# *Listeria* and listeriosis

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*Readers are invited to use this article as a self-assessment exercise and to update their knowledge.*

## ILLUSTRATIVE INCIDENTS

### Incident 1

A male veterinarian assisted in the manual delivery of a calf. The veterinarian used a long-sleeved glove which tore during the calving. The calf subsequently died. Two to three days later, vesicular lesions 1–2 mm in diameter developed on both forearms of the veterinarian. The appearance of the lesions was accompanied by fever. The veterinarian cultured the contents of the lesions and grew a pure culture of *Listeria monocytogenes*.

### Incident 2

A male infant was delivered at 32 weeks' gestation showing severe signs of sepsis. The mother of this infant had experienced a series of pyrexial episodes with influenza-like symptoms 3–4 weeks prior to delivery. At delivery, the amniotic fluid was stained with meconium. Shortly after delivery, respiratory resuscitation was necessary. Cultures taken from the infant's gastric aspirate, and with swabs from the ears, eyes, umbilicus, skin and the mother's high vagina, all yielded a heavy growth of *L. monocytogenes*. The infant was treated with antimicrobial agents and recovered.

A second full-term female infant was born 6 h later in an adjacent delivery suite. The delivery was uncomplicated but respiratory resuscitation equipment was also subsequently used. This infant developed meningitis 9 days later and culture of cerebrospinal fluid yielded a growth of *L. monocytogenes*. Despite antimicrobial treatment, this infant died.

### Incident 3

A 40-year-old HIV-positive male was admitted to hospital with fever, and *L. monocytogenes* was isolated from blood cultures taken on admission. The patient made a full recovery following antimicrobial treatment. The same strain of *L. monocytogenes* was isolated from five different opened items of food taken from the patient's refrigerator.

Subsequent interviews with the patient identified the predominant use of a single retailer where the implicated strain was isolated from a range of foods collected from a refrigerated display cabinet, including opened and unopened packages of a single brand of meat pâté. The implicated strain was also isolated from implements and machinery within the food factory which produced the meat pâté.

Examination of cultures submitted to the National Reference Laboratory did not reveal any further cases of listeriosis associated with this strain of *L. monocytogenes*.

### Incident 4

Twenty cases of listeriosis (12 as stillbirths or congenitally infected infants) occurred in a single mainly urban region (population 2 million) over a 21-month period. The cases showed no other geographic or temporal clustering. Isolates of *L. monocytogenes* from all cases were identified as a single strain by the National Reference Laboratory.

A case-control study was carried out after the first 12 months with eight of the patients but did not reveal the consumption of any particular foods as a risk factor for acquisition of infection. A second case-control study, however, after 18 months revealed a significant association with the consumption of ready-to-eat cooked and smoked shellfish. Shellfish from one of the patients' refrigerators were found to be heavily contaminated by the implicated strain of *L. monocytogenes*.

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A follow-up study of shellfish showed that unopened packs from a single manufacturer were commonly heavily contaminated by the implicated strain. The shellfish were processed by a local producer, given a 4–6-week shelf life at refrigeration temperatures and distributed only to local retailers. A voluntary recall of the product was carried out (19 months after the first case was identified). A further four cases due to the implicated strain occurred over the following 2 months where the patients identified consumption of this brand of shellfish prior to the recall. No further cases were identified after the 21-month period of this outbreak.

## MULTIPLE-CHOICE QUESTIONS

*In each of the numbered questions at least one, and up to four, of the individual entries are correct. (The answers are at the end of this article.)*

**1. Listeriosis features**

a) Species of *Listeria* other than *L. monocytogenes* cause approximately 5% of human listeriosis cases. True/False
b) Human listeriosis is usually a food-borne disease. True/False
c) Human listeriosis occurs most often in the spring. True/False
d) The numbers of reported human listeriosis cases have increased between 1990 and 1995 in both the UK and the USA. True/False
e) Diarrhea can be a feature of human listeriosis. True/False

