Foodborne disease outbreaks: Guidelines for investigation and control

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Foreword

Acute diarrhoeal illness is very common worldwide and estimated to account for 1.8 million childhood deaths annually, predominantly in developing countries (World Health Organization, 2005). The burden of diarrhoeal illness is substantial in developed countries as well (Scallan et al., 2005). Estimates of the burden of foodborne diseases are complicated by a number of factors: different definitions of acute diarrhoeal illness are used in various studies, most diarrhoeal illness is not reported to public health authorities, and few illnesses can be definitively linked to food. While not all gastroenteritis is foodborne, and not all foodborne diseases cause gastroenteritis, food does represent an important vehicle for pathogens of substantial public health significance. A number of studies are underway that aim to provide a better understanding of the global public health burden of gastroenteritis and foodborne diseases (Flint et al., 2005).

There are many reasons for foodborne disease remaining a global public health challenge. As some diseases are controlled, others emerge as new threats. The proportions of the population who are elderly, immunosuppressed or otherwise disproportionately susceptible to severe outcomes from foodborne diseases are growing in many countries. Globalization of the food supply has led to the rapid and widespread international distribution of foods. Pathogens can be inadvertently introduced into new geographical areas, such as with the discharge of ballast water contaminated with *Vibrio cholerae* in the Americas in 1991. Travellers, refugees and immigrants may be exposed to unfamiliar foodborne hazards in new environments. Changes in microorganisms lead to the constant evolution of new pathogens, development of antibiotic resistance, and changes in virulence of known pathogens. In many countries, as people increasingly consume food prepared outside the home, growing numbers are potentially exposed to the risks of poor hygiene in commercial foodservice settings.

All of these emerging challenges require that public health workers continue to adapt to a changing environment with improved methods to combat these threats.

Too often, outbreaks of foodborne disease go unrecognized or unreported or are not investigated. Many resources are available for the investigation of foodborne disease outbreaks, but few are directed at developing countries. These guidelines are intended to serve as a general introduction to the identification and investigation of foodborne disease outbreaks in a variety of settings. Numerous other resources are available for additional, more detailed, information on surveillance, epidemiology, statistical analyses and the medical aspects of foodborne diseases. It is important to remember that no general guidelines will fit a specific situation perfectly, and the local environment will always make it necessary to modify investigation techniques to account for the unique characteristics of every outbreak. It is also important to note that addressing the risk of foodborne disease goes beyond the public health worker. Ultimately it requires the implementation of a well functioning and integrated food control system. This necessitates collaboration among all the components of a food control system, including food law and regulations, food control management, inspection services, epidemiological and food monitoring (laboratory services) and education of and communication with the consumer.

Introduction

The investigation and control of foodborne disease outbreaks are multi-disciplinary tasks requiring skills in the areas of clinical medicine, epidemiology, laboratory medicine, food microbiology and chemistry, food safety and food control, and risk communication and management. Many outbreaks of foodborne disease are poorly investigated, if at all, because these skills are unavailable or because a field investigator is expected to master them all single-handedly without having been trained.

These guidelines have been written for public health practitioners, food and health inspectors, district and national medical officers, laboratory personnel and others who may undertake or participate in the investigation and control of foodborne disease outbreaks.

While the book focuses on practical aspects of outbreak investigation and control, it also provides generic guidance that can be adapted to individual countries and local requirements. At the field level it will be valuable in initial epidemiological, environmental and laboratory investigations, in implementation of appropriate control measures, and in alerting investigators to the need to seek assistance for more complex situations. At national and regional levels, the guidelines will assist decision-makers in identifying and coordinating resources and in creating an environment appropriate for the successful management of foodborne disease outbreaks.

The guidelines are divided into six main sections. Section 1 is a practical guide, outlining the steps of outbreak investigation and control. More detailed information about these steps and related activities is provided in the subsequent sections, which deal with planning and preparation, detection of foodborne disease outbreaks, investigations, control measures, and clinical features of foodborne disease pathogens.

The annexes contain background technical information, sample forms for data collection and analysis, questionnaires and other tools that may be useful during an investigation.

Despite a clear focus on foodborne diseases, much of the material in these guidelines is also applicable to the investigation of outbreaks of other communicable and noncommunicable diseases.

Section 1

Practical guide

This practical guide summarizes the steps that may be required during an outbreak investigation and which are dealt with in more detail in the subsequent sections. The purpose of this summary is to give a brief overview of the investigatory steps required and may serve as checklist. It is recognized that not all settings where outbreaks occur will have the necessary infrastructure to complete all steps described but efforts should be made to do so. The steps are presented in approximately chronological order but different situations will demand changes from this order. In practice, some steps will be carried out simultaneously, others will be required throughout the whole process while some may not be required at all.

❖ Preliminary assessment of the situation

- Consider whether or not the cases have the same illness (or different manifestations of the same disease).
- Determine whether there is a real outbreak by assessing the normal background activity of disease.
- Conduct in-depth interviews with initial cases.
- Collect clinical specimens from cases.
- Identify factors common to all or most cases.
- Conduct site investigation at implicated premises.
- Collect food specimens when appropriate.
- Formulate preliminary hypotheses.
- Initiate control measures as appropriate.
- Decide whether to convene a formal outbreak control team.
- Make a decision about the need for further investigation.

❖ Communication

- Consider the best routes of communication with colleagues, patients and the public.
- Ensure accuracy and timeliness. Include all those who need to know.
- Use mass media constructively.

❖ Descriptive epidemiology

- Establish case definitions for confirmed and probable cases.
- Identify as many cases as possible.
- Collect data from affected persons on a standardized questionnaire.
- Categorize cases by time, place and person.
- Determine who is at risk of becoming ill.
- Calculate attack rates.

- Food and environmental investigations
  - Inspect structural and operational hygiene in implicated food premises.
  - Assess procedures undergone by a suspect food.
  - Take appropriate food and environmental samples.
- Analysis and interpretation
  - Review all existing data.
  - Develop explanatory hypotheses.
  - Carry out analytical studies to test hypotheses as required.
  - Collect further clinical and food specimens for laboratory tests as required.
- Control measures
  - Control the source: animal, human or environmental.
  - Control transmission.
  - Protect persons at risk.
  - Declare the outbreak over when the number of new cases has returned to background levels.
  - Consider strengthening or instituting continuous surveillance.
- Further studies
  - Conduct further analytical (case-control, cohort) studies.
  - Conduct further food and microbiological investigations.
  - Make recommendations for the prevention of recurrences of similar outbreaks.
  - Determine remaining questions or areas for future research identified through this investigation.
  - Share information with public health colleagues in order to promote awareness and possibly prevent similar outbreaks in the future.

Section 2
Planning and preparation

2.1 General

Responsibilities for the investigation and management of outbreaks will vary between countries and according to a number of factors including the nature and size of the outbreak, its importance with regard to the health of the public, and its economic impact.

Successful investigation and control of foodborne disease outbreaks depend on working fast and responsibly. When an outbreak occurs, all individuals involved in the investigation must clearly understand the course of action; time should not be lost in discussing policy matters that should have been resolved in advance.

Typical steps in the investigation of a foodborne disease outbreak include:

- establishing the existence of an outbreak;
- verifying the diagnosis;
- defining and counting cases;
- determining the population at risk;
- describing the epidemiology;
- developing hypotheses;
- evaluating the hypotheses;
- undertaking additional epidemiological, environmental and laboratory studies, as necessary;
- implementing control and prevention measures;
- communicating findings.

The responsible authorities – in consultation with all agencies that may be involved in the investigations – should develop outbreak investigation and control plans to address:

- arrangements for consulting and informing authorities at local, regional, national and international levels;
- the exact roles and responsibilities of organizations and individuals involved;
- the resources/facilities available to investigate outbreaks;
- the composition and duties of an outbreak control team, and when it should be convened.

2.2 Outbreak control team

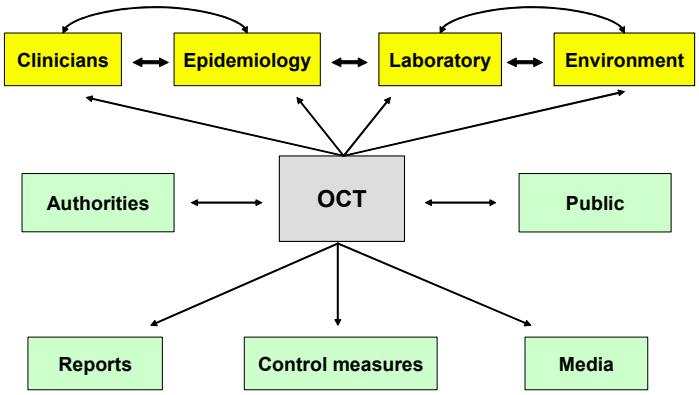
The criteria for convening a multidisciplinary outbreak control team (OCT) will vary according to the seriousness of the illness, its geographical spread, local circumstances and the available resources. An OCT may be considered when:

- the outbreak poses an immediate health hazard to the local population;
- there are many cases;
- the disease is important in terms of its severity or its propensity to spread;
- cases have occurred over a widespread area without obvious point source;
- cases have occurred in high-risk establishments (schools, day-care centres, hospitals, food premises, etc.).

