milk bars (local general stores) and convenience stores were not collected as part of this survey.

Sample analysis

Samples were processed by analysts authorised under the Victorian *Food Act* 1984 at one of three National Association of Testing Authorities, Australia (NATA) accredited laboratories. The Australian Standard methods used reflect the equivalent International Standards Organisation (ISO) methods, although they may be amended for local use. The egg samples were prepared in accordance with Australian Standard 5013.7-2004: Examination of specific eggs and egg products *(24)*. Specifically, soiled eggs were scrubbed clean, after which they were cleaned with either isopropyl alcohol or 70%

(v/v) ethanol and allowed to dry. The internal egg pulp from all six eggs was collected and analysed for the presence of *Salmonella* spp. and *E. coli*. For the detection of *Salmonella* spp. in a 25 g sample in buffered peptone water, pre-enrichment was in Rappaport-Vassiliadis medium with soya (41.5˚C, 24 h) and Muller-Kauffmann tetrathionate/novobiocin broth (37˚C, 24 h) according to Australian standard 5013.10-2009 *(26)*. Enrichment cultures were plated on xylose lysine deoxycholate agar (or another appropriate selective medium). Australian standard 5013.15-2006 was used for the enumeration of *E. coli* per gram of sample, using a most probable number technique *(25)*. Culture from selective enrichment medium lauryl sulphate broth (37˚C, 24 to 48 h) was subcultured into selective *E. coli* (EC) broth (44˚C, 24 to 48 h), and presumptive *E. coli* fermented lactose at 44˚C and produced indole from tryptophan.

A central database collated the microbiological results and responses of the completed questionnaires, and analysis was performed using the Microsoft Excel software program. A two-tailed z-test was used to assess statistical significance.

RESULTS

Types of food businesses

A range of food businesses participated in this survey, including cafes (25.8%), take away businesses (24.2%), restaurants (15.4%), class 1 premises (businesses that serve potentially hazardous food to vulnerable people, such as hospitals, child care centres and aged care facilities) (12.1%), bakeries (9.1%), hotels/bistros (6.5%), sandwich bars (1.7%), catering businesses (0.9%) and other (4.4%).

Microbiological results

Microbiological assessment of 667 of the 668 egg samples identified one sample (0.1%) containing *E. coli* in the pooled internal contents of six whole eggs. In this sample, *E. coli* were enumerated at 390 CFU/g. No *Salmonella* spp. were detected in any of the samples.

Food handling survey

Of the 668 egg samples collected, questionnaire responses were available for 662. When the types of eggs used were categorized, it was seen that 64.2% (425/662) of businesses used cage eggs, 14.8% (98/662) used free-range eggs, 2.4% (16/662) used barn laid eggs, 1.2% (8/662) used cage-free eggs and 17.4% (115/662) did not answer, did not know or selected "other." The EHO examined the eggs within the food business for cleanliness and cracks, and classified 90.2% (597/662) as clean and uncracked, 3.5% (23/662) as clean and cracked, 2.9% (19/662) as dirty and uncracked, 0.2% (1/662) as dirty and cracked, and 3.3% (22/662) as other. When the two most common types of eggs *(Table 1)*, namely cage eggs (n = 425) and free-range eggs (n = 98), were compared, free-range eggs were statistically significantly more likely to be dirty (8.2%, 8/98) than cage eggs (1.6%, 7/425, $P < 0.05$, two-tailed z test). Free-range eggs were cracked 2.0% (2/98) of the time, while cage eggs were cracked 4.0% (17/425) of the time, although it cannot be determined whether the cracking occurred on the farm, during transport or in the food business.

The condition of the shells were also classified by the EHOs *(Table 2)*, and 81.6% (540/662) were described as smooth, 3.5% (23/662) were coated with hard deposits, and 2.0% (13/662) were rough, and 0.2% (1/662) were misshapen, 0.2% (1/662) were soft and weak; for 12.7% (84/662), the respondent did not know or did not answer. While the majority of all egg types were smooth, including similar proportions of cage and free-range eggs, statistically significantly more free-range eggs were rough (5.1%, 5/98) compared with cage eggs (1.6%, 7/425, $P < 0.05$ two-tailed z test).