**2. Animal listeriosis**

a) A wide range of animals are susceptible to listeriosis. True/False
b) Among domestic animals, infection is most often recognized in sheep. True/False
c) Animal listeriosis is predominantly a food-borne disease. True/False
d) Animals infected by *L. monocytogenes* are the major source of the bacterium which infects humans. True/False
e) Systemic infection in veterinarians and farm workers is unlikely to ensue from cutaneous listeriosis. True/False

**3. Listeriosis during pregnancy and neonatal cross-infection**

a) Person-to-person transmission of listeriosis between adults commonly occurs. True/False
b) Transmission of listeriosis from a mother to her unborn infant occurs. True/False
c) *L. monocytogenes* is found in very high numbers in the amniotic fluid of congenitally infected infants. True/False
d) The pregnant woman with *L. monocytogenes* bacteremia is likely to develop a listerial meningitis. True/False
e) Neonatal cross-infection usually results in the infection of a single late-onset neonatal case. True/False

**4. Foodborne listeriosis**

Foods transmitting listeriosis to humans have included:

a) Dairy products. True/False
b) Cooked meat. True/False
c) Shellfish. True/False
d) Vegetable products. True/False
e) Only those which will allow the growth of *L. monocytogenes* during their shelf life. True/False

**5. Properties of *L. monocytogenes***

The following treatments of foods are likely to eradicate *L. monocytogenes* if properly applied:

a) Pasteurization. True/False
b) Microwave cooking. True/False
c) Freezing. True/False
d) Cold smoking. True/False
e) Vacuum packaging. True/False

**6. Growth of *L. monocytogenes* in foods**

*L. monocytogenes* is able to grow in certain foods under the following conditions:

a) Refrigeration at 6 °C. True/False
b) Refrigeration at 1 °C. True/False
c) pH 3.0. True/False
d) 5% sodium chloride. True/False
e) 200 ppm sodium nitrite. True/False

**7. Food-borne listeriosis**

a) The incubation period between consumption of contaminated foods and the onset of clinical listeriosis in humans can be 1–2 days. True/False
b) The incubation period can be > 50 days. True/False
c) The attack rate in exposed individuals is high. True/False
d) Food-borne listeriosis usually occurs in outbreaks of > 5 cases. True/False
e) All human outbreaks are due to a few very similar strains of *L. monocytogenes*. True/False

**8. Investigation of food-borne listeriosis**

A causal relationship between a specific food item and a case of food-borne listeriosis is strongly suggested by the isolation of the same strains of *L. monocytogenes* from:

a) Food taken from the patient's refrigerator. True/False
b) Loose foods collected from a delicatessen counter of a retailer used by the patients. True/False
c) Swabs from the hands of a food handler at the retailer. True/False
d) Unopened foods from the retailer and/or manufacturer. True/False
e) Drains and floor swabs from the food production environment. True/False

**9. Advice to the general public, including risk groups**

Pregnant women and the immunocompromised should avoid consumption of the following foods:

a) Hard cheese. True/False
b) Cottage cheese. True/False
c) Soft cheese described as made from pasteurized milk. True/False
d) Mold-ripened soft cheese. True/False
e) Ready-to-eat cooked poultry without thorough reheating. True/False

## COMMENTS

### Question 1

The genus *Listeria* comprises six species, *L. monocytogenes*, *L. ivanovii*, *L. innocua*, *L. welshimeri*, *L. seeligeri* and *L. grayi*. Almost all cases of human listeriosis are due to *L. monocytogenes*; although *L. seeligeri* and *L. ivanovii* have also been implicated, these are very rare. Out of a series of 2237 cases of human listeriosis in the UK (1965–94), all except two cases were due to *L. monocytogenes* [1]. The remaining two cases were due to *L. ivanovii* [2,3].

The widespread distribution of *L. monocytogenes* provides numerous potential ways in which the disease may be transmitted to humans, although it is now generally accepted that the consumption of contaminated food is the principal route of transmission [4]. Other routes of infection, however, do occur, such as contact with infected animals and by cross-infection during the neonatal period as illustrated by incidents 1 and 2.

