



Food
Authority

Hygiene failures in food service

Common causes of foodborne illness

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Summary

Using analyses of foodborne disease outbreaks and observations made at food businesses in the United States of America and in Australia, recurring problems contributing to foodborne illness and measures that can be used to prevent foodborne illness were identified.

In commercial and home kitchens the chance of foodborne illness can be reduced by:

- Minimising the time potentially hazardous food spends in the temperature danger zone (5–60°C) in which food poisoning bacteria can grow.
- Keeping eggs safely by using only clean and uncracked eggs, storing and cooking eggs appropriately.
- Avoiding cross contamination, which is where food poisoning organisms from raw food contaminate ready-to-eat food.
- Keeping high standards of personal hygiene.
- Understanding how to properly clean food processing equipment and surfaces.
- Purchasing food from safe sources, which is particularly important when buying fish and shellfish.

Introduction

OzFoodNet (2006) estimates there are about 5.4 million cases of foodborne disease in Australia each year, with costs estimated to be \$1.2 billion. Where outbreaks are identified and investigated the cause of the outbreak and details of what went wrong can often be determined.

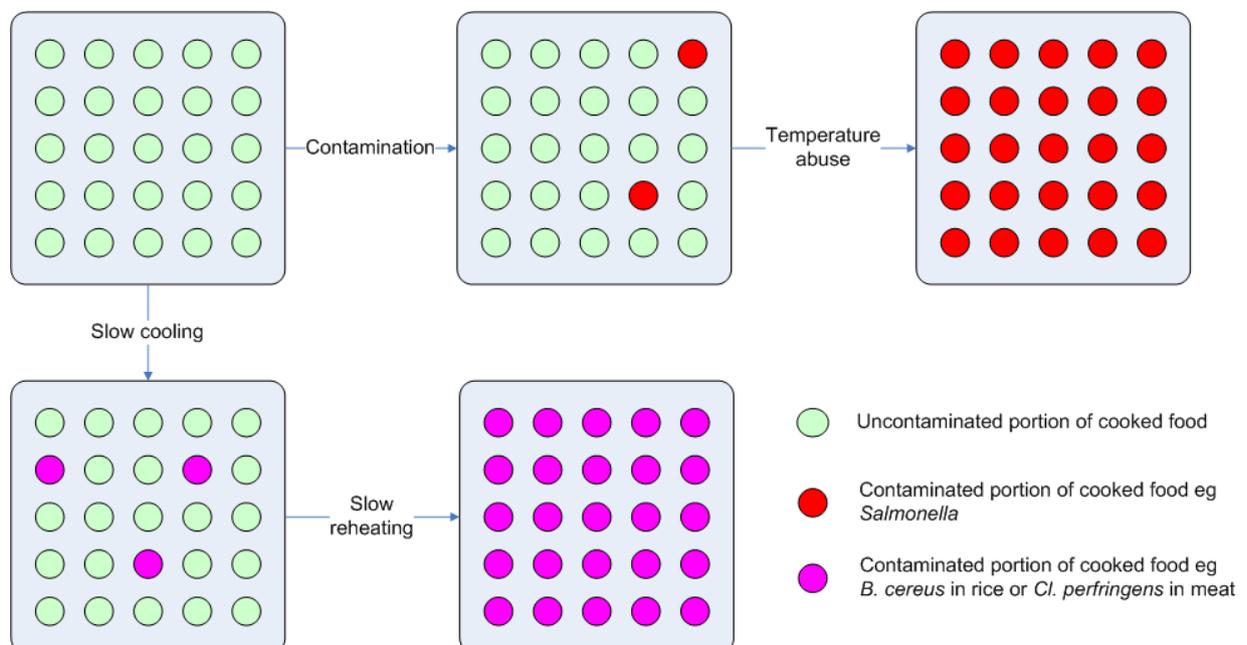
Having identified what went wrong, the objective is to prevent a recurrence. There are examples of well thought out plans that have reduced foodborne illness. However, there are also many examples of lessons not being learned. This report considers these recurring problems and suggests a number of measures that can be used to prevent foodborne illness.

Three sources of information were used for this report:

- Analysis of foodborne disease outbreaks in the United States from 1973 to 1987.
- Analysis of 900 carefully controlled inspections of food businesses in the United States.
- Analysis of foodborne disease outbreaks in Australia from 1995 to mid-2008 that were associated with food industry sectors regulated by the NSW Food Authority.

The three sources of information provide a different viewpoint of food hygiene failures and yet all the reports lead to similar conclusions:

- The US data points to the critical importance of food temperature control.
- The Australian data highlights food contamination.
- Often failures in both factors combine to cause foodborne illness.



Most of the measures suggested to reduce foodborne illness can be used in the home, commercial kitchens and in food retail businesses.

What leads to foodborne illness?

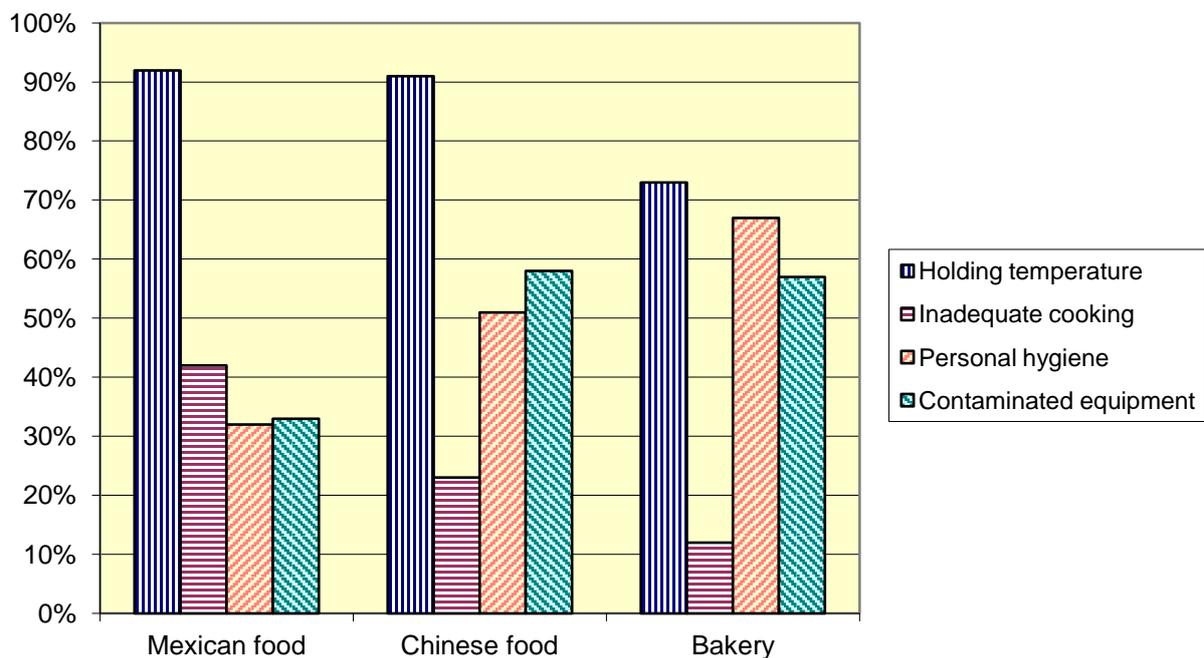
Scientists from the *Centers for Disease Control* in the United States (Bean & Griffin, 1990) studied reports of 7458 foodborne disease outbreaks that occurred between 1973 and 1987.