The role of the OCT is to coordinate all the activities involved in the investigation and control of an outbreak (see Figure 1). This may involve:

- deciding whether there is really an outbreak;
- deciding on the type of investigations to be conducted;
- case-finding and interviews;
- planning the appropriate clinical and environmental sampling;
- ensuring that all collaborators use a complementary methodology;
- conducting an environmental investigation of suspected food premises;
- agreeing and implementing control measures to prevent the further spread by means of exclusions, withdrawal of foods, closure of premises, etc;
- working in concert with local medical providers to make recommendations on treatment and/or prophylaxis;
- organizing ongoing communications among OCT members about the outbreak;
- making arrangements for liaison with the media;
- producing reports, including lessons learned, for health authorities and other interested parties;
- requesting external assistance, e.g. secondment of a national investigation team.

Figure 1. **Coordinating role of the OCT in an outbreak investigation**



Usually, the health authority in the area that first identified and reported the outbreak initiates the establishment of an OCT. In an outbreak that crosses administrative boundaries, the team should determine, at its first meeting, who is represented on the team and should identify the individual who will act as chairperson. A typical draft agenda for a first outbreak control meeting is provided in Annex 2. Once established, the OCT should be in charge of all investigation and control activities.

Membership will vary according to circumstances but the OCT normally includes:

- a public health practitioner or epidemiologist answerable to the Public Health Officer in charge;
- a food safety control officer;
- a specialist in laboratory medicine (microbiologist, toxicologist, or other as appropriate);
- secretarial and logistic support.

In addition, one or more of the following may be needed according to the presumed nature of the outbreak:

- food scientist (chemist, food microbiologist, technologist);
- clinician;
- veterinarian;
- toxicologist;
- virologist;
- other technical experts;
- press officer;
- representatives of local authorities (community leaders, etc.);
- hospital director, members of a hospital infection control group.

2.3 Record keeping

From the beginning of an outbreak it is essential that all information received and all decisions taken by the OCT and others be recorded reliably and with the appropriate level of confidentiality. This means that:

- individual members of the OCT keep records of all activities performed during investigation of the outbreak;
- minutes are kept and distributed;
- action notes are agreed upon and distributed immediately after OCT meetings;
- notes and other records collected during all environmental, epidemiological and laboratory investigations are maintained;
- copies are kept of all communications with the public, including letters, fact sheets, public notices and media reports.

2.4 Communication

Effective communication is a crucial aspect of successful outbreak management. Throughout the course of an outbreak, it is important to share relevant information with:

- authorities and other professional groups;
- local health care providers (as appropriate);
- the media;
- the people directly affected;
- the general public.

Authorities and other professional groups

The most relevant authorities and professional groups include local health authorities, food, water, agricultural and veterinary authorities, and educational organizations. The objectives of keeping these groups fully informed are to ensure accurate case-finding and to facilitate the implementation of control measures.

Other professional groups that have no direct part in the investigation may still be affected by the outbreak (e.g. local hospitals and general practitioners) and good communication with them should also be maintained. Colleagues in other administrative areas or from other districts/countries may also benefit from information about the outbreak and may be able to provide additional insight and knowledge of similar occurrences.

Whenever possible, established communication channels and regular meetings should be used as the most efficient means of keeping authorities and other professional groups fully informed.

Public

Public concern can become an important feature of an outbreak investigation. To achieve a proper balance between the scientific requirements of the investigation and responsiveness to public concern, public health authorities must deal actively with the need for public information. The outbreak control plan should therefore include an information policy plan, outlining how full information can be made regularly available to the public.

The purpose of public information in the event of an outbreak of foodborne disease is to provide:

- accurate information about the outbreak;
- information on implicated food products and how they should be handled;
- advice on personal hygiene measures to reduce the risk of person-to-person spread.

In some outbreaks, communication with the public will also help in identifying additional cases. Methods of communication will depend on local circumstances but may include regular press releases via newspapers, radio or television, public meetings, leaflets delivered to households and public gathering places, face-to-face advice in clinics, and messages displayed on notice boards and disseminated to consumer groups. Since it is critical to reach all segments of the population at risk, it may be necessary to issue communications in several languages.

The information provided should always be objective and factual: unconfirmed information should not normally be released. If a public health warning is required in the absence of confirmed results, the public should be told why this has been done and advised that the information they have been given may have to be changed in the light of new knowledge.

If a major outbreak is in process or an outbreak has attracted intensive publicity, it may be necessary to establish a telephone helpline for the public. It is important that such helplines are staffed by individuals who have been trained in gathering additional information (e.g. details about cases) from callers.

Media

As the major interface between the general public and the health authorities, the media play an important role in outbreak investigation and control. Developing good relationships with the media before an outbreak occurs may be very helpful in facilitating crisis-related communication. Accurate and comprehensive reporting of foodborne disease outbreaks by the media can:

- facilitate case-finding through enhanced reporting of cases by the public and medical practitioners;
- inform the public about avoidance of risk factors for illness and about appropriate preventive measures;
- maintain public and political support for disease investigation and control;
- minimize the appearance of conflicting information from different authorities (which may undermine their credibility).

Thus the information policy plan should also contain a clear media strategy that adheres to the following principles:

- Information provided must be timely, accurate and consistent.
- All official information passed to the media should be cleared with the OCT.
- The OCT should identify a media spokesperson, who may be a disease expert, and a media relations officer, who may be a media expert. The media relations officer should be someone who can devote appropriate attention to dealing with media issues without detrimentally affecting the investigation: his or her responsibilities include protecting those actively involved in the investigation from being distracted from their critical work.
- The media relations officer should communicate regularly with their media counterparts in other agencies. This may require daily or even more frequent contact.
- The media relations officer should establish a clear policy on the roles that investigators will take in communicating publicly about the outbreak.
- Fact sheets on common foodborne diseases should be prepared and kept available for distribution to the media and public.
- If there are media demands for interviews with key people in charge of the investigation, it may be wise to call regular press conferences so that busy investigators are not distracted by responding to multiple media agencies.
- Communication should be maintained with all appropriate media outlets, which may include radio, television, the Internet, newspapers and other publications.

Extensive additional resources on risk communication and interacting with the media and the public during outbreaks or crises are available:

http://www.who.int/infectious-disease-news/IDdocs/whocds200528/whocds200528en.pdf
http://www.who.int/foodsafety/publications/micro/feb1998/en/index.html
http://www.cdc.gov/communication/emergency/leaders.pdf
http://www.cdc.gov/communication/emergency/part_man.pdf

Section 3

Surveillance to detect foodborne disease outbreaks

3.1 Introduction

Public health surveillance involves the systematic collection, analysis and interpretation of the morbidity and mortality data essential to the planning, implementation and evaluation of public health practice, and the timely dissemination of this information for public health action. The primary goal of surveillance for foodborne disease outbreaks should be the prompt identification of any unusual clusters of disease potentially transmitted through food, which might require a public health investigation or response.

3.2 Definitions

Some key terms are defined here to ensure clarity. Additional definitions are provided in Annex 1.

surveillance

The systematic collection, analysis and interpretation of data essential to the planning, implementation and evaluation of public health practice, and the timely dissemination of this information for public health action.

foodborne disease

Any disease of an infectious or toxic nature caused by consumption of food.

foodborne disease outbreak

Various definitions are in use:

a) The observed number of cases of a particular disease exceeds the expected number.
b) The occurrence of two or more cases of a similar foodborne disease resulting from the ingestion of a common food.

sporadic case

A case that cannot be linked epidemiologically to other cases of the same illness.

cluster/outbreak/epidemic

Epidemiologists may use "cluster", "outbreak", and "epidemic" interchangeably. Typically, "cluster" is used to describe a group of cases linked by time or place, but with no identified common food or other source. In the context of foodborne disease, "outbreak" refers to two or more cases resulting from ingestion of a common food. The term "epidemic" is often reserved for crises or situations involving larger numbers of people over a wide geographical area.

3.3 Data sources

Detecting outbreaks requires efficient mechanisms to capture and respond to a variety of data sources. In most countries, the main data sources for detecting foodborne disease outbreaks are:

- the public;
- the media;
- reports of clinical cases from health care providers;

- surveillance data (laboratory reports, disease notifications);
- food service facilities.

The public

Members of the public are often the first to provide information about foodborne disease outbreaks, particularly when they occur in well-defined populations or at local level. Public health authorities should have guidelines on how to deal with and respond to such information: outbreak reports received by the public should never be dismissed without consideration.

When reports of an outbreak are received, the following information should be gathered:

- the person(s) reporting the outbreak;
- characteristics of the suspected outbreak (clinical information, suspected etiologies, suspected foods);
- persons directly affected by the outbreak (epidemiological information).

The challenge in dealing with these reports is to follow up on all relevant information without wasting resources in investigating a large number of non-outbreaks. The initial response can be facilitated if one individual is designated as the focal point for the event. This person should receive all additional information that is obtained from other sources, maintain contact with the person(s) reporting the outbreak, contact additional cases as appropriate and ensure that staff members of different departments (e.g. epidemiology, food inspection) do not contact cases independently or without each other's knowledge. Standardized forms should be used to collect information about such events (see Annex 3).

The media

The media are usually very interested in foodborne outbreak reports and may devote considerable resources to detecting and reporting them. A local journalist may be the first to report an outbreak of which the community has known for some time. Public health authorities may first learn of a possible outbreak through media reports. Journalists may detect outbreaks that have been hidden from the health authorities because of their sensitive nature or because of legal consequences. Internet editions of regional or national newspapers and web-based discussion groups may provide a timely and accurate picture of ongoing outbreaks throughout the country or the region. However, media reports will inevitably be inaccurate at times and should always be followed up and verified. This will also help public health authorities in controlling public anxiety caused by outbreak rumours in the media.