In Victoria, food businesses are required to have a food safety program, part of which involves keeping records of all food suppliers. In this survey, 78.1% (517/662) of food businesses classified their supplier as an approved supplier, in accordance with their food safety program. However, 7.1% (47/662) said they used a non-approved supplier and 14.8% (98/662) did not know or did not answer. This survey found that 75.1% (497/662) of businesses could identify the brand

TABLE 1. Cracked and dirty eggs from different production systems

	Dirty Number (%)	Cracked Number (%)
Cage (n = 425)	7 (1.6)[a]	17 (4.0)[a]
Free-range (n = 98)	8 (8.2)[b]	2 (2.0)[a]
Other[1] (n = 139)	5 (3.6)	5 (3.6)

[1]Includes not recorded

Values with identical superscripts in the same column did not differ significantly ($P < 0.5$ two-tailed z-test).

Statistical analysis was not performed on "other" category.

TABLE 2. Condition of egg shell from different production systems

	Smooth Number (%)	Hard deposits Number (%)	Rough Number (%)	Misshapen Number (%)	Soft/weak Number (%)	Not recorded or other Number (%)
Cage (n = 425)	350 (82.4)[a]	15 (3.5)[a]	7 (1.6)[a]	0 (0.0)[a]	1 (0.2)[a]	52 (12.2)
Free-range (n = 98)	77 (78.6)[a]	4 (4.1)[a]	5 (5.1)[b]	1 (1.0)[b]	0 (0.0)[a]	11 (11.2)
Other[1] (n = 139)	113 (81.3)	4 (2.9)	1 (0.7)	0 (0.0)	0 (0.0)	21 (15.1)

[1]Includes not recorded
Values with identical superscripts in the same column did not differ significantly ($P < 0.5$ two-tailed z-test).
Statistical analysis was not performed on "other" categories or where the condition of the egg shell was not recorded.

TABLE 3. Identifiable supplier food safety system for different production systems

	Number (%)
Cage (n = 425)	150 (35.3)[a]
Free-range (n = 98)	24 (24.5)[b]
Other[1] (n = 139)	39 (28.1)

[1]Includes not recorded
Values with identical superscripts in the same column did not differ significantly ($P < 0.5$ two-tailed z-test).
Statistical analysis was not performed on "other" category.

TABLE 4. Storage of eggs in different premises types

	Refrigeration Number (%)	Room Temp. Number (%)	Both Number (%)	Not recorded Number (%)
Café (n = 171)	122 (71.3)[a]	47 (27.5)[a]	2 (1.2)	0 (0.0)
Take away (n = 160)	127 (79.4)[a,b]	30 (18.8)[a,b]	3 (1.9)	0 (0.0)
Restaurant (n = 102)	88 (86.3)[b,c]	14 (13.7)[b,c]	0 (0.0)	0 (0.0)
Class 1 premises (n = 80)	72 (90.0)[c]	8 (10.0)[b,c]	0 (0.0)	0 (0.0)
Bakery (n = 60)	43 (71.7)[a]	16 (26.7)[a]	0 (0.0)	1 (1.7)
Hotel/bistro (n = 43)	40 (93.0)[c]	2 (4.7)[c]	1 (2.3)	0 (0.0)
Other[1] (n = 46)	19 (41.3)	24 (52.2)	2 (4.3)	1 (2.2)

[1]Includes sandwich bars, catering businesses, and not recorded
Values with identical superscripts in the same column did not differ significantly ($P < 0.5$ two-tailed z-test).
Statistical analysis was not performed on "other" category or when egg storage conditions were not recorded.

or producer of their eggs from the packaging, container or invoice, while 21.5% (142/662) could not. When businesses were asked if their egg supplier had an accredited food safety system, 56.0% (371/662) of businesses said that they did not know, 15.7% (104/662) identified a HACCP-based system, 10.9% (72/662) identified an industry standard, 2.7% (18/662) identified a supermarket standard, 2.9% (19/662) selected other and 11.8% (78/662) did not answer *(Table 3)*. It was statistically significantly more likely that cage eggs were sourced from a supplier with an identifiable food safety system (35.3%, 150/425) than that free-range eggs were (24.5%, 24/98, $P < 0.05$ two-tailed z test).