They identified:

- the food involved,
- the cause of the illness (eg the bacteria, virus or chemical) and, where possible, and
- the factors (the mistakes or faults) that contributed to the outbreak occurring.

The main contributing factors are shown in the following graphics.

Factors contributing to food poisoning (US data)



The main factor contributing to food poisoning from three quite different styles of food is related to 'holding temperature'. This means that food is held for too long at temperatures where food poisoning bacteria can grow. Food under refrigeration must be held at 5°C or less and food displayed hot for service must be 60°C or more. Food between 5° and 60°C is in the temperature *danger zone* where food poisoning bacteria can grow. The time that food is in the danger zone must be kept to a minimum. The time food takes to cool or reheat is often overlooked and problems can result.

Food is cooled too slowly

Example: A Mexican restaurant prepares a large pot of chilli (minced meat, tomato base, chilli) for use the following day. The pot of chilli is placed in a coolroom after cooking but because the volume of chilli is so great it stays warm all night. Some bacteria that form spores (like a tough seed) are not killed by cooking and grow to large numbers in the chilli overnight. The product is warmed through for use in burritos the next day and customers are poisoned.

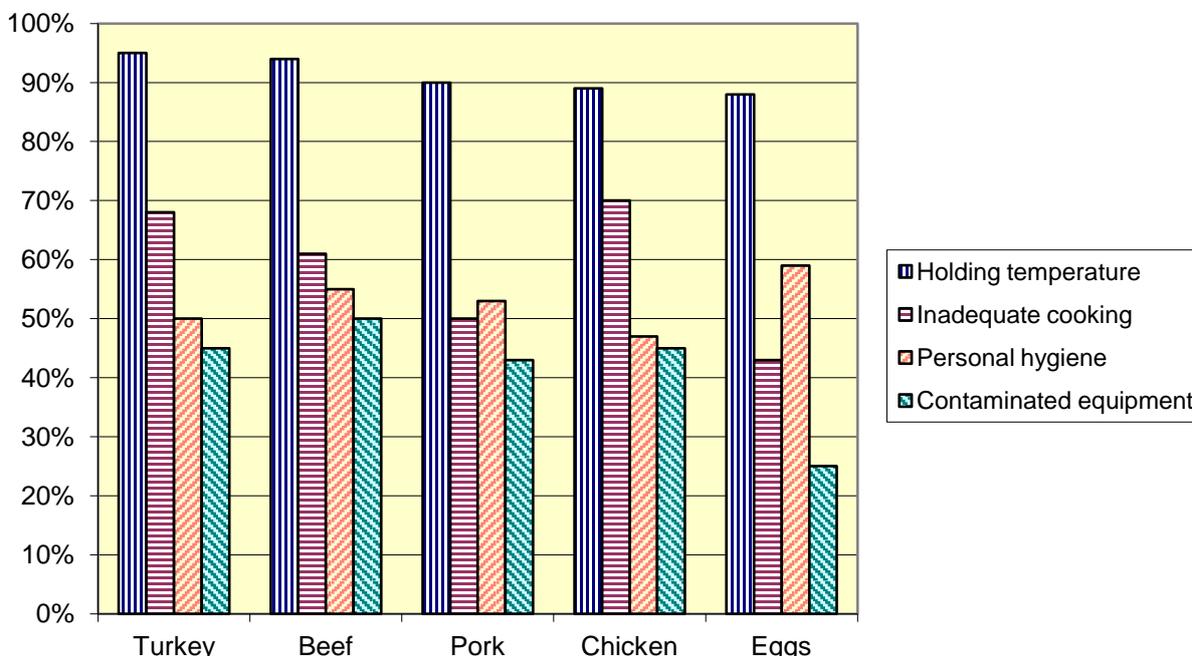
Example: A Chinese restaurant boils rice to use in fried rice the next day. To keep the rice soft and fluffy it is stored on the kitchen bench overnight and not in the coolroom. Again spore forming bacteria survive boiling and grow to very large numbers overnight. The rice is only gently heated during preparation of fried rice and customers are poisoned.

Food is reheated too slowly

Example: The Mexican restaurant serves chilli from a bain marie throughout the day. The chilli is not reheated prior to display and warms very slowly in the bain marie. The chilli stays in the temperature danger zone for much of the day and food poisoning bacteria flourish in the warm food.

The perfect storm: If food is cooled and reheated too slowly and then held below 60°C, conditions are perfect for food poisoning bacteria to persist or grow.

Factors contributing to food poisoning (US data)



When the contributing factors to food poisoning are examined by main ingredients rather than cuisine, holding temperatures are still found to be the leading problem. Turkey has been associated with many outbreaks following Thanksgiving Day dinners. Problems are more common if the turkey is prepared in advance and reheated for the dinner. The large birds are difficult to cook through, slow to cool and slow to reheat. The inside of the bird can spend many hours in the danger zone, particularly if stuffing is used. Undercooking is a further risk.

Large beef or pork roasts can have similar problems to turkeys, particularly if rolled and filled or minced and prepared as a loaf. Casseroles, stews or curries prepared in large volumes are just as slow to cool as the chilli mentioned above, unless they are refrigerated in small, easier to cool portions. A shallow Gastronorm pan in a coolroom (5°C or less) with good air circulation around it will typically cool within the required time.