Reports of clinical cases from health care providers

Health care providers may report clinical cases or unusual health events directly to the public health authorities. These reports may come from such sources as a doctor working in the emergency department of a large hospital, a general practitioner, a public health nurse with knowledge of the community, or the medical department of a large company. Information sharing of this kind is common and often enables faster and more efficient detection of foodborne outbreaks than legally mandated reporting channels (e.g. statutory disease notification).

Information received by astute or concerned health care providers should always be followed up unless there are very good reasons not to do so. The rationale for not acting on such

information should always be explained to the health care provider in order to maintain credibility.

Surveillance data

Surveillance activities are conducted at local, regional and national levels through a variety of systems, organizations and pathways (Borgdorff & Motarjemi, 1997). Among the many surveillance methods for foodborne disease, laboratory reporting and disease notification may contribute importantly to outbreak detection. Other types of surveillance that may be of value in detecting foodborne disease outbreaks are hospital-based surveillance, sentinel site surveillance, and reports of death registration. Generally, however, these are not primary data sources for detecting outbreaks and their usefulness will depend on the inherent quality of the systems and the circumstances in which they are employed.

Laboratory-based surveillance

Laboratories receive and test clinical specimens from patients with suspected foodborne disease (e.g. faecal samples from patients with diarrhoea). Often, positive microbiological findings from these specimens are also sent by laboratories to the relevant public health authorities. In addition, some laboratories send patient material or isolates to a central reference laboratory for confirmation, typing or determination of resistance patterns. The collation of these reports and their systematic and timely analysis can provide useful information for detecting outbreaks, particularly when cases are geographically scattered or clinical symptoms are nonspecific.

Detecting outbreaks is facilitated by early typing of isolates of foodborne pathogens. Routine typing may detect a surge of a particular subtype and link apparently unrelated infections. Interviewing affected individuals about their food consumption may then identify contaminated foods that may have not been recognized otherwise.

Other factors that determine the usefulness of laboratory reporting in the detection of outbreaks include the proportion of cases from whom specimens are taken for laboratory examination, how often laboratories send their reports, how complete these reports are, how many laboratories participate in the reporting and whether the tests employed allow direct comparison of results.

Traditional laboratory-based surveillance is “passive”, i.e. dependent on laboratories to report cases to public health authorities. In some situations, such as when a potential problem is suspected, “active” surveillance may be warranted for a period of time: laboratories may then be actively and regularly contacted by food safety or public health authorities to enquire about recent positive tests indicative of potential foodborne diseases.

Disease notification

In most countries medical practitioners are required to notify public health authorities of all cases of certain specified diseases. Notification of cases is usually based on clinical judgement and may not require confirmation by other diagnostic means.

It is widely recognized that most statutory disease notification systems suffer from substantial under-reporting of diagnosed cases and long delays in notification. Moreover, many people with foodborne disease do not seek medical advice or will not be diagnosed as suffering from a foodborne disease because of the nonspecific nature of their symptoms. Notification of

laboratory-confirmed illnesses is thus substantially more likely. Medical practitioners who become aware of unusual clusters of diarrhoeal disease or other syndromes that may indicate foodborne disease should also be urged to report these promptly to public health authorities.

Other sources

Other sources may alert public health authorities to the occurrence of outbreaks. Often, some creativity is needed to detect outbreaks as many of these sources were created for other purposes. Examples include reports of increased absenteeism from the workplace, schools or child-care facilities, pharmacy reports of increased drug sales, e.g. of anti-diarrhoeal medications, and consumer complaints to health departments or food regulators. Outbreaks may be anticipated after an increased risk of population exposure has been detected, for example contaminated drinking-water or contamination of a commercially available food product.

3.4 Interpreting data sources

Outbreaks are often detected when sick people share an easily recognized potential source of infection (such as in schools, hospitals, nursing facilities, correctional facilities, etc.). When such events are limited to small, well-defined populations, the number of affected persons can usually be quickly established. The main emphasis of an investigation is on verifying that an outbreak has indeed occurred and controlling its spread.

Detecting community outbreaks from surveillance data can be more difficult. Above all, it requires the timely collection, analysis and interpretation of the data to indicate whether the number of observed cases exceed expected numbers. This requires knowledge of the background rates or traditional disease patterns in a particular population at a particular time and in a particular place, including typical seasonal changes in disease occurrence. A small local outbreak may be missed by regional or national surveillance; conversely, a widespread national outbreak may not be detectable by regional or local surveillance. A sudden increase in disease occurrence may clearly point towards an outbreak (see Figure 2) while small changes in baseline levels can be difficult to interpret (see Figure 3). Even if the overall number of cases is not unusually high, a steep increase confined to a subgroup in the community or to a particular subtype of pathogen may be significant (see Figure 4).

Local health authorities will usually know if more disease is occurring than would normally be expected. Where there is doubt, seeking additional information from other sources (e.g. absenteeism reports, telephone survey with general practitioners, checking outpatient departments of major hospitals, etc.) may help in the interpretation of surveillance data.

There are causes other than outbreaks that may lead to an increased number of observed or reported cases. These are referred to as “pseudo-outbreaks”; examples include changes in local reporting procedures or in the case definition for reporting a specified disease, increased interest as a result of local or national awareness, changes in diagnostic procedures, or heightened concern among a specific population (e.g. “psychogenic” outbreaks). In areas subject to sudden changes in population size – such as resort areas, college towns, farming areas with migrant workers – changes in the numerator (number of reported cases) may only reflect changes in the denominator (population size).

Figure 2. **Weekly number of reported cases indicating an outbreak in week 34**

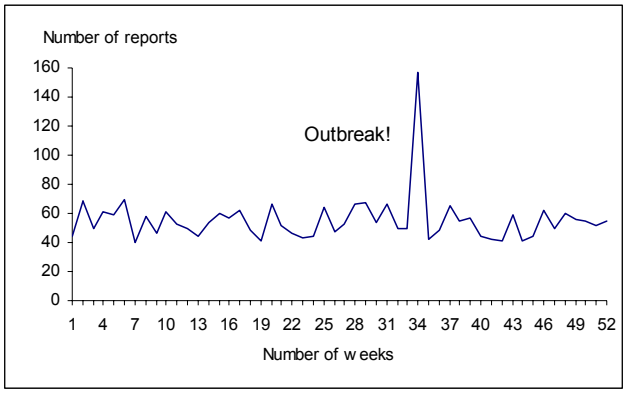


Figure 3. **Weekly number of reported cases where it is not clear whether or not the observed number of cases in week 34 has exceeded expected numbers**

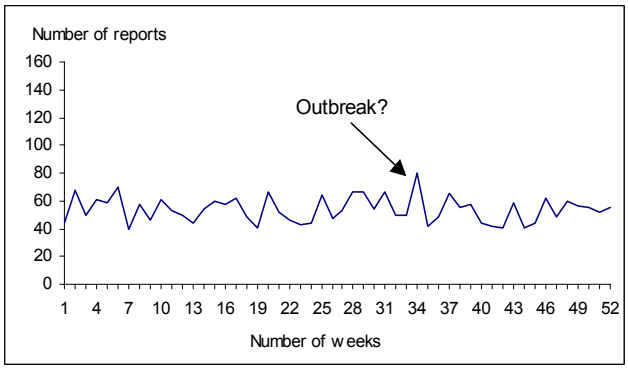
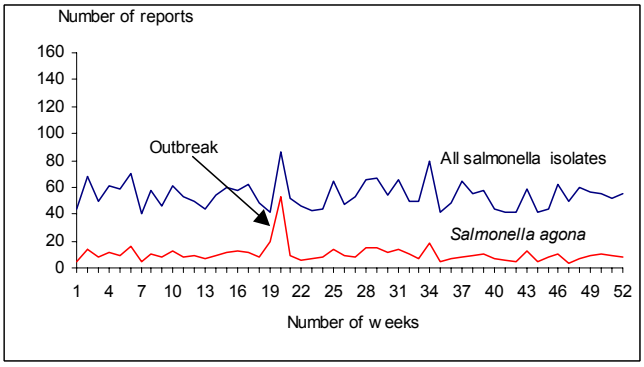


Figure 4. **Weekly number of *Salmonella* isolates: the outbreak of *S. agona* may have been missed without data on specific serotypes**



Section 4

Investigation of foodborne disease outbreaks

4.1 General

Foodborne disease outbreaks are investigated to prevent both ongoing transmission of disease and similar outbreaks in the future. Specific objectives include:

- control of ongoing outbreaks;
- detection and removal of implicated foods;
- identification of specific risk factors related to the host, the agent and the environment;
- identification of factors that contributed to the contamination, growth, survival and dissemination of the suspected agent;
- prevention of future outbreaks and strengthening of food safety policies;
- acquisition of epidemiological data for risk assessment of foodborne pathogens;
- stimulation of research that will help in the prevention of similar outbreaks.

The scale of an outbreak may range from a local outbreak of a small number of linked cases with mild disease to a nationwide or international outbreak of severe disease involving the mobilization of public health resources from all levels. Irrespective of the scale, a full investigation of a foodborne disease outbreak will normally include:

- epidemiological investigations;
- environmental and food investigations;
- laboratory investigations.