The majority of eggs (77.2%, 511/662) were stored under refrigeration, 21.3% (141/662) were stored at room temperature, and 1.2% (8/662) were stored at both. The storage conditions varied by premises type *(Table 4)*, with 93.0% (40/43) of hotels/bistros, 90.0% (72/80) of class 1 premises, 86.3% (88/102) of restaurants, 79.4% (127/160) of take away businesses, 71.7% (43/60) of bakeries, 71.3% (122/171) of cafes, 50.0% (3/6) of catering businesses, and 45.5% (5/11) of sandwich bars storing eggs under refrigeration. It was statistically significantly more likely for hotels/bistros, class 1 premises and restaurants to store their eggs under refrigeration than for other premises types to do so *(Table 4)*. Sixty per cent of businesses (397/662) self-reported using their eggs straight from the refrigerator, while 19.6% (130/662) self-reported allowing eggs to reach room temperature before use, 5.1% (34/662) did both, and 15.3% (101/662) did not know or did not answer.

It was found that 81.1% (537/662) of eggs had a clearly identifiable "best before" date on the egg or packaging, while 8.5% (56/662) did not, and the remaining 10.4% (69/662) of businesses did not know or did not answer. Only 0.6% (4/662) eggs were reported to be outside their best before date; however, 15.6% (103/662) of business did not know if their eggs were within their best before date.

In the majority of participating businesses (79.0%, 523/662), all eggs were self-reported to be used in cooked products *(Table 5)*. This compares with 0.3% (2/662) of businesses that self-reportedly use all their eggs in raw egg products and 16.3% of businesses (108/662) that use their eggs in both cooked and raw egg products. In total, 96.3% (77/80) of all class 1 premises self-reported using all their eggs in cooked products. Similarly, 93.1% (149/160) of take away businesses and 90.9% (10/11) of sandwich bars self-reported using all their eggs in cooked products, while 78.3% (47/60) of bakeries, 75.5% (77/102) of restaurants, 74.9% (128/171) of cafes, 50.0% (3/6) of catering businesses, and 41.9% (18/43) of hotels and bistros self-reported using all their eggs in cooked products. It was statistically significantly more likely for take away businesses and class 1 premises to use all their eggs in cooked products than for other premises types to do so *(Table 5)*.

DISCUSSION

In 2013, the year this study was conducted, 25% of the Australian egg laying flock was located in Victoria, with grocery sales of cage eggs making up 56% of eggs produced by volume *(3)*. In the current study, 64.2% of the eggs tested were cage eggs. In 2010, grocery sales of cage eggs made up 65% of eggs produced by volume, but by 2014, this had dropped to 52% *(3)*. This change in consumer preference for eggs produced in free-range systems affect levels of microbiological contamination of eggs *(31)*, and one study has found that free-range eggs had greater microbiological contamination than eggs produced in a

TABLE 5. Self-reporting by food business of egg use in different premises types

	All cooked Number (%)	Cooked and uncooked Number (%)	Not recorded or other Number (%)
Café (n = 171)	128 (74.9)[a]	38 (22.2)[a]	5 (2.9)
Take away (n = 160)	149 (93.1)[b]	8 (5.0)[b]	3 (1.9)
Restaurant (n = 102)	77 (75.5)[a]	25 (24.5)[a]	0 (0.0)
Class 1 premises (n = 80)	77 (96.3)[b]	1 (1.3)[b]	2 (2.5)
Bakery (n = 60)	47 (78.3)[a]	11 (18.3)[a]	2 (3.3)
Hotel/bistro (n = 43)	18 (41.9)[c]	24 (55.8)[c]	1 (2.3)
Other[1] (n = 46)	27 (58.7)	1 (2.2)	18 (39.1)[2]

[1]Includes sandwich bars, catering businesses and not recorded
[2]Two businesses in this category reported using all their eggs in raw egg products
Values with identical superscripts in the same column did not differ significantly ($P < 0.5$ two-tailed z-test).
Statistical analysis was not performed on "other" category or when egg use was not recorded.