Food is contaminated after cooking

Most of the bacteria that cause food poisoning do not form spores and are killed during cooking. These bacteria still cause many cases of food poisoning following recontamination of food after cooking. In the graphs above, contamination is shown as failures of personal hygiene or the use of contaminated equipment.

The most common personal hygiene failure is likely to be caused by handling food with unclean hands. Hygiene standards state that direct hand contact with food is to be avoided. Despite such standards, hand contact with food remains common, especially in food service. Alternatives include handling food with clean tongs or forks, using a plastic bag like a glove when selecting delicatessen items or carefully using food handler gloves. Hands can be contaminated by handling raw food, during toilet breaks, by using a handkerchief or tissue, or touching the hair or face. The single best defence is regular and thorough hand washing.

Food can be contaminated by the use of unclean equipment. One of the common problem pieces of equipment is the slicer. Complete disassembly is required to properly clean slicers and this can be inconvenient and time consuming. If cleaning doesn't occur regularly a slicer that is outwardly clean can contaminate every slice of product it prepares. Other hard-to-clean food preparation equipment includes blenders, juicers and food processors. Any machine that traps food in seals or around drive shafts can cause contamination.

Cross contamination: *Campylobacter* is a major cause of foodborne illness in the industrialised world (Domingues et al 2012). Significant food risks for *Campylobacter* are chicken prepared at a restaurant, non-poultry meat prepared at a restaurant and consumption of undercooked or pink chicken. Studies show when *Campylobacter* is introduced into a commercial kitchen surrounding work areas become contaminated and, because the infectious dose of *Campylobacter* is small, haphazard cleaning of surfaces with soap and water might not eliminate the risk of cross contamination (Friedman et al 2004).

Cross contamination occurs when bacteria that are present on raw foods contaminate ready-to-eat food. This can occur if a kitchen implement such as a knife or a cutting board used to prepare raw food is reused, without proper cleaning, for cooked foods or salads. Another common problem is the drip from raw meat or poultry falling onto ready-to-eat food in a refrigerator. As noted above, poor personal hygiene can also transfer bacteria from raw foods to cooked products.

Food is inadequately cooked

There are special cases when undercooking is a significant risk—including undercooked eggs. Eating a rare hamburger carries a risk far greater than eating a rare steak. Bacteria are found on the surface of steak and these are killed when the meat is seared. When meat is minced surface bacteria are spread through the whole mix and bacteria can survive at the centre of a patty cooked rare. Children, in particular, have been exposed to illness due to eating rare beef patties.

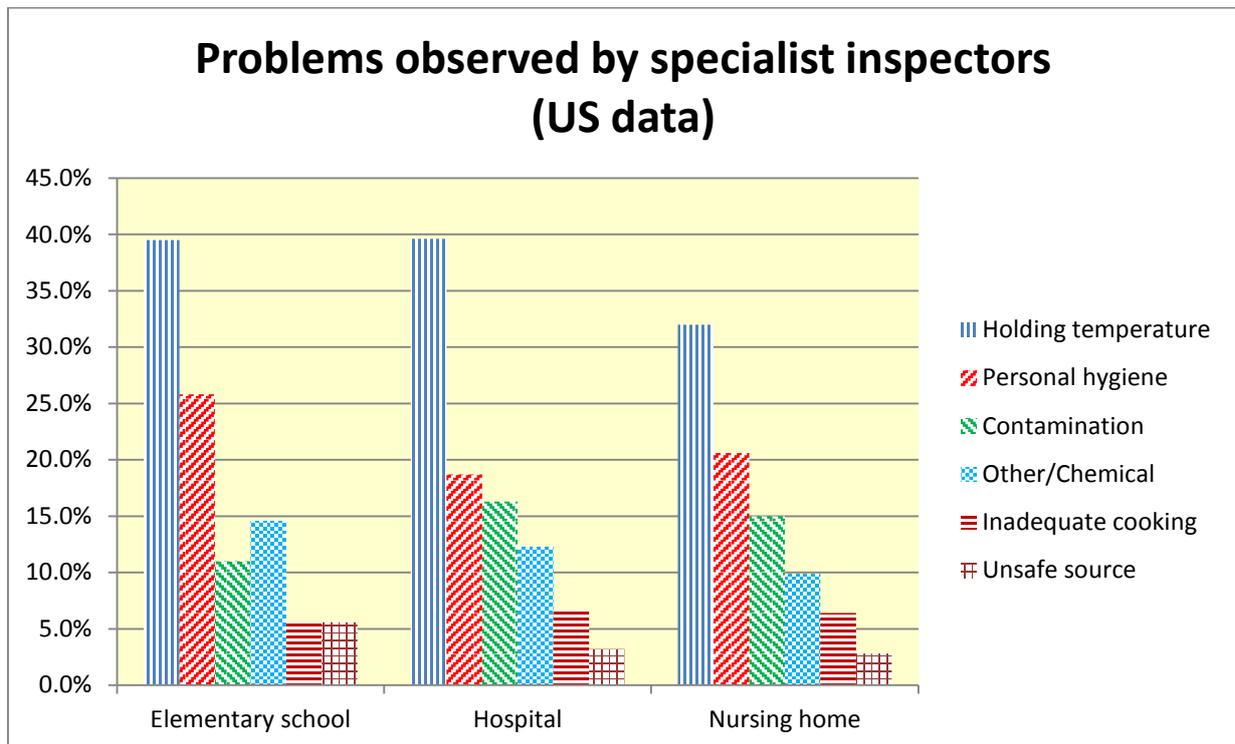
Other problems

Food from unsafe sources was also a significant contributing factor. This is discussed below. As is common in foodborne illness investigations, there were many cases where 'other' unspecified factors are associated with the outbreak.

Viruses also cause foodborne illness: Norovirus is estimated to be the most common cause of foodborne disease in the United States, accounting for two-thirds of all food-related illnesses. Norovirus is a principal cause of outbreaks of acute-onset vomiting and diarrhoea in all age groups—most commonly via contamination of uncooked foods by infected food handlers, but also via foods contaminated at their sources, such as oysters and raspberries. Prevention of foodborne norovirus disease lies in the provision of safe food and water. It is likely that simple measures, such as correct handling of cold foods, frequent hand washing and paid sick leave, will significantly reduce foodborne transmission of NLV infection (Bresee *et al* 2002).