4.2 Epidemiological investigations

Preliminary assessment of the situation

Investigation of a potential outbreak starts with the assessment of all available information; this should confirm or refute the existence of an outbreak and allow a working case definition to be established. This assessment must be initiated quickly and completed promptly in order to prevent further illnesses, and should include:

- checking the validity of the information;
- obtaining reports of applicable laboratory tests that have been performed;
- identifying cases and obtaining information about them;
- ensuring the collection of appropriate clinical specimens and food samples.

Once the validity of the reporting source has been verified, a group of the initial cases – perhaps 5 to 10 persons – should be identified and interviewed as soon as possible. This critical step helps to provide a clearer picture of the clinical and epidemiological features of the affected group. Delays in conducting these interviews can lead to recall bias or to people's inability to remember what they ate or what they did. The interviews should be open and comprehensive and include questions about:

- demographic details, including occupation;
- clinical details, including date of onset, duration and severity of symptoms;
- visits to health care providers or hospitals;
- laboratory test results;
- contact with other ill persons;
- food consumption history;

- the respondent's thoughts on what caused their illness;
- whether the respondent knows others with the same or a similar illness;
- potential common exposures among those who have the same or a similar illness;
- date of exposure to suspected foods.

Clinical specimens (e.g. faecal samples, vomitus) from cases should be collected at the time of first contact: many of the pathogens and toxins that cause foodborne disease remain in the intestinal tract for only a short time after the onset of illness. If any of the foods that are suspected or were eaten during the potential incubation period remain available, they should be sampled for laboratory examination. Laboratory confirmation of these initial cases is essential to guide further investigation. If there is any doubt about the source of contamination, it may be reasonable to collect and store many samples, with subsequent testing determined by epidemiological data as they become available. Information on the collection of clinical and food samples can be found in Section 4.4.

If the vehicle of infection is thought to be food, the premises where the suspect food was produced, processed or handled should also be visited. It is important to visit these premises as early as possible – the amount of physical evidence of what may have caused the outbreak will diminish with time. If the food premises are located outside the jurisdictional zone of the local responsible authority, it may be necessary to contact other authorities/agencies. Relevant food and environmental samples should be collected, and it may also be appropriate to collect clinical specimens from food-service workers at this time.

Form preliminary hypotheses and plan further action

With the initial information from case interviews, the laboratory and the environmental inspection, it is often possible to describe the event in simple epidemiological terms and to form preliminary hypotheses about the cause of the outbreak. Apparent "outliers" or unusual cases – for example, the only case who resides in a different town, the oldest case, the youngest case – can often provide useful clues for generating hypotheses. General control and precautionary measures may be implemented at this stage. For example, suspect foods can be removed from sale or from the premises, ill food-handlers should be excluded from work, and the public may be advised to avoid a certain food product or to seek appropriate medical treatment (see Section 5). While obvious control measures must never be delayed at this early stage simply because investigations are still under way, it is important to proceed with caution and to acknowledge that initial hypotheses have yet to be proved. Failure to exercise this caution may result in the wrong food being implicated and the credibility of both investigators and the food producer being damaged.

At the end of this first phase, a decision must be taken on whether to continue with the investigation. When it is obvious that the outbreak is over or that there is no continuing public health risk, the value of further investigation needs to be weighed against local priorities and resources. However, it is often difficult to be certain that an outbreak is indeed over. Generally, specific control measures can be implemented only when the source and the mode of transmission are known – which provides a convincing argument for continuing with the known investigations. Other likely reasons for continuing may include the following:

- The outbreak poses an immediate health hazard to the local population.
- There are many cases.
- The disease is important in terms of its severity or its rapid spread.
- Cases have occurred over a widespread area without an obvious point source.

- Cases have occurred in high-risk establishments (schools, day-care centres, hospitals, housing or long-term care facilities for the elderly, food premises, etc.).
- There is a high level of public concern.
- There are potential legal implications.
- An investigation would generate new knowledge, e.g. in the area of food safety and risk assessment.
- An investigation would provide valuable learning opportunities for investigators.

If, on the other hand, a decision is taken to halt the investigation, the reasons for this decision should be carefully documented and included in the final investigation report.

Descriptive epidemiological investigations

Careful description and characterization of the outbreak is an important first step in any epidemiological investigation. Descriptive epidemiology provides a picture of the outbreak in terms of the three standard epidemiological parameters – time, place and person. This can direct immediate control measures, inform development of more specific hypotheses about the source and mode of transmission, suggest the need for further clinical, food or environmental samples, and guide the development of further studies.

The steps of descriptive epidemiology include:

- establishing a case definition;
- identifying cases and obtaining information from them;
- analysing the data by time, place and person characteristics;
- determining who is at risk of becoming ill;
- developing hypotheses about the exposure/vehicle that caused the disease;
- comparing the hypotheses with the established facts;
- deciding whether analytical studies are needed to test the hypotheses.

Establishing a case definition

A case definition is a set of criteria for determining whether a person should be classified as being affected by the disease under investigation. As such, it is an epidemiological tool for counting cases – it is not used to guide clinical practice. A case definition should be simple and practical and should include the following four components:

- clinical and laboratory criteria to assess whether a person has the illness under investigation; the clinical features should be significant or hallmark signs of the illness;
- a defined period of time during which cases of illness are considered to be associated with the outbreak;
- restriction by "place" – for example, limiting the group to patrons of a particular restaurant, employees of a particular factory or residents of a particular town;
- restriction by "person" characteristics – limiting the group to, for example, persons over one year of age, persons with no recent diarrhoeal disease, etc.

Ideally, a case definition will include all cases (high sensitivity) but exclude any person who does not have the illness (high specificity). A sensitive case definition will detect many cases but may also count as cases individuals who do not have the disease. A more specific case definition is more likely to include only persons who truly have the disease under investigation but also more likely to miss some cases.

There are no rules about how sensitive or specific a case definition should be. In the early stage of an outbreak investigation the aim is to detect as many cases as possible; this requires a sensitive case definition (e.g. a person with three or more loose stools in a 24-hour period). At a later stage, the clinical picture is often clearer and the diagnosis is laboratory-confirmed; this allows the use of a more specific case definition (e.g. laboratory-confirmed *Salmonella* infection), which may then be used to conduct further analytical studies. Criteria included in a case definition cannot be tested as risk factors in subsequent statistical analyses.

Because a single case definition that suits all needs is rare, it is quite common for case definitions to change during an investigation or for different case definitions to be used for different purposes. Many investigators use the following (or similar) case definitions in parallel:

- **Confirmed** cases – have a positive laboratory result (isolation of the causative agent or positive serological test). This case definition has high specificity.
- **Probable** cases – have the typical clinical features of the illness but without laboratory confirmation.
- **Possible** cases – have fewer or atypical clinical features. This case definition has high sensitivity.

Box 1. **Example of case definition used in the investigation of an *Escherichia coli* O157 outbreak**

A case is defined as gastrointestinal illness in any resident of Area A within five days of attending the Area A Fair in June 2003. Cases may be further categorized as:

Confirmed case:	gastrointestinal illness with microbiological confirmation of *E. coli* O157
Probable case:	bloody diarrhoea or haemolytic uraemia syndrome without microbiological confirmation
Possible case:	non-bloody diarrhoea without microbiological confirmation

Identifying cases

The cases that prompt an outbreak investigation often represent only a small fraction of the total number of people affected. To determine the full extent of the problem and the population at risk of illness, an active search for additional cases should be undertaken.

Methods for finding additional cases will vary from outbreak to outbreak. Many foodborne disease outbreaks involve clearly identifiable groups (for example, persons all attending the same wedding party), so that case-finding is relatively straightforward. In other outbreaks, particularly those involving diseases with a long incubation period and/or with mild or asymptomatic illness, case-finding may be quite difficult. Directly contacting physicians, hospitals, laboratories, schools or other populations at risk may help to identify unreported cases.

In some cases, public health officials decide to alert the public directly. For example, in outbreaks caused by a contaminated commercial food product, announcements in the media can alert the public to avoid the implicated product and to see a medical practitioner if they have symptoms typical of the disease in question.

Cases themselves may know other people with the same condition – particularly among household members, work colleagues, classmates, friends or neighbours.

If an outbreak affects a restricted population (e.g. students in a school or factory workers) and if a high proportion of cases are unlikely to be diagnosed, a survey of the entire population can be conducted. Questionnaires may be administered to determine the true incidence of clinical symptoms.

Finally, a review of laboratory surveillance data can help to find people with similar infections, assuming the cause of the outbreak is known. Cases that may be epidemiologically linked to an outbreak can often be identified through a unique subtype or biochemical or molecular feature of the causative organism, which may be particularly helpful in an outbreak caused by a widely distributed food product that crosses jurisdictional or even international boundaries.

Interviewing cases

Once cases are identified, information about them should be obtained in a systematic way by use of a standard questionnaire. This is in contrast to the preliminary phase of the investigation during which the interviews may be more wide-ranging and open-ended to allow for generation of hypotheses.

Questionnaires may be administered by an interviewer (face-to-face or by telephone) or may be self-administered. Sometimes patients themselves will not be interviewed but their parents, spouses or caregivers may provide data; the sources of information should always be recorded on the questionnaire. Self-administered questionnaires may be distributed in person or by mail, e-mail, fax or internet. Annex 4 outlines the advantages and disadvantages of the various methods and provides information on the design of questionnaires.