cage system *(18)*. However, evidence is conflicting as to the influence of differing egg production systems on the likelihood of detecting *Salmonella* spp. *(31)*. In the current survey, free-range eggs were statistically significantly more likely to be dirty than cage eggs. However, it should be noted that Australia has a number of different accreditation systems for free-range eggs, which vary widely with respect to factors such as stocking density, ground cover requirements, beak-trimming, induced moulting and use of antibiotics; in addition, many free-range farms are large industrial operations *(19)*. If the greater dirtiness of free-range eggs compared with cage eggs actually represents a greater microbiological risk, and consumer preference is pushing for greater production in this type of system, then strategies to mitigate these risks are needed. It was also more likely for cage egg producers to have an identifiable food safety system than for those producing free-range eggs to have one. However, the majority of businesses claimed that they did not know about the food safety systems employed by their supplier.

A number of surveys have been conducted to assess the frequency of microbiological contamination in eggs. Given that Australia, unlike many countries, does not have endemic *S.* Enteritidis, comparison of the current study with other Australian surveys is the most relevant. With this in mind, in Australia, *Salmonella* spp. have not been detected in any of the surveys in internal egg contents *(5, 6, 8, 11, 13)*. However, *Salmonella* spp. have been detected at low frequencies on the egg external surface, either by egg wash *(6, 13)* or egg shell swabs *(5)*, with rates of detection ranging between 4.5% of 310 samples (pooled samples of six eggs each) collected from cage eggs on farm *(13)*, 3.5% of 199 retail eggs including both cage and free-range eggs *(11)*, 2.7% of 260 pooled samples consisting of 6 eggs each collected from cage eggs on farm *(6)*, and 0% of 500 cage eggs collected on farm *(5)* and 11,036 cage, free-range and barn laid eggs *(8)*. It should be noted that there are likely to be differences when comparing the microbiology of eggs collected on farm with retail eggs and eggs used in food businesses. In Australia, egg washing is a common practice in commercial egg production, with the intention of reducing the bacterial load on egg shell surfaces, although the efficacy of this process is debated *(31)*. Given the absence of endemic *S.* Enteritidis in Australian layer flocks and the lack of detection of *Salmonella* spp. in egg internal contents, it is unsurprising that in the current survey *Salmonella* spp. were not detected in any of the 667 samples for which microbiological data were available. As this survey was conducted shortly after the introduction of new Australian legislation prohibiting the sale and supply of unacceptable eggs *(12)*, which includes eggs that are cracked and dirty, only internal contents of the eggs were tested, as internal contamination is likely to be reflective of unacceptable eggs. It may be useful in future studies to include testing of the external surface of eggs as well.

Testing for the bacterial family *Enterobacteriaceae* can indicate egg hygiene. In one Australian survey, *Enterobacteriaceae* were detected on the surface of egg shells collected from cage eggs on farm *(13)*, but internal contents were not tested. In another survey, *E. coli* was detected on the shell surface of 7.0% of 500 samples and in 2.0% of 500 shell pores, but not in the internal egg contents of cage eggs collected on farm *(5)*. In the current study, one pooled sample of six eggs (0.1%) contained *E. coli*.

While rates of bacterial contamination of eggs are low, consumption of eggs is high. During the 2012/13 financial year, egg production in Australia was estimated at 396.8 million dozen eggs *(3)*, highlighting the importance of eggs in the Australian diet and the importance of appropriate food safety measures.

Hence, egg safety measures do not stop at the production stage. Given that potentially pathogenic microorganisms have been detected on egg surfaces in Australia, including on retail eggs *(11)*, and the potential for exponential growth of contaminating bacteria under conducive conditions, safe food handling practices are essential. Consequently, surveys to investigate egg handling practices are critical in order to identify and understand potential risks posed by poor egg handling practices. The current survey focused on egg use in food businesses, as many large outbreaks have been associated with food businesses *(9, 10, 17, 20, 21, 27, 28)*, and specifically examined the condition of egg shells, food safety programs, and storage and use of eggs.