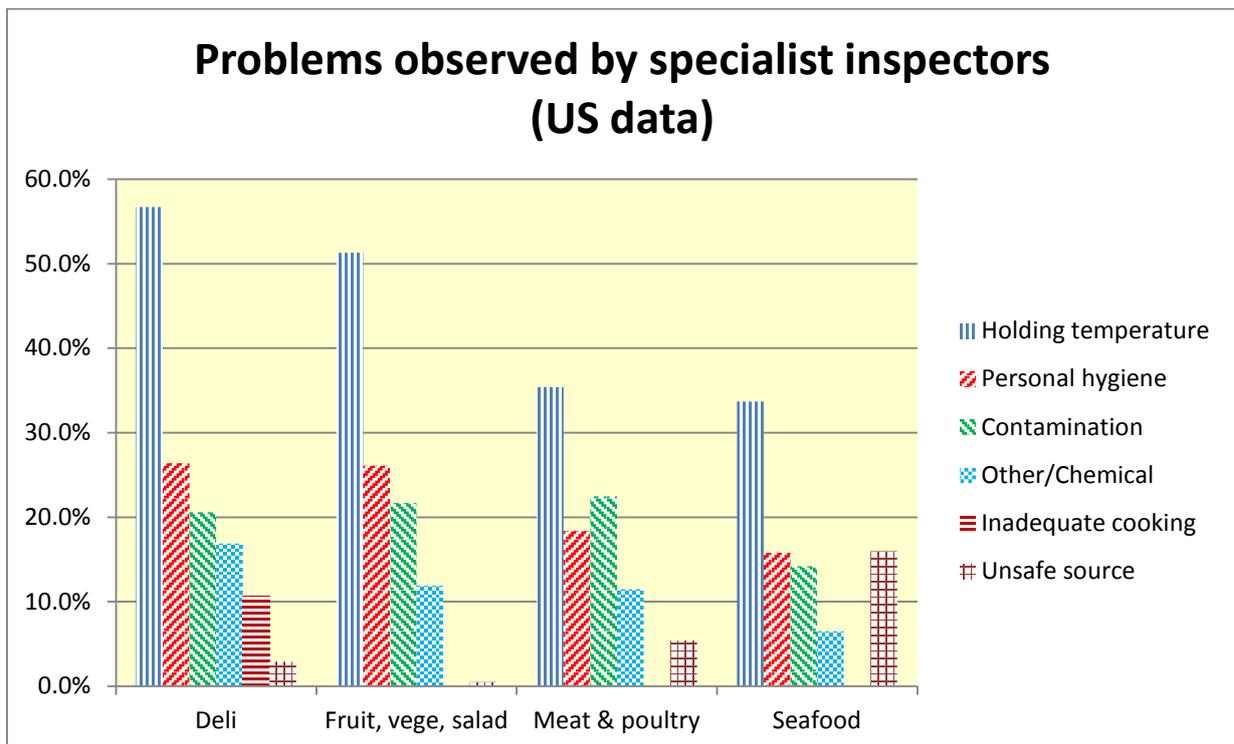
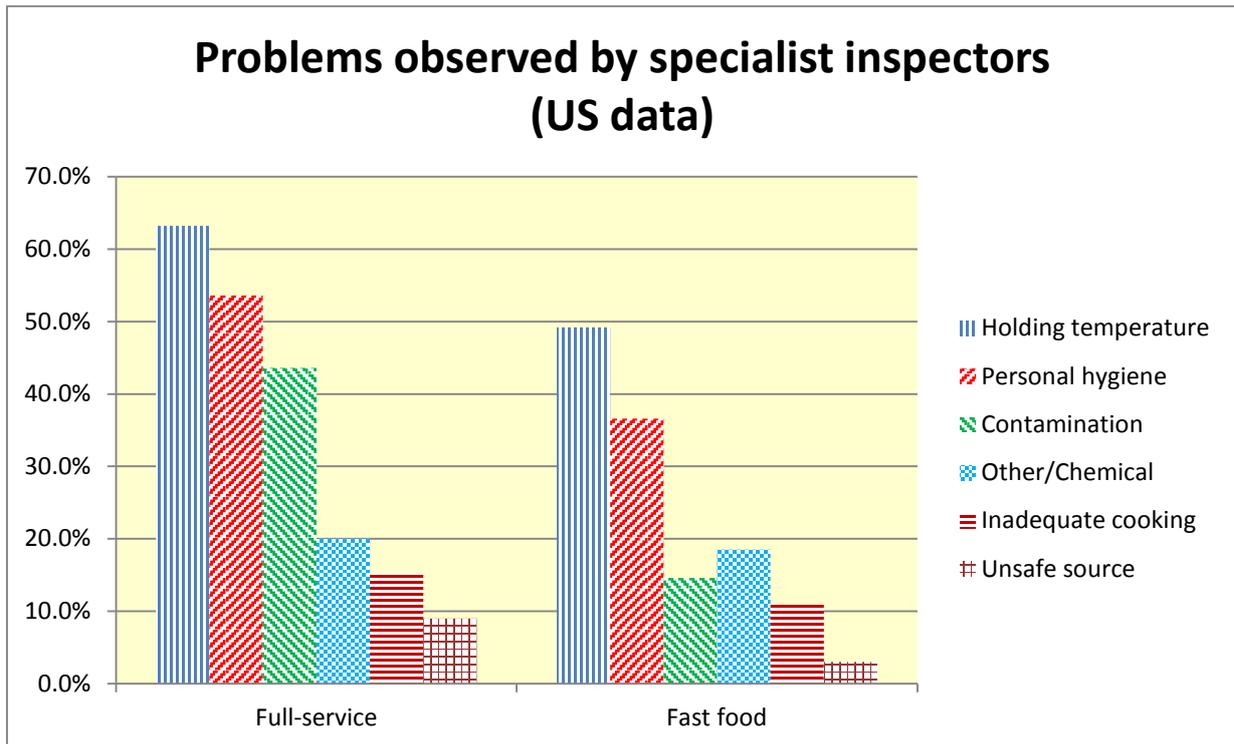
What practices concern food safety specialists during inspections?

A group of experts from the United States Food and Drug Administration (FDA 2000) studied foodborne illness risk factors. Nine hundred inspections were undertaken by a team of twenty food safety specialists. They inspected institutions, restaurants and retail stores and assessed compliance with important food safety requirements. The next three graphics summarise the results.



US inspectors identified 'holding temperature' as the most frequent problem observed. Kitchens were marked down for slow cooling of foods, poor refrigeration temperatures and hot holding temperatures below 60°C.