Listeriosis most often affects the contents of the pregnant uterus, the central nervous system or the bloodstream. In non-pregnant humans, listeriosis usually presents as meningitis or septicemia in the immunocompromised or elderly [5]. During pregnancy, infection can spread to the fetus, and may precipitate a stillbirth or the birth of a severely ill infant [6]. In the non-pregnant individuals, a wide range of risk factors are associated with infection, particularly in those with malignancies or undergoing immunosuppressive therapies. The incidence is notably higher in patients with AIDS [7]. Listeriosis also occurs in apparently previously healthy individuals without any of the above risk factors [8].

The peak of human listeriosis occurs during the end of the summer and in the autumn [5] and not during the spring. The reasons for this are not known.

Since 1990 the numbers of reported cases of human listeriosis have declined in both the USA and in England and Wales [9,10]: the incidence of reported cases per million was 4.2 in the USA during 1993, and between 1.6 and 2.5 for England and Wales between 1990 and 1996 [9,10]. The reasons for the decline may involve the advice to the general public and specific risk groups to modify their diet (see comments on Question 9) as well as the efforts by the food industry to implement hazard analysis and introduce codes of practice. There is evidence (at least for foods examined in England and Wales) that since the late 1980s there has been considerable improvement in the microbiological quality of specific food items (including soft cheese and pâté) with respect to contamination by *L. monocytogenes* [11].

Diarrhea was not a feature of cases involved in the 1985 Californian outbreak of listeriosis associated with soft cheese [12]. However, recent outbreaks of systemic listeriosis in the USA and Italy, transmitted via contaminated prawn salad, chocolate milk and rice salad, identified *L. monocytogenes* also as a cause of mild infection involving gastroenteritis and fever [13–15]. It is not clear whether the ability to cause diarrhea is specific to certain strains of *L. monocytogenes*, or (especially in view of the long incubation period; see comments on Question 7) has hitherto been unrecognized. The recognition of relatively mild disease in the pregnant woman [6] also suggests that listeriosis may cause subclinical infection. Listerial diarrhea in animals is well recognized [16].

### Question 2

Listeriosis has been recognized in a very wide range of animals and is of major veterinary importance in cattle, sheep and goats, but in the UK is most common in sheep [16]. As with human listeriosis, infection in animals is believed to be predominantly food-borne and has been particularly associated with the feeding of silage. Changes in agricultural practices from the production of silage in clamps to bales (the latter

favoring the growth of *L. monocytogenes*) has probably led to an increase in the incidence of this disease in domestic animals.

The genus *Listeria* contains a group of somewhat marginal pathogens which are probably not host adapted and occur widely in the environment. For both humans and animals, the majority of *L. monocytogenes* infections probably result from ingestion of environmentally contaminated food or feed containing large numbers of *L. monocytogenes* bacteria. Apart from human infection acquired as a direct result of attending infected animals (as described in incident 1), or from food directly contaminated from an infected animal (as may be the case with milk from an animal with listerial mastitis [17]), there is probably little direct connection between human and animal listeriosis. The autumn peaks of human listeriosis and the spring peaks of animal listeriosis also suggest that disease in these two groups is not usually causally related.

Incident 1 illustrates that listeriosis may be transmitted by direct contact with infected animals or animal material, and a series of 17 such cases was reviewed by McLauchlin and Low [18]. Infection resulted in cutaneous lesions almost exclusively amongst farmers or veterinarians 1–4 days after contact with congenitally infected calves. Since listeriosis is much more common in sheep, it is not clear why these human cutaneous infections should be associated only with bovine abortions. All the cases reviewed by McLauchlin and Low [18] were mild and successfully resolved; however, some of the infected individuals developed fever and axillary lymph node tenderness. Meningitis has been described in individuals following contact with bovine abortions. In view of the serious nature of systemic listeriosis, it is recommended that individuals should have suspect lesions microbiologically examined and receive appropriate antimicrobial therapy.