Regardless of the disease under investigation, the following types of information should be collected about each case:

- **Identifying information** – name, address, contact details (e.g. daytime telephone number, work address) – to allow patients to be contacted with additional questions and to be notified of laboratory results and the outcome of the investigation. Names will be helpful in checking for duplicate records, and addresses may allow mapping of cases. When identifying information is recorded, issues of confidentiality must always be addressed in accordance with prevailing laws and regulations.
- **Demographic information** – age, date of birth, sex, race and ethnicity, occupation, residence, etc. – to provide the "person" characteristics of descriptive epidemiology that help to define the population at risk of becoming ill.
- **Clinical information** – to identify cases, verify that the case definition has been met, define the clinical syndrome or manifestations of disease, and identify potential etiologies:
  - date and time of first signs and symptoms;
  - nature of initial and subsequent signs and symptoms;
  - severity and duration of symptoms;
  - medical visits and hospital admission;
  - treatment;
  - outcome of illness.

- **Risk factor information** – to allow the source and the vehicle of the outbreak to be identified. This type of information will need to be tailored to the specific outbreak and the disease in question. Generally, the questionnaire will address both food-related and personal risk factors.

Food-related risk factors:
- detailed food history (see below);
- sources of domestic food and water supply;
- specific food-handling practices, cooking preferences;
- eating away from home.

Personal risk factors:
- date and time of exposure to an implicated food or event (if known);
- contact with people with similar clinical signs and symptoms;
- information on recent travel (domestic and international);
- recent group gatherings, visitors, social events;
- recent farm visits;
- contact with animals;
- attending or working in a school, child-care facility, medical facility;
- working as a food handler;
- chronic illness, immunosuppression, pregnancy;
- recent changes in medical history, regular medications;
- allergies, recent immunizations.

Depending on the suspected etiology and local patterns of food consumption and availability, enquiries should be conducted about any foods that could be a potential source of contamination in the outbreak. It is important to collect a thorough history of food consumption for the entire suspected incubation period (which is often 3 to 5 days before illness for many common foodborne pathogens). An accurate and thorough food history will often require direct questions about specific foods as well as open-ended questions. Data should also be collected on the number and size of meals eaten, and the source and handling of suspected foods should be noted. Some sample questionnaires are provided in Annex 5.

If the pathogen is known, questions can focus on foods and other risk factors known to be associated with the particular pathogen. For information about the types of foods that are commonly associated with certain pathogens, see Section 6 and Annex 8. Knowledge of the incubation period of the pathogen can point to the most likely period of exposure or identify an unusual event or a suspect meal. If certain foods are known to be associated with the pathogen, specific questions should be asked about them (although enquiries should not be limited to these foods).

If the pathogen is not known but the clinical details suggest a short incubation period, information should be gathered about all meals eaten during the 72 hours before the onset of illness. Most people cannot remember all foods eaten over a 72-hour period: add a calendar, the menu of a suspect meal, or a list of foods to the questionnaire that may help their recall of relevant items.

In protracted outbreaks, when investigating illnesses with incubation periods longer than 72 hours (e.g. hepatitis A, typhoid fever, listeriosis) or when a person does not remember specific foods eaten, questions should be asked about food preferences, i.e. foods usually eaten or routine dietary habits. Information should also be obtained about foods purchased during the incubation period of the disease under suspicion.

Collating data

Once the first questionnaires have been completed, the information they contain should be collated promptly to provide insight into the distribution of clinical symptoms and other factors among cases. The data can be summarized in a line listing, with each column representing a variable of interest and each row representing a case. New cases can be added conveniently to the list and updated as necessary (see Table 1). A line listing can be created directly by copying relevant information from the questionnaires or from a computerized database into which case data have been entered. Many types of computer software are available for this purpose, some of which are available free of charge, including Epi Info™, (www.cdc.gov/epiinfo/) and EpiData (www.epidata.dk/).

While entering data, their consistency and quality should be critically evaluated. If feasible, the respondents may be re-contacted to clarify illegible or ambiguous responses on the questionnaire.

Table 1. **Example of a line list for summarizing case data**

ID	Name	Age	Sex	Date & time of illness onset	Major signs and symptoms				Laboratory tests	
					D[a]	V[b]	F[c]	A[d]	Specimen[e]	Results
1	MT	34	f	10/05, 22:00	+	–	+	+	ND	
2	TG	45	f	11/05, 08:00	+	–	dk	+	ND	
3	SH	23	m	11/05, 05:00	+	–	+	+	faeces	*E. coli* O157
4	RF	33	f	10/05, 18:00	+B	+	+	+	faeces	Pending
5	SM	23	m	11/05, 12:00	+	–	–	+	faeces	Pending
etc.										

[a] diarrhoea, B = bloody
[b] vomiting
[c] fever, dk = unknown/can't remember
[d] anorexia
[e] ND = not done

Analysing data

Clinical details

The percentage of cases with a particular symptom or sign should be calculated and arranged in a table in decreasing order (see Table 2). Organizing the information in this way will help in determining whether the outbreak was caused by an intoxication, an enteric infection or a generalized illness. For example:

- If the predominant symptom is vomiting without fever and the incubation period is short (less than 8 hours), intoxication by, for example, *Staphylococcus aureus*, *Clostridium perfringens* or *Bacillus cereus* is likely.
- Fever in the absence of vomiting and an incubation period of more than 18 hours points to an enteric infection such as *Salmonella, Shigella*, *Campylobacter* or *Yersinia* (see Section 6 for clinical features of foodborne pathogens).

Table 2. **Frequency of signs and symptoms among cases (*n* = 296)**

Signs and symptoms	No. of cases	Percentage (%)
Diarrhoea	260	88
Abdominal pain	122	41
Fever	116	39
Nausea	105	35
Headache	68	23
Muscle pain	56	19
Vomiting	42	14

Time

The time course of an outbreak is usually shown as a histogram with the number of cases on the *y*-axis and the date of onset of illness on the *x*-axis. This graph, called an **epidemic curve**, may help in:

- confirming the existence of an epidemic;
- forecasting of the further evolution of the epidemic;
- identifying the mode of transmission;
- determining the possible period of exposure and/or the incubation period of the disease under investigation;
- identifying outliers in terms of onset of illness, which might provide important clues as to the source.

To draw an epidemic curve, the onset of illness must be known for each case. For diseases with long incubation periods, day of onset is sufficient. For diseases with a short incubation period – such as most foodborne diseases – day and time of onset are more suitable.

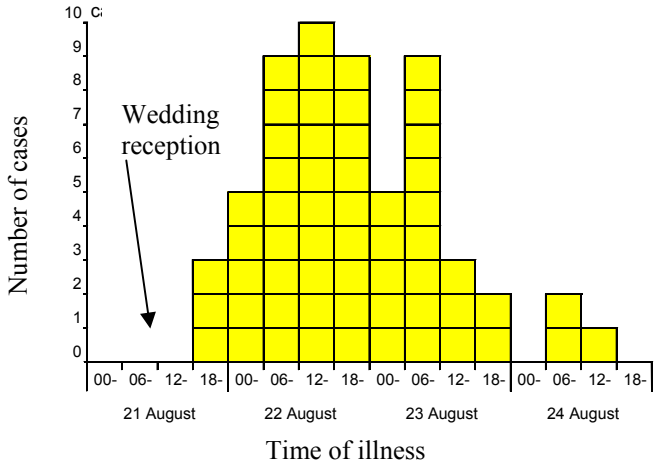
The unit of time on the *x*-axis is usually based on the apparent incubation period of the disease and the length of time over which cases are distributed. As a rule of thumb, the *x*-axis unit should be no more than one-quarter of the incubation period of the disease under investigation (although this rule may not apply if the outbreak has occurred over a prolonged period of time). Thus, for an outbreak of salmonellosis, with an average incubation period of 24 hours and cases confined to a few days, a 6-hour unit on the *x*-axis would be appropriate (see Figure 5).

If the disease and/or its incubation time are unknown, several epidemic curves with different units on the *x*-axis can be drawn to find one that portrays the data best. The pre-epidemic period on the graph should be shown to illustrate the background or "expected" number of cases or the index case. If the outbreak has a known source (e.g. a particular food served at a common event such as a wedding), the epidemic curve can also be labelled with this information.

The shape of an epidemic curve is determined by:

- the epidemic pattern (point source, common source or person-to-person spread);
- the period of time over which persons are exposed;
- the incubation period for the disease.

Figure 5. **Date and time of onset of illness among cases (*n* = 58), salmonellosis outbreak, wedding reception, Dublin, Ireland, 1996[a]**



[a] Source: Reproduced with permission of the publisher, from Grein et al., 1997.

In **common-source outbreaks**, a single source of pathogen results in exposure of persons at one point in time (point source), at several points in time (intermittent common source) or over a continuous period (continuous common source). An epidemic curve with a steep up slope, a more gradual down slope and with a width approximating the average incubation period of the pathogen indicates a **point-source outbreak** (see Figure 6A).

If there is a single source of pathogen but exposure is not confined to one point in time, the epidemic is either an **intermittent common-source** or a continuous **common-source outbreak**. In both these types of epidemic, onset will still be abrupt but cases will be spread over a greater period of time than one incubation period, depending upon how long the exposure persists (Figure 6B, 6C).