Poor personal hygiene ranks higher than in the food poisoning graphs above. Premises were marked down if they didn't have clean hand washing facilities in both the toilet and the kitchen. Soap, a hand drier/paper towel and information on when to wash hands were all inspected. Kitchen staff were also required to prevent the contamination of food by hand contact or when tasting food.



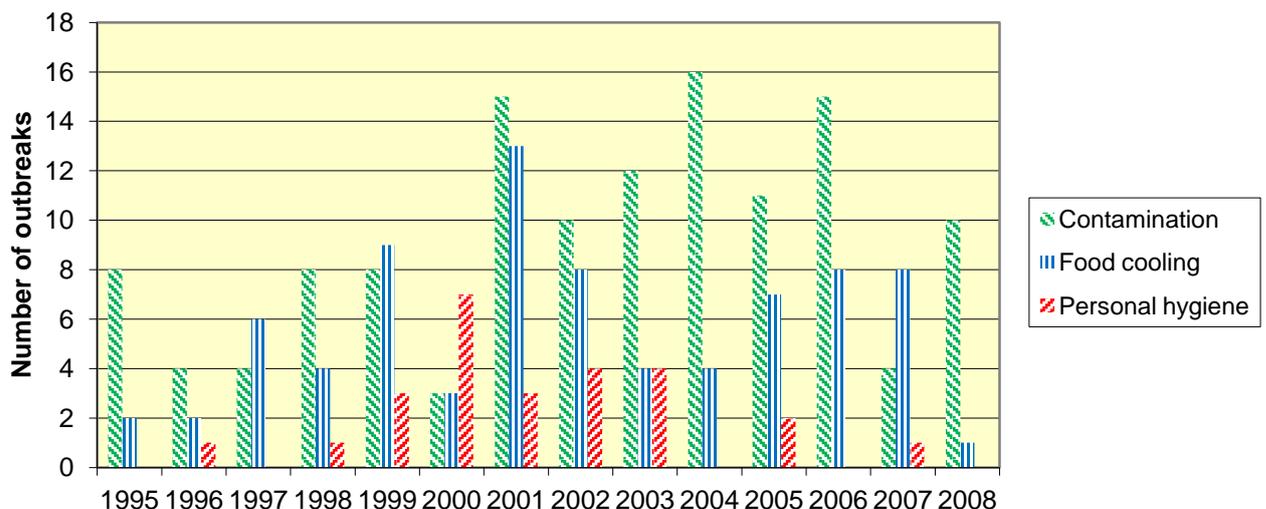
The top three problems observed are very similar in institutions, restaurants and food retail shops. Full service restaurants face more problems because they have more complex menus and prepare food ahead of time (and face the problems of cooling and reheating). Retail seafood shops have more problems with food from unsafe sources. This issue is discussed below with reference to Australian disease outbreaks.

Main factors contributing to Australian foodborne illness outbreaks

This information was extracted from the records of Australian foodborne illness outbreaks that were reported in *Food safety risk assessment of NSW Food Safety Schemes* (NSWFA 2009). The records of illness were re-analysed and, where possible, one contributory factor was assigned as the main cause. When assigning causes the findings of the authors of the original reports and the characteristics of the organisms that caused the illness were considered. However, the assignments are subjective—they identify possible causes but are not definitive. While the assignments are similar in some ways to the studies reported above, they are not directly comparable. For example:

- 'Holding temperature' does not appear in the following graphs. 'Food cooling' failures are the only holding temperature problem reported. Where the outbreak was caused by *Clostridium perfringens* the main cause was considered to be 'food cooling' because the bacteria is known to grow in meats if they cool too slowly.
- 'Personal hygiene' is reported as the main cause when the responsible organism is typically spread by food handlers. There will be many other personal hygiene failures but they are not easily recognised from the case report summaries.
- In many outbreaks where 'contamination' was reported as the main cause, temperature control problems would also have occurred.

Main cause by year (Australian data)



Contamination, food cooling and personal hygiene failures are significant causes of problems in Australia just as they are in the US. The isolation of temperature issues to just 'Cooling' is useful because it demonstrates the major impact of cooling failures on foodborne illness.

Outbreaks attributed to 'Contamination' include problems such as cross-contamination (bacteria spread from raw to ready-to-eat food) and issues with unclean equipment.

A number of surveys published by the NSW Food Authority and partner agencies have identified food handling practices that have the potential to lead to foodborne illness, particularly when combined with temperature abuse. A survey of the safety of raw egg dressings in cafes and restaurants (Food Regulation Partnership 2011) identified risky practices:

- Of 39 premises surveyed, 17 separate egg yolk from the white using bare hands, four use gloved hands and five use the broken shells.
- Twenty-three per cent of premises had eggs with cracked or dirty shells in storage.
- Over half of the raw egg dressings were stored in squeeze bottles and often the dispensers were observed to be dirty around the rim and topped up without first washing and sanitising.
- There was potential for growth of any contaminating pathogens because 10% of raw egg dressings were stored at ambient temperatures. While 21% were stored in a cold bar the temperature of over half the products stored in cold bars exceeded 5°C.
- Raw egg hollandaise sauce is generally stored within heated areas or under heat lamps to heat the sauce to around 40°C, which is close to the optimum temperature for growth of many foodborne pathogens.

A survey of takeaway chicken shops that involved 31 local councils (NSW Food Authority 2011) identified risky practices and some of them were quite widespread:

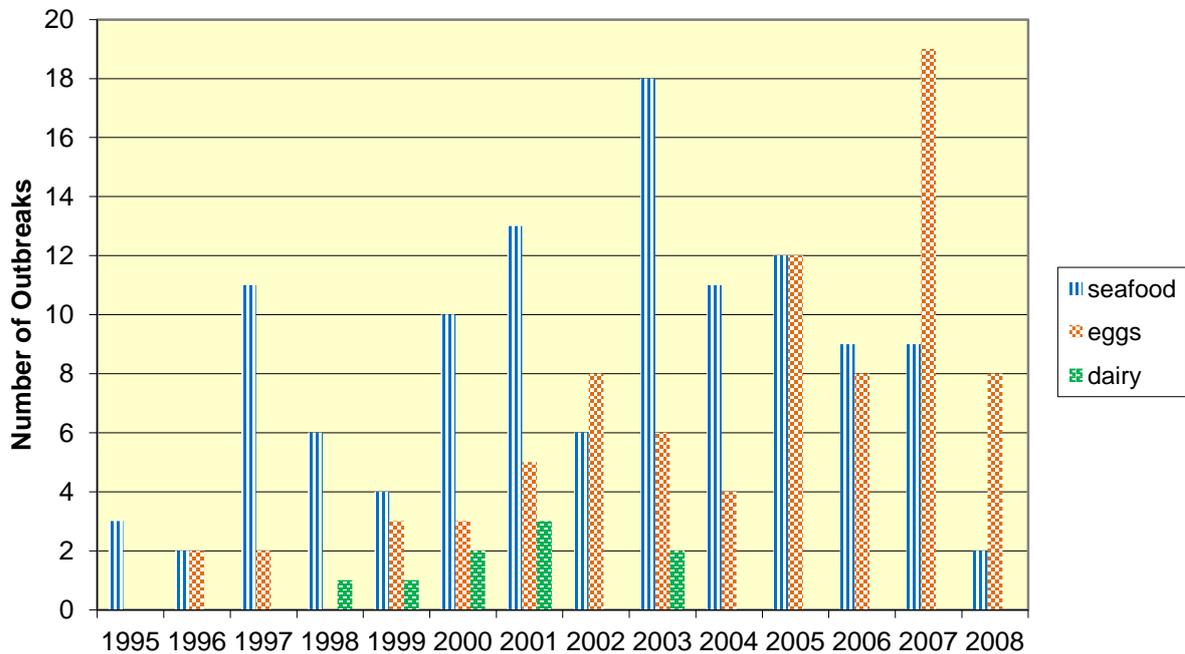
- Fifty four per cent of businesses displayed gravy and 75% displayed mayonnaise-based salads within the temperature danger zone (between 5°C and 60°C).
- Forty per cent of businesses shredded or diced chicken after it had been displayed for a period of time outside temperature control, for use the next day
- Forty per cent of businesses cooled gravy using large containers (>5L).
- Forty-five per cent of businesses did not use appropriate sanitisers to sanitise food preparation surfaces.

The reports note that poor handling practices observed at the surveyed premises will not lead to foodborne illness on their own. When foodborne illness occurs, it is normally due to a series or combination of events. For microbial foodborne illness to occur, four essential elements need to come together:

- a susceptible consumer,
- a microorganism in a form that is able to cause illness and is in sufficient numbers,
- the microorganism is present in a food that supports its transmission and, in some cases, amplifies it, and
- an environment (eg temperature) that supports the microorganism's transmission and, in some cases, amplifies it.

The use of ingredients that are not safe

Outbreaks by year (Australian data)



Note: 2008 results are for part of the year only.

A small number of foods cause most of the foodborne illness attributed to an unsafe source.

Seafood – shellfish

In the 1990's quite a few outbreaks were caused by oysters and pipis. These outbreaks occurred prior to the introduction of management plans for the harvest of NSW shellfish. Outbreaks attributable to Australian shellfish are now infrequent.

Seafood – fish with ciguatera

Ciguatera is a toxin associated with large predatory reef fish from the tropics. The toxin is not destroyed by cooking and there is no way to test fish prior to sale. Fish marketers have taken steps to reduce the amount of illness. Wholesale fish markets ban certain tropical fish and limit the size of others. Ciguatera hot-spot areas are excluded from commercial harvest. Recent ciguatera outbreaks have been limited to northern Australia.

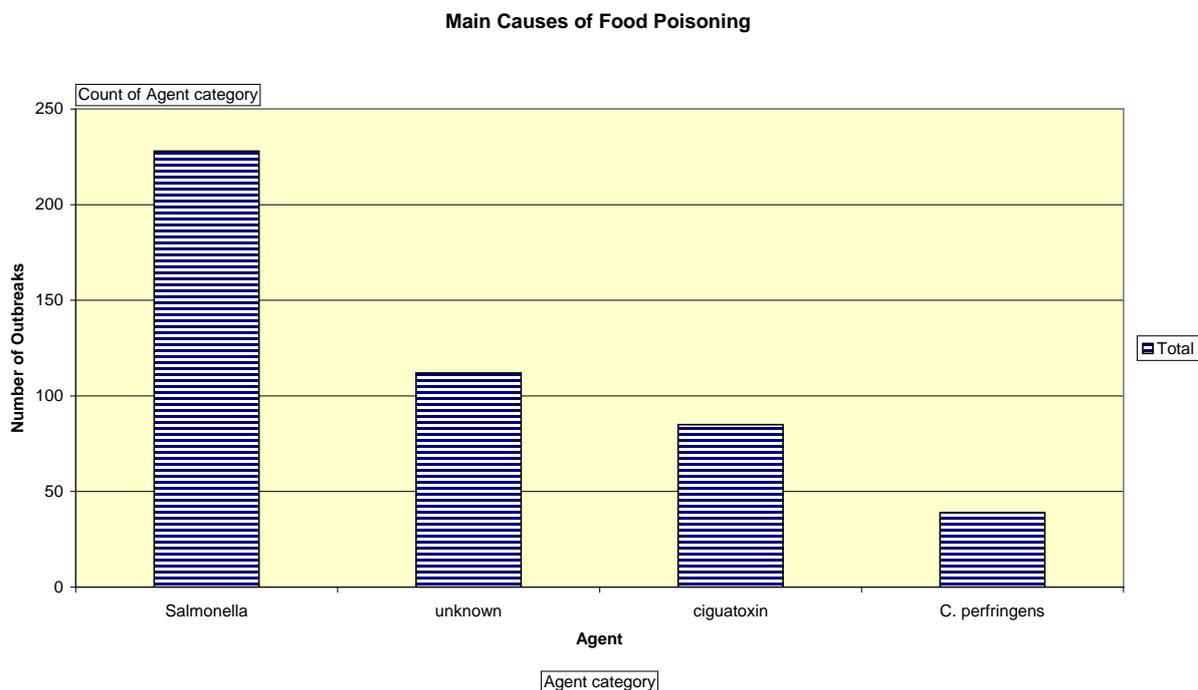
Eggs – served raw or undercooked

Outbreaks attributed to the use of raw or undercooked eggs have been increasing. Raw egg products including mayonnaise, sauces and desserts have become trendy. While the chance of getting a contaminated egg is low the increasing popularity of raw egg products means that eventually someone will hit an unwelcome jackpot of a contaminated product and a string of handling errors. Some large outbreaks traced back to bakeries or cafes have been caused by mayonnaise, aioli or 'egg butter' prepared using raw eggs, too little vinegar and too much time outside of refrigeration.