**Question 3**

Although it has been previously suggested that person-to-person transmission of listeriosis occurs amongst adults [19], this is now believed unlikely, and the consumption of a common contaminated food is the more likely causal association between such clusters of cases. As previously mentioned, *L. monocytogenes* infects the contents of the pregnant uterus probably via the maternal bloodstream, although such a consequence is not inevitable. During infection, the pregnant woman may experience a series of mild, pyrexial, influenza-like episodes during which *L. monocytogenes* can be cultured from the blood. Despite this blood-borne challenge, the innate maternal immune response is well able to resolve the bacteremia, and serious disease (such as meningitis) does not result. However, in the intrauterine environment a severe multisystem invasion of the unborn infant occurs and extremely high levels of bacteria are found in the amniotic fluid ($10^8$ CFU/mL [20]). Hence in both humans and other animals, very large numbers of bacteria are present at delivery on the newborn, in the maternal birth canal, and on sites, personnel and instruments contaminated during delivery, as well as in the immediate postnatal environment. The very large numbers of bacteria present during congenital infection can cause infection of further human neonatal cases (late-onset infection) by nosocomial cross-infection, and cutaneous lesions on farmers or veterinarians attending infected animals (as illustrated in incidents 2 and 1, respectively).

Hospital cross-infection between newborn infants has shown a common pattern; where an infant was born with congenital listeriosis (onset within 1 day of birth), in the same hospital and within a short period (usually within 1 day), apparently healthy neonates were born who subsequently developed late-onset listeriosis (the majority between the 5th and 12th day after delivery). In most of these incidents, the infection was transmitted to one late-onset case only, although a single report describes transmission to a further eight neonatal cases [21]. In most of the episodes, the cases were either delivered or nursed in the same or adjacent rooms, and consequently staff and equipment were common to both: in the largest series, resulting in eight late-onset cases, a common mineral oil bath was identified as the agent of transmission [21]. In one episode, the mother of the early-onset case was nursed in an open ward and handled a neonate from an adjacent bed who subsequently developed late-onset listeriosis [22]. A high infective dose during the human neonatal period is suggested, since transmission arises from contact shortly after delivery, and usually results in single rather than multiple cases. If the infective dose were lower, larger numbers of secondary cases might be expected.

Appropriate infection control measures should be instigated in delivery units to prevent neonatal hospital-acquired infection.

**Question 4**

Although soft cheese and pâté (incident 3) have been particularly associated with listeriosis, as illustrated by incident 4, other foods should also be considered. Smoked mussels have been associated with two small listeriosis outbreaks in Australia and New Zealand (Table 1), and a very wide range of food types have now been implicated in transmission of this disease. These foods have included dairy, meat, seafood and vegetable products (Tables 1 and 2). These foods have generally

**Table 1** Foodborne outbreaks of human listeriosis

| Country | Year | No. of cases | Implicated foods |
|---|---|---|---|
| USA | 1976 | 20 | Raw salad[a] |
| New Zealand | 1980 | 22 | Shellfish or raw fish[a] |
| Canada | 1981 | 41 | Coleslaw |
| USA | 1983 | 49 | Milk[a] |
| USA | 1985 | 142 | Soft cheese |
| Switzerland | 1983–87 | 122 | Soft cheese |
| UK | 1987–89 | >350 | Pâté |
| USA | 1989 | 2[b] | Shrimps[a] |
| Australia | 1990 | 9 | Pâté |
| Australia | 1991 | 4 | Smoked mussels |
| New Zealand | 1992 | 4 | Smoked mussels |
| France | 1992 | 279 | Pork tongue in aspic |
| France | 1993 | 33 | Pork rillettes |
| Italy | 1993 | 2[c] | Rice salad[a] |
| USA | 1994 | 3[d] | Chocolate milk |
| France | 1995 | 17 | Soft cheese |
| Australia | 1996 | 5 | Chicken sandwiches |

[a]Epidemiologic association only, without isolation of epidemic strain from implicated food.
[b]Included 10 other cases with diarrhea and/or fever [13].
[c]Included 18 cases with diarrhea and/or fever [14].
[d]Included also 45 individuals with diarrhea and/or fever [15].
For futher details see McLauchlin [1].