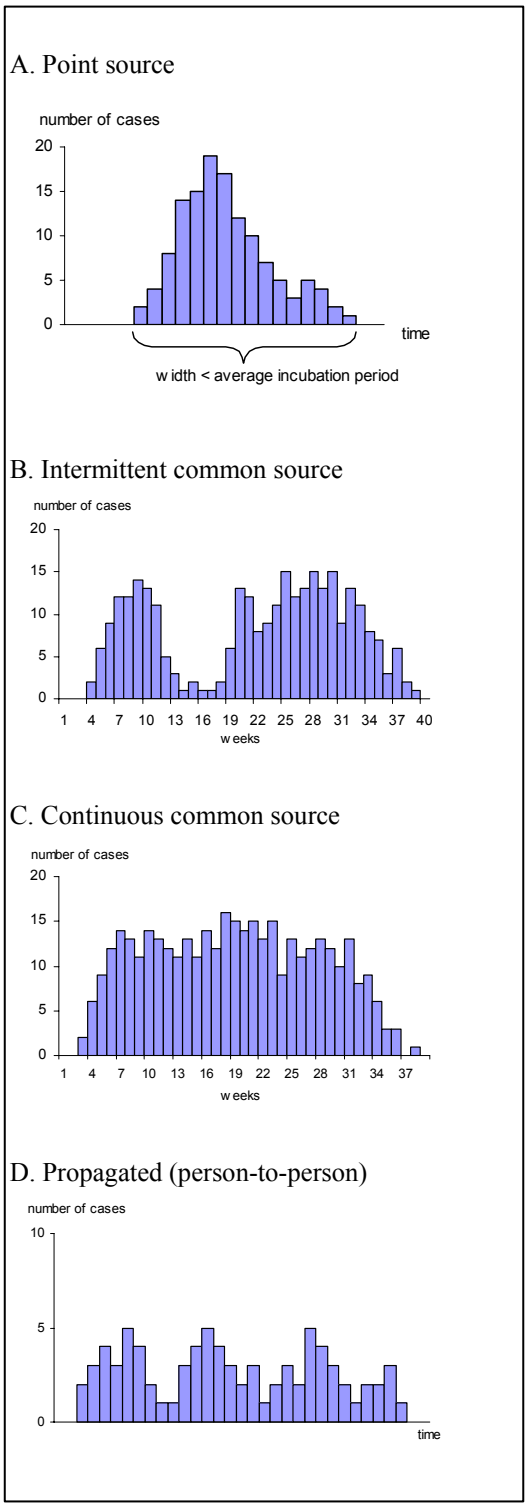
A **propagated epidemic** is caused by the spread of the pathogen from one susceptible person to another. Transmission may occur directly (person-to-person spread) or via an intermediate host. Propagated epidemic curves tend to have a series of irregular peaks reflecting the number of generations of infection. The time between the peaks may approximate the average incubation period of the pathogen (Figure 6D).

A **mixed epidemic** involves both a common source epidemic and secondary propagated spread to other individuals. Many foodborne pathogens (such as norovirus, hepatitis A, *Shigella*, and *E. coli*) commonly exhibit this mode of spread.

Calculate incubation periods

The incubation period is the interval between ingestion of food contaminated with enough pathogens or toxins to cause illness and the first sign or symptom of the illness. Incubation periods will vary with individual resistance and with the different amounts of pathogens/toxins ingested and their uneven distributions in food.

Figure 6. **Examples of types of epidemic curves**



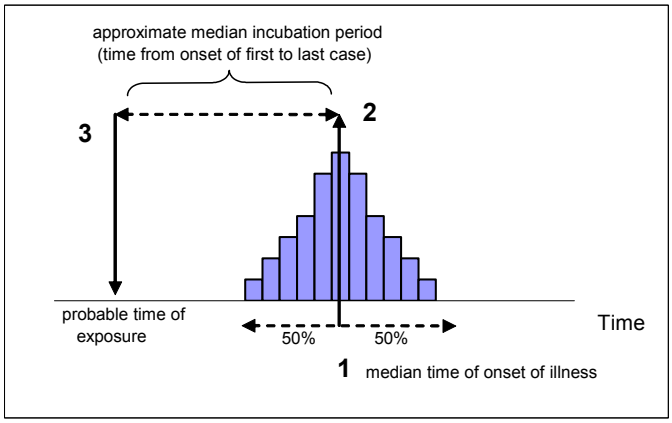
It is often best to characterize outbreaks using the *median* incubation period. Unlike the mean (or average), the median is a measure of central tendency which is not influenced by very short or very long incubation periods. For details of how to calculate the median, see Annex 7.

If the time of exposure and the time of onset of illness are known, individual incubation periods can be calculated directly and summarized by calculating the median.

If only the time of onset of illness is known and the shape of the epidemic curve suggests a point-source outbreak, inferences about the average incubation period and thus the suspected time of exposure may be drawn from the epidemic curve:

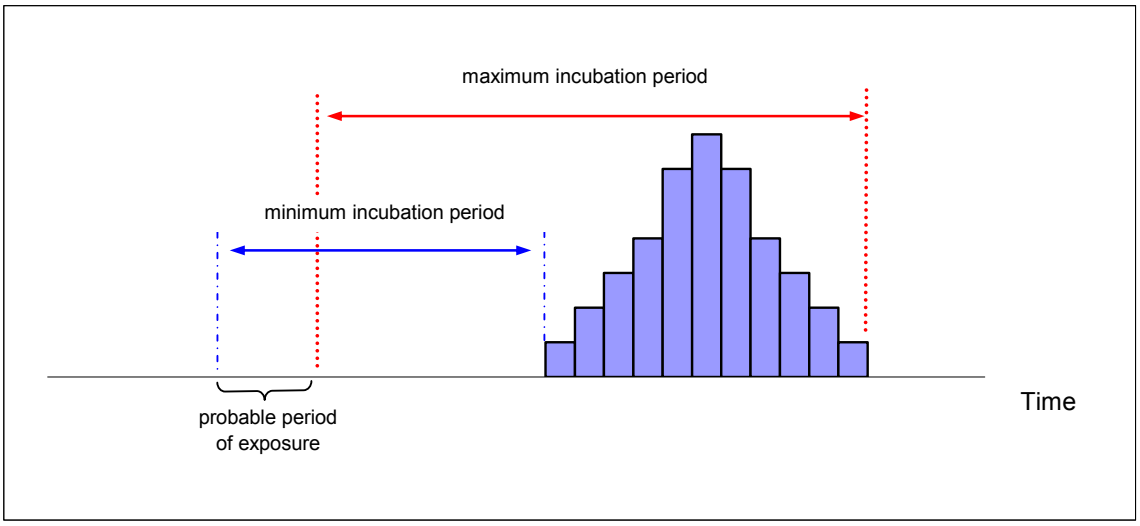
- Identify the median time of onset of illness.
- Calculate the time between occurrence of the first and last case (width of the epidemic curve).
- Count back this amount of time from the median to obtain the probable time of exposure (see Figure 7).

Figure 7. **Determining the median incubation period and probable time of exposure in a point-source outbreak**



If the organism and the time of onset of illness are known and the shape of the epidemic curve suggests a point-source outbreak, the probable time of exposure may be determined from the epidemic curve as shown in Figure 8.

Figure 8. **Determining the probable period of exposure in a point-source outbreak with known pathogen**



If the pathogen and onset of illness are known, the range of time during which the exposure probably occurred can be calculated as follows:

- Look up the minimum and the maximum incubation period for the disease (see Section 6).

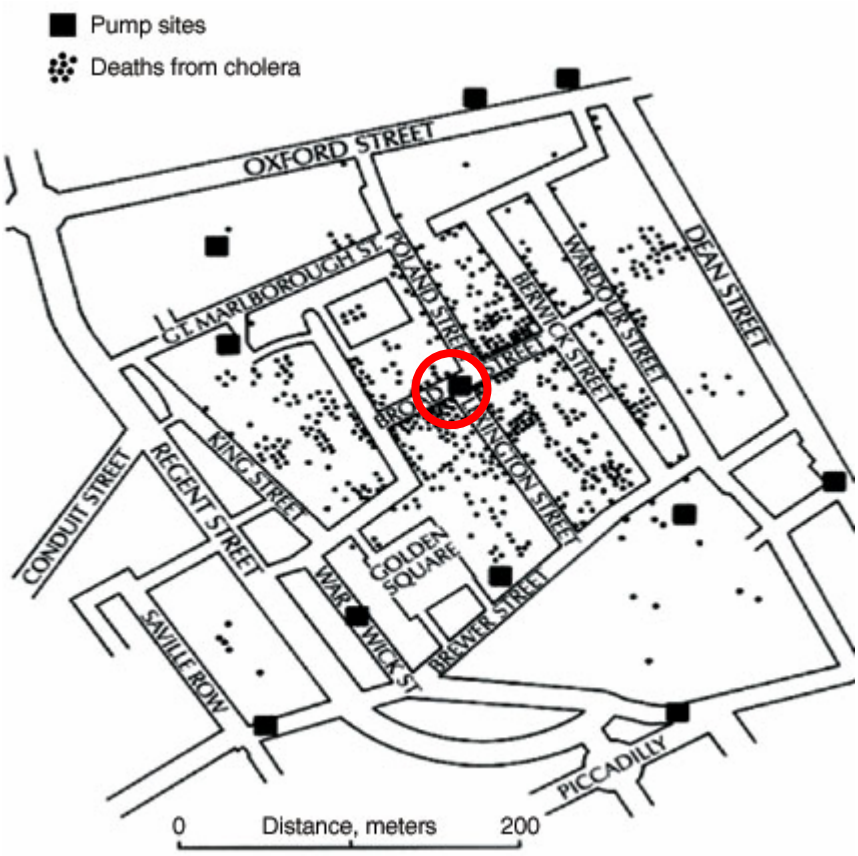
- Identify the last case of the outbreak and count back on the *x*-axis one maximum incubation period.
- Identify the first case of the epidemic and count back the minimum incubation period.
- Ideally, the two dates will be similar and represent the probable period of exposure.
- Alternatively, identifying the peak of the epidemic and counting back one average incubation period can determine the probable time of exposure. This method is useful in ongoing outbreaks in which the last cases have not yet appeared.
- These methods cannot be used if secondary spread is involved or exposure is prolonged.