Milk – consumed raw/unpasteurised.

A relatively small volume of raw milk is consumed in Australia. The recorded outbreaks are related to children consuming raw milk on farm camps.

Important agents of foodborne illness in Australia (1995–2008)



Salmonella heads this list and is at or near the top of most international lists of food poisoning causes. Eggs were associated with 103/228 (45%) of the *Salmonella* incidents. The use of raw or undercooked eggs was the main contributing factor with contamination being a long way second. Meat was associated with 76/228 (27%) of incidents. About half of the meat incidents were attributed to chicken. Contamination was the dominant contributing factor to *Salmonella* outbreaks associated with meat.

'Unknown' is second on the list of causes. When an outbreak of food poisoning follows on quickly from the consumption of food, and involves many unrelated people, then investigators are likely to identify the cause and the contributing factors. Small outbreaks, especially involving people from a single household that take a day or more to develop are much harder to investigate. Some illnesses take 36 hours to develop while others take seven or more days. Victims usually blame the last meal eaten but this is often not the case. By the time illness has developed the responsible food has frequently all been sold, consumed or discarded.

Reductions in ciguatera poisoning and the association between poor food cooling and *Clostridium perfringens* have been discussed above.

Infections identified as *Campylobacter* are well down the list and are not shown in the graph. However, underreporting of *Campylobacter* is a problem because illnesses usually occur in small numbers and are dispersed throughout the community. *Campylobacter* is the most common cause of gastroenteritis (all sources not exclusively food) in the community.

Some measures to reduce foodborne illness

Two examples show that food poisoning can be reduced when businesses implement good strategies. The reputation of NSW shellfish was damaged in the 1980s and 1990s by a number of high profile food poisoning incidents. Industry and government cooperated to ensure shellfish harvest was limited to areas with good sanitary standards at times when water and shellfish quality were excellent. Similarly, seafood marketers implemented plans to control the sale of fish contaminated with ciguatera toxin in NSW. Both schemes have proven to be very effective. There have been benefits for the seafood industry and public health.

A number of tactics can be used in commercial and home kitchens to reduce the chance of foodborne illness. *Safe Food Australia – A Guide to the Food Safety Standards* (ANZFA 2001) explains the requirements of the Food Standards Code and provides some excellent tips on food safety. Some of the successful tactics are summarised below.

1. Minimise the time potentially hazardous food spends in the temperature danger zone (5–60°C) in which food poisoning bacteria can grow:
 - Potentially hazardous foods are foods in which food poisoning bacteria can grow. Virtually all prepared meat, cereal and vegetable dishes that might appear on a meal plate are potentially hazardous. Potentially hazardous food can only be held at 5–60°C for up to 4 hours and after 2 hours food must not be returned to refrigerated storage. Use it quickly or discard it (this is called the '4-hour/2-hour rule').
 - Store and display cold food below 5°C. This is relatively easy in modern refrigerators or coolrooms but remains difficult in cold displays unless they have overhead refrigeration units or use forced circulation of chilled air. If food cannot be displayed below 5°C it must be discarded before the 4 hour time limit is exceeded.
 - Cool food quickly after cooking. This is probably the most overlooked requirement. Food must cool from 60 to 21°C within 2 hours and within a further 4 hours cool from 21 to 5°C. It is hard to meet this requirement with large roasts, kebab spits or large pots of food. Divide food into smaller portions so it can cool in the permitted time.
 - Rice which is boiled to be used the following day to prepare fried rice must also be cooled quickly. It used to be common to store rice on the bench overnight to keep it soft and fluffy. Many food poisoning incidents were the result. Fortunately that practice is now rarely encountered.
 - Display hot food at temperatures above 60°C. This can be achieved if food is displayed immediately after cooking or if it is fully reheated prior to display in a unit set at the right temperature. It takes many hours to reheat food in a bain marie and this practice can lead to food poisoning.
2. Keep eggs safe:
 - Buy fresh, clean, uncracked and refrigerated eggs from a trusted supplier.
 - Store eggs in the refrigerator.
 - Use pasteurised egg pulp to prepare raw egg mayonnaise, sauces or desserts.
 - Avoid raw and undercooked eggs.

3. Avoid cross contamination, which is where food poisoning organisms from raw food contaminate ready-to-eat food:
 - Use different cutting boards and knives for raw food and ready to eat foods. Colour-coded boards and knives with colour coded handles have been designed to make this easier.
 - Don't reuse barbecue marinades as a sauce unless they are thoroughly cooked.
 - Don't allow juices from raw meat or poultry to drip onto ready-to-eat food. Cover ready-to-eat foods and store them on the top shelf of the refrigerator. Store raw meat and poultry on the lower shelves and use a tray or bag to catch drips.
 - Wash hands thoroughly after handling raw foods. Use clean kitchen implements to handle ready-to-eat foods.
4. Ensure high standards of personal hygiene:
 - Regular and thorough hand washing is essential. Wash your hands after using the toilet, handling raw food, touching your face, nose or hair or using a handkerchief.
 - Commercial kitchens must have a hand basin in the toilet and a dedicated hand basin adjacent to food preparation areas. Soap or cleanser and a way of drying hands must be provided. Single-use paper towels are preferred.
 - Avoid hand contact with ready-to-eat foods. Use clean implements.
 - Food handlers' gloves can assist with food safety but they are often poorly used. Contaminated gloves are as risky as contaminated hands.
5. Ensure food processing equipment is clean and free of food residues:
 - Choose easy-to-clean professional food processing equipment for use in a commercial kitchen.
 - Clean equipment thoroughly and regularly. Disassemble the equipment to ensure all food residues are removed. Wash and dry hands before reassembly.
 - Cleaning is a multi-step process—remove food residues, rinse, clean using a good quality detergent, rinse and dry. A food grade sanitiser should also be used in a commercial kitchen.
 - Regularly remove food scraps, and clean and sanitise bench tops and food preparation areas.
6. Purchase food from a safe source:
 - Commercial kitchens and fish mongers should buy fish using the conventional marketing channels. The benefits include traceability and quality assurance. Recreational fishers are not permitted to sell fish.
 - Shellfish must be purchased through conventional marketing channels which are based on shellfish harvested by licensed fishers or shellfish farmers. Recreational harvesters are not permitted to sell shellfish. Recreational harvesters are not bound by harvest area management plans and food safety cannot be assured.
 - Milk must be purchased through normal commercial channels. Raw or unpasteurised cows milk may only be sold to dairy processing companies and not to commercial kitchens or consumers.