The condition of the egg shell is important, as studies have shown that shell abnormalities, such as unusual shell thickness or translucency, may influence microbial penetration of the egg *(5, 22)*. In the current study, the vast majority of eggs were classified as smooth, with only 3.5% being described as coated with hard deposits, 2.0% as rough, 0.2% as misshapen and 0.2% as soft and weak. Assessment of shell quality was made by multiple EHOs from 43 different local councils. Thus, there may be inconsistencies in reporting of shell quality. In Australia, eggs are considered "unacceptable" if they are cracked or dirty *(12)*. In this survey, eggs from 7.3% of businesses were classified as cracked, dirty or both. However, information was not recorded on the proportions of eggs within these businesses that met this description, or on whether these eggs would have been discarded by the business or used in food preparation. As for egg shell quality, there may be inconsistencies in reporting of the cleanliness of the eggs, as this survey relied on the assessment of numerous EHOs.

When questioned, the majority of food businesses (78.1%) reported that they received their eggs from an approved supplier as defined in their food safety program. In Victoria, it is a legal requirement for certain food businesses that handle potentially hazardous food to have a food safety program. One of the requirements of the food safety program is to keep a record of all suppliers that the food business deems

to have adequate food safety procedures to supply safe food. However, any knowledge of food safety systems the supplier used was scanty. More than half of the businesses surveyed (56.0%) did not know if the supplier was aligned to an accredited food safety system.

Lower temperatures inhibit bacterial growth, and bacterial penetration of eggs has been shown to be reduced when eggs are stored at 4°C compared with eggs stored at room temperature *(5)*. In Australia, it is not required that businesses store eggs under refrigeration, although they are encouraged to do so, and it is considered best practice. The different premises types in this survey had varying rates of storage of eggs under refrigeration. In particular, hotels/bistros, class 1 premises and restaurants had high rates of refrigeration of eggs (all above 86%). The lowest rates of egg refrigeration were observed for catering businesses and sandwich bars (50% or below).

Only a very small proportion of eggs found in food businesses were beyond their best before date (0.6%); however, 15.6% of businesses could not be sure if their eggs were within their best before date. This may be a result of eggs being supplied without a best before date or of businesses removing egg packing that displays this date. This may pose little risk in businesses where egg turnover is high and appropriate rotation of eggs is achieved. However, given that some eggs with a best before date were beyond this date, then the risk of out-of-date eggs being used by businesses cannot be disregarded. In a similar study in food service premises in the UK in 2005–2006, 3.1% of eggs were past their best before date, and eggs within a week of their best before date had higher rates of *Salmonella* spp. detection *(16)*. It should be noted that in Australia the current Code of Practice for shell egg production, grading, packing and distribution *(4)* states that eggs should be "sold under a best before date of a period of six weeks or less from the date of pack on the understanding that the eggs are continually kept under optimal temperature conditions." However, as seen in this survey, around 20% of food businesses were storing eggs at room temperature, and thus not under optimal conditions.

Cooking is an effective method of reducing the risk of foodborne illness from microbiological contamination of eggs *(14)*. A number of outbreaks of salmonellosis have been associated with raw or undercooked eggs *(9, 10, 15, 17, 20, 21, 27, 28)*. A high proportion of class 1 premises (96.3%), which serve food to vulnerable groups of people in hospitals, aged care and childcare facilities, use all their eggs in cooked foods. Given that salmonellosis is often more severe in the elderly and those with an underlying illness or compromised immune system and also more common in young children (29), these food businesses are more likely use eggs in cooked dishes. In contrast, other types of food businesses were more likely to use eggs in both cooked and raw foods. For example, 41.9% of hotels and bistros self-reported using all their eggs in cooked products. This may be part of a consumer trend for more unprocessed and raw foods *(31)*.

In conjunction with microbiological surveys, egg handling surveys provide important information on the potential food safety risk posed by poor egg handling. Safer egg handling practices include appropriate storage temperatures and times as well as cooking. In addition, reducing the chance of cross contamination following the handling of eggs may reduce the likelihood of foodborne illness. This is particularly important given that in Australian surveys, microorganisms (including *Salmonella* spp.) were more commonly found on the egg shell surface than in the egg contents *(6, 11, 13)*.

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