Place

Assessment by "place" provides information on the geographical extent of the outbreak and may reveal clusters or patterns that provide important clues about its cause. Geographical information is best displayed by the use of maps: the types most commonly used in outbreak situations are spot maps and area maps. These can be produced by hand or by using sophisticated geographical information systems.

A **spot map** is produced by placing a dot or other symbol on the map showing where a case lives, works or may have been exposed. Different symbols can be used for multiple events at a single location. On a spot map of a community, clusters or patterns may reflect water supplies or proximity to a restaurant or to a grocery (see Figure 9). On a spot map of a hospital or a nursing home, clustering of cases is consistent with a focal source or person-to-person spread, while scattering of cases throughout the facility may be more consistent with a widely disseminated vehicle or a source common to all residents.

Figure 9. **Spot map showing the occurrence of 578 fatal cases of cholera, clustering around a shared well, London[a]**



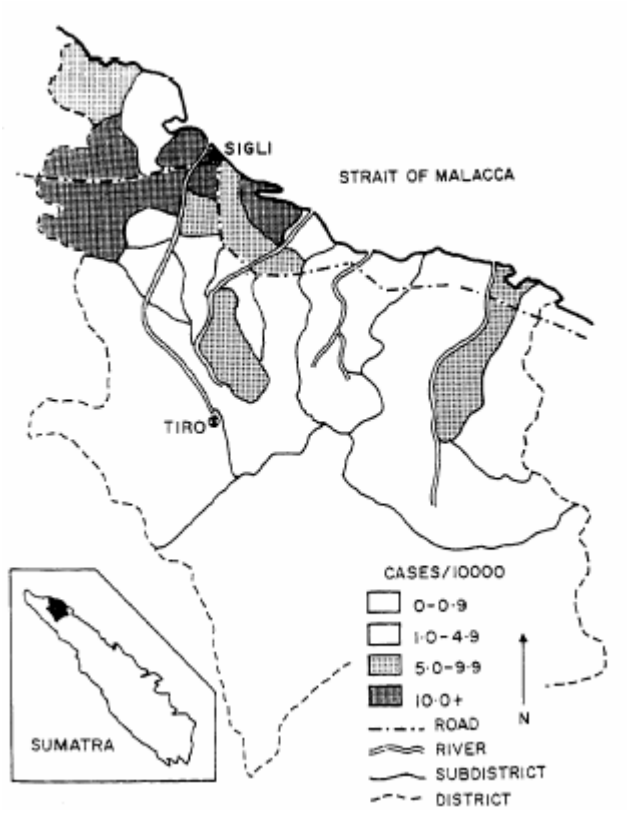
[a] Source: Snow, 1854.

If the size of the population varies between areas, a spot map that shows only numbers of cases can be misleading. In such instances, an **area map** (or density map) should be used. An area map takes differences in population size into consideration by employing rates (cases/population) rather than absolute numbers (see Figure 10).

Person

The purpose of describing an outbreak by "person" characteristics is to identify features that are common to cases as a clue to etiology or sources of infection. Age, sex, ethnicity and occupation are among the numerous characteristics that can be used to describe the case population. If a single or specific characteristic emerges, this often points towards the population at risk and/or towards a specific exposure. For example, it may be apparent that only certain students in a school became ill, or only workers in a single factory or a group of people who attended a local restaurant were involved. Nevertheless, even if it appears that only a single group of people was at risk, it is important to look carefully at the entire population to be sure that no other groups are affected. Certain groups of people may be more susceptible to disease or more likely to seek medical attention for their symptoms, for example people who live in a city where medical care is readily available. Sometimes cases in a particular group are more likely to be detected and reported than cases in other groups, and premature conclusions about the population affected could therefore be misleading.

Figure 10. **Area map of the distribution of suspected cholera cases, Kabupatan Pidie, Indonesia, July–August 1982**[a]



[a] Source: Reproduced with permission of the publisher, from Glass et al., 1984.

Determining who is at risk of becoming ill

A measure of disease frequency is important in characterizing an outbreak, and the commonest such measure in epidemiology is a *rate*. Rates adjust for differences in population size and thus allow comparison of the occurrence of disease in various subgroups (see Table 3). Calculating rates of disease requires knowledge both of the number of cases and of the number of people in the population group(s) in which the disease may occur in a given period of time (often referred to as the *denominator*). This population group is called the *population at risk* and is usually defined on the basis of general demographic factors. For example, if the disease affects only children aged 5 to 14 years, the population at risk is the children in this age group living in the area of the outbreak.

Excluding population groups in which the disease does not occur helps the investigation to focus only on those affected, leading to clearer findings and allowing more effective intervention and control activities. If only a certain ethnic group within a region is involved, for example, the investigation may focus on food items specific to that group.

Table 3. **Cholera attack rate by age group, Mankhowkwe Camp, Malawi, March–May 1988, showing the highest rates of disease among persons aged 15 years and above**[a]

Age group (years)	No. of cases	Population	Attack rate (%)
<5	131	5 303	2.5
5 to 14	261	12 351	2.1
≥15	392	12 091	3.2
Total	784	29 745	2.6

[a] Source: Reproduced with permission of the publisher, from Moren et al., 1991.

The *attack rate* is commonly used in disease outbreak investigations and is a key factor in the formulation of hypotheses. It is calculated as the number of cases in the population at risk divided by the number of people in the population at risk (see Annex 7).

Sometimes it may be impossible to calculate *rates* because the population at risk is not known. In such situations, the distribution of cases themselves may help in formulating hypotheses.

Developing explanatory hypotheses

At this stage of the investigation the data need to be summarized and hypotheses formulated to explain the outbreak. Hypotheses should address the source of the agent, the mode and vehicle of transmission, and the specific exposure that caused the disease. They should also be:

- plausible;
- supported by the facts established during the epidemiological, laboratory and food investigations;
- able to explain most of the cases.

While it is important to consider what is already known about a disease, an unlikely or unusual hypothesis should not be automatically discarded. In 1985, for example, when epidemiological data incriminated horse meat as the source of a trichinosis outbreak in France, the hypothesis that consumption of horse meat caused this outbreak seemed unlikely. Before then, it had always been assumed that only carnivores were a source for *Trichinella* infection. However, this proved not to be the case, and since 1985 several trichinosis outbreaks have been traced back to horse meat (Ancelle, 1988).

Formal testing of a hypothesis may be unnecessary if it is strongly supported by epidemiological, laboratory or food data, but if such support is lacking or important questions remain unanswered, further studies may be needed. For example, descriptive epidemiology will often explain the source of the outbreak and the general mode of transmission but not reveal the specific exposure that caused the disease. Analytical epidemiological studies are then used to test the hypotheses.

Analytical epidemiological investigations

Analytical epidemiological studies frequently involve comparisons of the characteristics of a group of well persons with those of ill persons in order to quantify the relationship between specific exposures and the disease under investigation. The two types of analytical studies most commonly used in outbreak investigations are **cohort studies** and **case–control studies**.

When investigating outbreaks a rapid result may be required to assist in control efforts, and it may be advisable to conduct a limited analytical study initially. More thorough investigations can be conducted later, for example to increase the knowledge of a particular food pathogen.

The value of a comparison group for identifying specific exposures is illustrated by the example of a school outbreak of gastroenteritis, in which 30 cases are identified. Interviewing all 30 cases about their food consumption shows that all ate vanilla ice cream purchased from a street-vendor one day before illness. Enquiries about consumption of other foods show that no other food item was consumed by as many cases as vanilla ice cream.

Comparing the 30 cases with a group of 60 healthy students from the same school reveals that all the healthy students also ate vanilla ice cream purchased from the same street-vendor. Comparison of other exposures, however, reveals that most of the 30 cases had lunch in the school canteen the day before illness while most of the healthy students did not. This difference indicates that food from the school canteen is the more likely vehicle for the outbreak than vanilla ice cream: the finding that all cases had eaten vanilla ice cream merely reflects its popularity among the students.

Retrospective cohort studies

Retrospective cohort studies are feasible for outbreaks in small, well-defined populations in which all exposed and all non-exposed persons are identifiable. These studies compare the occurrence of disease among those who were exposed to a suspected risk factor with occurrence among those who were not (Box 2, page 33). For example, all persons attending a wedding reception (the "cohort") may be interviewed to determine whether they became ill after the reception, and to identify what foods and drinks they had consumed. After collecting information from each attendee, attack rates for illness are calculated for those who ate a particular food and for those who did not eat that food (see Table 4).