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Appendix: Case studies

Case 1: Salmonella outbreak from contaminated aioli served in a burger bar

(NSW Food Authority, 2010a)

In early 2010 the Authority investigated an outbreak of food poisoning linked to a popular burger bar in NSW. The initial notification from NSW Health was that twenty people who had eaten from the burger bar on one weekend had suffered gastroenteritis. Within two weeks the number of people affected by the outbreak had risen to 179, with the bacterium *Salmonella* responsible. Investigations revealed that:

- the burger bar was using aioli made from raw eggs which did not receive any further cooking or processing.
- *Salmonella* was present in samples of aioli taken from the burger bar.
- the aioli had a pH of 5.8 which would not prevent the growth of any *Salmonella* present, particularly at high ambient temperatures.
- the outbreak occurred during the summer when ambient temperatures at the burger bar were high (>30°C).
- *Salmonella* was also present in a swab from a chopping board, indicating poor controls over cross contamination and inadequate sanitising of equipment and surfaces.
- the burger bar was sourcing eggs from a local hobby farm rather than a commercial egg supplier. The hobby farm did not have any system for quality control, such as candling or crack detection, and eggs were not washed prior to sale. Eggs were also placed into reused cartons which increased the potential for cross contamination of *Salmonella* to the outside of shells.
- the eggs were not refrigerated.

All these factors combined to contribute to this outbreak.

Case 2: Pre-cooked meats: *Clostridium perfringens*

(NSW Food Authority 2010b)

On 12 December 2006 the Authority was notified of possible foodborne illness among people who attended a private party two days prior. Catering for the main meal was provided by a local business. During the following week there were two further complaints from people that attended different functions catered by the same local business, with roast pork being the only common food consumed.

The caterer was aware of separate complaints from three different groups who had ordered various foods from his shop on 9 December 2006. At all three functions illness was reported by the majority of attendees. The caterer had already concluded that the roast pork, common in all three orders, had caused the food poisoning.

From an interview with the caterer it was found that raw pork from a butcher was supplied to the caterer on 7 December 2006 and cooked that morning. A total of five raw pork roasting items were cooked to cover the three orders for roast pork for 9 December 2006.

The cooking involved placing raw pork into pans into the oven set at a maximum 300°C for four hours. The pork was left in the oven for 30 minutes after cooking and then removed, juices discarded, allowed to cool down on the bench in the same cooking pans for about one hour and then placed into clean plastic crates with clean black plastic lining and covered in the coolroom.

There was no measuring of internal temperature of the pork at any stage during or after cooking despite there being a meat thermometer probe available in the premises. The coolroom temperature was between 1°C and 3.5°C at the time of inspection on 13 December 2006.

The reheating process for all three orders on the day of the functions commenced no more than 1.5 hours prior to the supply to customers. The chilled, cooked roast pork was placed into fresh clean pans and into an oven set at 160–180°C for 45 minutes, then 250°C for a further 15 minutes to make the crackling. After reheating, the pork was sliced, packed into foil trays and loaded into a van departing the shop at about 7:45pm and arriving at the function venue about 20 minutes later.

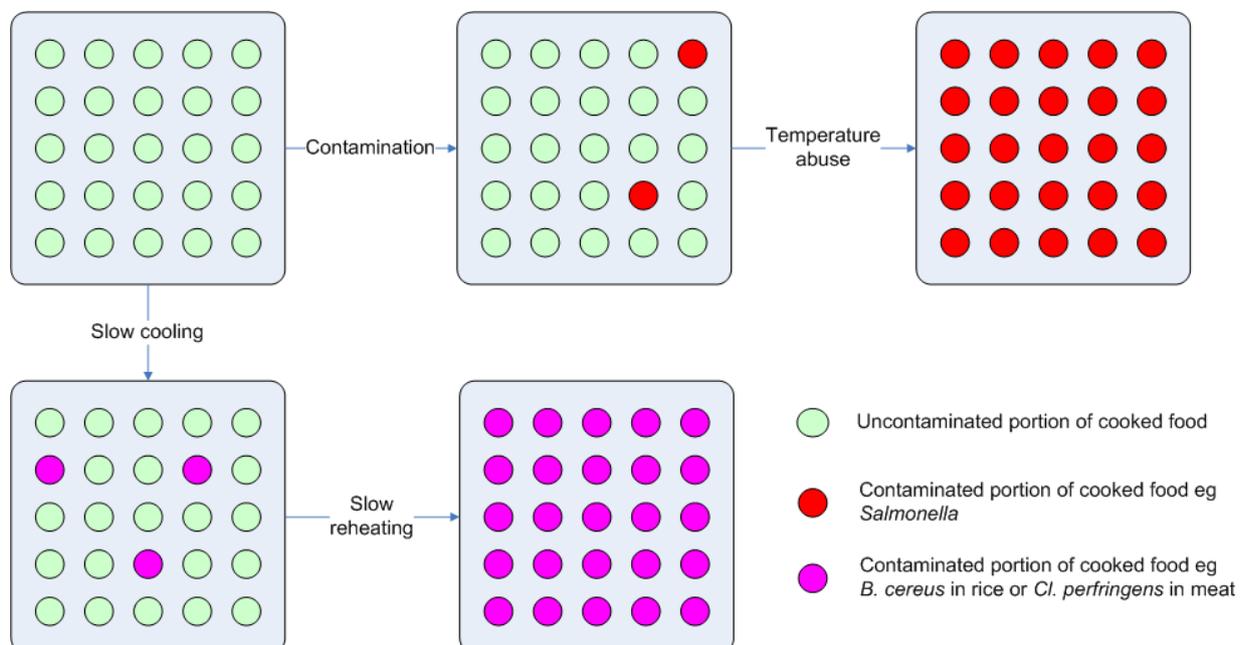
Inadequate initial cooking of rolled roast pork, coupled with slow cooling and prolonged storage of the cooked roast pork for up to two days prior to reheating are the likely causes of *Cl. perfringens* growth.

Inadequate reheating time and temperature will allow the organism to survive in high numbers and lead to illnesses. While there was no food to sample or records at the caterer, the:

- high levels of spores and toxin of the organism in the clinical samples from people ill, and
- a toxic level of *Cl. perfringens* in the food recovered from the complainant,

strongly support temperature abuse as the contributing factor of the outbreak.

The graphic below illustrates strings of errors similar to those reported in the above cases.



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