**Table 2** Sporadic cases of food-borne human listeriosis

| Country | Year | Implicated food |
|---|---|---|
| UK | 1986 | Soft cheese |
| USA | 1987 | Raw milk |
| UK | 1988 | Soft cheese |
| UK | 1988 | Cooked chicken |
| UK | 1988 | Rennet |
| USA | 1988 | Turkey frankfurters |
| Canada | 1989 | Alfalfa tablets |
| USA | 1989 | Sausage |
| Finland | 1989 | Salted mushrooms |
| Italy | 1989 | Sausage |
| Italy | 1989 | Fish |
| Denmark | 1989 | Smoked cod roe |
| Canada | 1989 | Soft cheese |
| Belgium | 1989 | Fresh cream and ice cream |

For further details see McLauchlin [1].

been highly processed, consumed without further cooking, have extended shelf lives (often at refrigeration temperatures) and are able to support the growth of *L. monocytogenes* [1]. For further details concerning the properties of *L. monocytogenes* which favor transmission through foods, see comments on Questions 5 and 6. One food (alfalfa tablets), however, which was associated with a single sporadic case of listeriosis in Canada [23], was quite different in that it was a dry product in which *L. monocytogenes* would not be able to grow. However, one of the ingredients (alfalfa) did show similar properties to that described above, in that prior to drying and encapsulation it had been stored wet, when deterioration and presumably growth of *L. monocytogenes* had occurred.

Changes in eating habits and the ways in which foods are produced have led to a growth in the sale of foods which are highly processed, have an extended shelf life, and may be consumed without further cooking. It is just such foods which are more likely to be vehicles for the transmission of this infection. Although listeriosis has recently declined in both the USA and the UK, there is a need for continued vigilance and surveillance.

### Question 5

*L. monocytogenes* is not a spore-producing bacterium and does not have unusual characteristics which allow survival in conditions commonly used in food processing. It will not survive pasteurization or microwave cooking, if properly carried out. It can, however, survive other commonly used food processes, such as freezing, cold smoking and vacuum packaging [24].

### Question 6

*L. monocytogenes* does have some more unusual properties of being able to grow in some of the conditions commonly used to preserve food. These include the ability to multiply over a very wide temperature range (−0.5–44 °C) and in 10% sodium chloride and 200 ppm sodium nitrite (the maximum level permitted in cooked meats). It is somewhat pH restricted, in that growth only occurs within the range pH 5–9.6 [24]. The ability to colonize and survive in specific sites within food production environments for long periods of time makes *L. monocytogenes* a particular problem as a contaminant of foods during processing (see comments on Question 8).

### Question 7

The incubation period between consumption of contaminated foods and onset of clinical listeriosis is extremely variable, and ranges from 1 day [8] to more than 90 days [12]. In the 1985 Californian outbreak, which predominantly involved pregnancy-associated cases [12], the median incubation period was 35 days. It is not known whether the differences in incubation period after oral ingestion are dose or strain dependent, or perhaps reflect unknown differences in host susceptibility. Although foods were recovered from the patient's refrigerator which were found to be contaminated with the implicated strains in incidents 3 and 4, the long incubation periods shown by some patients contribute

to the relatively rare identification of specific foods as vehicles of infection because of the unavailability for examination after these extended periods. However, since case-control studies may not always be very successful when investigating listeriosis (see later comments in this section), clinicians should be aware of these properties and wherever possible arrange for examination of foods collected from listeriosis patients.

The duration of listeriosis outbreaks has varied from a number of months to > 5 years. Although this may in part be due to the long incubation periods shown by some of the patients, it may also reflect the ability of *L. monocytogenes* to colonize specific sites within food production environments; see comments on Question 8.

The lengthy incubation period means that cases of listeriosis may occur even after an implicated food has been withdrawn from sale (as illustrated in incident 4). This was a feature in the Californian outbreak in 1985 [12], although following the withdrawal of contaminated pâté in the UK in 1989 there was a dramatic decline in the numbers of new cases [11].

Food-borne listeriosis can occur in large or small outbreaks (incident 4, Table 1) or as sporadic cases (incident 3, Table 2). The predominant form of the disease, however, is probably as single sporadic and unrelated cases [7]. When occurring as outbreaks, these can involve different patient groups, i.e. predominantly pregnancy associated, predominantly non-pregnant or a mixture of the two. The reasons for this are not clear, but may reflect the eating habits of different sections of the population. Both the differences between sporadic cases or outbreaks and the composition of cases within outbreaks may, however, be linked to the type, production size and shelf life of the food vehicle, as well as as-yet uncharacterized interstrain differences in the virulence of *L. monocytogenes*.

Human listeriosis presents particular difficulties for investigation of a food-borne infectious disease. Difficulties involving the unusually long incubation periods and unavailability of food or food remnants from the patients have already been mentioned (see comments earlier in this section). This characteristic, together with the ability of *L. monocytogenes* to colonize sites within food production environments for long periods of time, and with the now common national or international distribution of foods, means that cases related by a common food source may be extremely widely separated both temporally and geographically. Listeriosis also presents difficulties for investigation because it is a rare disease (see comments on Question 1), and hence surveillance systems have to be rigorously applied to detect unusual changes in the incidence in both small and large populations. It has been commented elsewhere [25] that the recognition of the 1985 listeriosis outbreak of 142 cases in the Los Angeles area was greatly facilitated because the majority of the cases occurred in a single hospital. Had the outbreak been distributed between many different hospitals in California, many more cases might have resulted before the outbreak was recognized. Evidence for subclinical infection is mentioned in the comments on Question 1, and data from both sporadic cases [26] and outbreaks of listeriosis [25] have shown that despite exposure of considerable numbers of individuals to what is clearly likely to constitute an infective dose, the attack rate for serious disease is very low (as illustrated by incident 3). The widespread distribution of the bacterium presents further difficulties, since outbreak investigation may require the resources to examine very large numbers of foods and subtyping of similarly large numbers of *L. monocytogenes*. This approach was essential in the elucidation of the food vehicle (pork tongue in aspic) of the listeriosis outbreak in France in 1992 involving 279 cases, where >15 000 cultures of *L. monocytogenes* were subtyped [27]. The implications of the widespread distribution of *L. monocytogenes* are further discussed in the comments on Question 8.

The wide range of potential food vehicles (Tables 1 and 2), and the difficulties in investigating this disease (outlined above), mean that case-control studies have been problematic and have not always been initially very successful in identifying foods associated with transmission of this disease (as illustrated in incident 4).

There is now a range of techniques available to subtype *L. monocytogenes* and epidemiologic evidence has shown that certain *L. monocytogenes* types are more frequently associated with sporadic human disease and are reported more frequently with large food-borne outbreaks of listeriosis: hence it is likely that there are interstrain differences in the potential to cause disease within this bacterial species. However, a diverse range of strains of *L. monocytogenes* is involved with sporadic human cases, which probably represent the predominant form of the disease, and not all of the large outbreaks have been caused by a restricted group of *L. monocytogenes* types. Hence a wide range of strains has the potential to cause serious disease. In the interests of public safety and for public health purposes, all *L. monocytogenes* types, including those recovered from food, should be regarded as potentially pathogenic [28].

### Question 8

*L. monocytogenes* is widespread in the environment, and hence it is important that subtyping or fingerprinting methods on isolates are applied when investigating incidents of listeriosis. These methods are generally only available through national reference laboratories

**Table 3** Recommendations to at-risk groups for prevention of food-borne listeriosis

| USA | UK |
|---|---|
| **Advice to the general public** | |
| Cook thoroughly raw food from animal sources such as beef, pork or poulty | Keep foods for as short a time as possible, follow the storage instructions carefully and observe the 'best by' and 'eat by' dates on the label |
| Wash raw vegetables thoroughly before eating | Do not eat undercooked poultry or meat products. Make sure you reheat cooked–chilled meals thoroughly and according to the instructions on the label. Wash salads, fruit and vegetables that will be eaten raw |
| Keep uncooked meats separate from vegetables and from cooked foods and ready-to-eat foods | Make sure that your refrigerator is working properly and keeping the food stored in it really cold |
| Avoid raw (unpasteurized) milk or foods made from raw milk | Store cooked foods in the refrigerator away from raw foods and cheeses |
| Wash hands, knives, and cutting boards after handling uncooked foods | When reheating food, make sure that it is heated until piping hot all the way through and do not reheat more than once |
| | When using a microwave oven to cook or reheat food, observe the standing times recommended by the oven manufacturer to ensure that the food attains an even temperature before it is eaten |
| | Throw away left-over reheated food. Cooked food which is not to be eaten straight away should be cooled as rapidly as possible and then stored in the refrigerator |
| **Advice to 'at-risk' groups** | |
| Cook until steaming hot left-over foods or ready-to-eat foods such as hot dogs, before eating | Pregnant women and anyone with low resistance to infection should not eat soft ripened cheeses of the brie, camembert or blue-veined types. Nor should they eat pâté. Any bought cooked–chilled meals or ready-to-eat poultry should be reheated until piping hot. Do not eat them cold |
| Avoid soft cheeses such as feta, brie, camembert, blue-veined and Mexican-style cheese. (Hard cheeses, processed cheeses, cream cheese, cottage cheese or yogurt need not be avoided) | |
| Raw vegetables should be thoroughly washed before eating | |
| Although the risk of listeriosis associated with foods from deli counters is relatively low, pregnant women and immunosuppressed persons may choose to avoid these foods or thoroughly reheat cold cuts before eating | |

For further details see references [7, 32–37].

because of their specialist nature and the considerable investment in personnel and resources necessary.

*L. monocytogenes* was isolated from multiple foods taken from the refrigerator of a sporadic case of listeriosis in the USA in 1988 [29]. The implicated strain, however, was only recovered from unopened turkey frankfurters taken from his local store, together with a conveyor belt in the food production factory [30].

Incident 3 and Question 8 highlight the possibilities of cross-contamination between several food items in a domestic refrigerator, contamination of foods from the patient, and cross-contamination between foods, via hand contact or by implements at the retailer. Beumer et al [31] reported that *L. monocytogenes* was found in over 25% of dishcloths, drains and washing-up brushes taken from >200 domestic kitchens in the absence of infection. Hence there may be numerous opportunities for cross-contamination in domestic and retail environments. The application of subtyping methods can be useful in indicating possible relationships between isolates; however, the recovery of the implicated strain from unopened foods is essential in establishing the likely source of infection.

*L. monocytogenes* survives well in a variety of environments where food is manufactured, particularly those that are moist and contain organic material. Contamination of food from such sites during processing is well recognized, and has been responsible for large outbreaks of listeriosis. Contamination from a sponge rubber conveyer belt (for at least 4 months) to turkey

frankfurters, leading to a single sporadic listeriosis case has already been mentioned [30]. Wooden cheese-making equipment was believed to be responsible for contamination over at least a 5-year period for the outbreak of 122 cases in Switzerland [1].

### Question 9

Dietary advice has been given to vulnerable groups in a number of countries including the USA and UK [7,32–37] (Table 3). Similar advice has been given out in France [38], Australia and New Zealand.

Hard cheese, because of the low pH and water content, will not support the growth of *L. monocytogenes* and has not been associated with listeriosis. Similarly, cottage cheese has a low pH and relatively short shelf life. Hence advice in the USA and UK has only been to risk groups to avoid consumption of soft cheese (in the UK only soft ripened cheese).

Outbreaks of listeriosis have been associated with soft cheese produced from both purportedly pasteurized/heat-treated [1,12] and unpasteurized milk [39]. Hence it is reasonable for at-risk groups to avoid consumption of both types of soft cheese.

Ready-to-eat cooked poultry has also presented problems with respect to contamination by *L. monocytogenes*, and hence it is prudent for at-risk individuals to reheat these types of food until piping hot before consumption.

Answers to the multiple choice questions

**Q1**: a. False; b. True; c. False; d. False; e. True
**Q2**: a. True; b. True; c. True; d. False; e. True
**Q3**: a. False; b. True; c. True; d. False; e. True
**Q4**: a. True; b. True; c. True; d. True; e. False
**Q5**: a. True; b. True; c. False; d. False; e. False
**Q6**: a. True; b. True; c. False; d. True; e. True
**Q7**: a. True; b. True; c. False; d. False; e. False
**Q8**: a. False; b. False; c. False; d. True; e. False
**Q9**: a. False; b. False; c. True; d. True; e. True

### Further reading

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