Table 4. **Cohort study**

Exposure	**Ill**	**Not ill**	**Total**	**Attack rate**
Ate food "A"	48	20	68	71%
Did not eat food "A"	2	100	102	2%
Total	50	120	170	29%

In this example, of a total of 68 persons who ate food "A", 48 fell ill (attack rate 48/68 or 71%). The attack rate for those who did not eat food "A" was 2/102 or 2%. Food "A" is a likely risk factor for illness because:

- the attack rate is high among those exposed to food "A" (71%);
- the attack rate is low among those not exposed to food "A" (2%), so the difference (risk difference) between the two attack rates is high (69%);
- most cases (48/50 or 96%) were exposed to food "A".

In addition, a ratio of the two attack rates, known as the *relative risk* (RR), can be calculated in the following way:

$$\text{relative risk (RR)} = \frac{\text{Attack rate for those who ate food "A"}}{\text{Attack rate for those who did not eat food "A"}} = \frac{71\%}{2\%} = 35.5$$

A relative risk has no units and is a measure of the strength of association between the exposure and the disease. In the above example, the relative risk associated with eating food "A" is 35.5. This means that persons who ate food "A" were 35.5 times more likely to develop disease than those who did not. Statistical significance tests are used to determine the probability that this relative risk could have occurred by chance alone. For information about statistical significance testing, see Annex 7.

Case–control study

In many circumstances, no clearly defined "cohort" of all exposed and non-exposed persons can be identified or interviewed. In such situations – when cases have already been identified during a descriptive study and information has been gathered from them in a systematic way – a case–control study can be an efficient study design (Box 3, page 34).

In a case–control study, the distribution of exposures among cases and a group of healthy persons ("controls") are compared with each other (see Table 5). The questionnaire used for the controls is identical to that administered to the cases, except that questions about the details of clinical illness my not pertain to the controls.

Table 5. **Case-control study**

Exposure	Cases	Controls	Total
Ate food "A"	48	20	68
Did not eat food "A"	2	100	102
Total	50	120	170
Percentage exposed	96%	17%	40%

In this example, 96% of all cases had consumed food "A" compared with only 17% of the controls. This suggests that consumption of food "A" is associated with illness in one way or another. In contrast to a cohort study, attack rates (and therefore relative risk) cannot be calculated since the total number of persons at risk is unknown. Instead, a different measure of association – *odds ratio* (OR) – is used in case-control studies. The odds ratio is calculated as the "cross-product" of a two-by-two table (see Table 6).

Table 6. **Example of a two-by-two-table from a case-control study**

	Cases	Controls	Total
Ate food "A"	48	20	54
Did not eat food "A"	2	100	21
Total	46	29	75

$$\text{Odds ratio} = \frac{(48 \times 100)}{(20 \times 2)} = 120$$

Chi-square 92.6, p-value $<6 \cdot 10^{-22}$

The odds ratio is calculated as the cross-product from a two-by-two table (the number of cases exposed times the number of controls not exposed, divided by the number of controls exposed times the number of cases not exposed). For rare conditions (i.e. less than 5% in the general population are affected), the odds ratio is a good estimate of the relative risk. Thus, in this example, an exposure odds ratio of 120 for food "A" can be interpreted as: the odds of having been exposed to the contaminated food in those who developed the disease was 120 times that of people who did not eat food "A". This odds ratio means that there is a very strong association between being a case and consumption of food "A". As in a cohort study, statistical significance can be calculated to determine the probability that such an odds ratio could have occurred by chance alone. For the example above, this probability is extremely small ($1/6 \cdot 10^{22}$). Box 3 (page 34) gives a calculated example of a case-control study.

Choosing controls

An important decision in the design of a case-control study is defining who should be the controls. Conceptually, controls must not have the disease in question but should represent the population from which the cases come. In this way, controls provide the level of background exposure that might be expected among cases. If cases have a much higher exposure than controls, exposure may be associated with disease.

Often it is difficult to know who the controls should be. Practical matters need to be taken into consideration, such as how to contact potential controls rapidly, gain their permission, ensure that they are free of the disease under investigation (and not just asymptomatic), and get appropriate exposure data from them. In a community outbreak, a random sample of the healthy population may be the best control group. Sometimes such community controls are identified by visits to randomly selected homes in the community of interest or by telephone calls to randomly selected telephone numbers within the area.

Other common control groups consist of:

- neighbours of cases;
- patients from the same physician practice or hospital who do not have the disease in question;
- family members or friends of cases;
- people who attended an implicated event but did not become ill;

- people who ate at an implicated food service facility during the time of exposure but did not become ill.

While controls from these groups may be more likely to participate in the study than randomly identified population-based controls, they may not be as representative of the population. This kind of bias in the control group can distort the data in either direction masking an association between the exposure and disease or producing a spurious association between an innocent exposure and disease. However a group of controls is chosen substantial efforts should be made to interview all those selected. Making only a single attempt to contact randomly selected controls, for example, could result in a biased sample of people who are most likely to be available at a certain time of the day rather than being representative of the entire population of interest.

When designing a case-control study, the number of controls must be considered. While the number of cases is limited by the size of the outbreak the number of potential controls will usually be greater than is needed. In general, the more subjects are included in a study, the easier it will be to find a statistical association between exposure and disease.

In an outbreak of 50 or more cases, one control per case will usually suffice. In smaller outbreaks, two, three or four controls per case can be used. Increasing the number of controls beyond four per case, however, will rarely be worth the effort.

Box 2. **Example of a cohort study**[1]

Table A is based on an outbreak of gastroenteritis following a church supper. Of the 80 persons attending the supper, 75 were interviewed. Forty-six met the case definition. Attack rates were calculated for those who did and did not eat each of the 14 food items.

Table A. **Attack rates by food items served at church supper, Oswego, New York, April 1940**

	Number of persons who ate food item			Number of persons who did not eat food item		
	Ill	**Total**	**Attack rate (%)**	**Ill**	**Total**	**Attack rate (%)**
Baked ham	29	46	63	17	29	59
Spinach	26	43	60	20	32	62
Mashed potatoes	23	37	62	23	37	62
Cabbage salad	18	28	64	28	47	60
Jello	16	23	70	30	52	58
Rolls	21	37	57	25	38	66
Brown bread	18	27	67	28	48	58
Milk	2	4	50	44	71	62
Coffee	19	31	61	27	44	61
Water	13	24	54	33	51	65
Cakes	27	40	67	19	35	54
Vanilla ice cream	43	54	80	3	21	14
Choc. ice cream*	25	47	53	20	27	74
Fruit salad	4	6	67	42	69	61

* Excludes one person who was unsure of consumption.

Looking at this table the most likely vehicle is vanilla ice cream. It has the highest attack rate (80%) for those who ate vanilla ice cream and the lowest for those who did not. Forty-three of the 47 cases can be "explained" by having eaten vanilla ice cream. The attack rates for the other 13 food items do not display the same characteristics.

Table B shows the same data for vanilla ice cream in the format of a two-by-two table which makes the calculation of attack rates, relative risks and statistical significance easier to visualize:

Table B. **Two-by-two-table for consumption of vanilla ice cream (cohort study)**

	Ill	**Well**	**Total**	**Attack rate (%)**
Ate vanilla ice cream	43	11	54	79.6
Did not eat vanilla ice cream	3	18	21	14.3
Total	46	29	75	61.3

RR = 79.6/14.3 = 5.6

The relative risk (RR) for eating vanilla ice cream is 79.6/14.3 or 5.6. This means that persons who ate vanilla ice cream were 5.6 times more likely to become ill than those who did not.

To determine the probability that the relative risk of 5.6 could have occurred by chance alone a statistical significance test can be calculated. This shows that the probability of obtaining a relative risk of 5.6 or even higher is 1/5 000 000 and therefore very unlikely to have occurred by chance alone. For details of how this calculation was obtained see Annex 7.

[1] Source: Reproduced with permission of the publisher, from Goss, 1976.

Box 3. **Example of a case–control study**[1]

Table A. **Odds ratios for exposure to foods served in hospital "X", Dublin, Ireland, 1996**[a]

	Cases (*n* = 65)		Controls (*n* = 62)		Odds ratio
	Ate	Did not eat	Ate	Did not eat	
French onion soup	8	51	15	45	0.47
Baked ham	21	37	18	42	1.32
Parsley sauce	18	40	15	45	1.35
Cold salads	5	54	8	52	0.60
Creamed potatoes	23	35	23	35	1.00
Turnips and cabbage	30	29	21	38	1.87
Chicken curry rice	15	44	7	53	2.58
Sandwiches	6	53	3	56	2.11
Danish pastries	1	58	6	53	0.15
Chocolate mousse cake	42	16	5	53	27.83
Ice cream	10	48	16	43	0.56
Scones	1	58	4	56	0.24

[a]Persons who were uncertain about consumption of a particular food item are excluded.

Table A is based on a salmonellosis outbreak in a hospital. Sixty-five patients and staff members met the case definition. Their exposures to specified foods were compared to those of 62 healthy patients and staff members. To determine the most likely vehicle of the outbreak, odds ratios were calculated for a total 56 food items served during breakfast, lunch and dinner over a three day period (Table A shows only food items served during one lunch). The highest odds ratio was found for consumption of chocolate mousse cake.

Table B. **Two-by-two table for consumption of chocolate mousse cake (case control study)**

	Cases	**Controls**	**Total**
Ate chocolate mousse cake	42	5	47
Did not eat chocolate mousse cake	16	53	69
Total	58	58	115

$$\text{Odds ratio (OR)} = \frac{(42 \times 53)}{(5 \times 16)} = 27.8$$

The odds ratio for being exposed to chocolate mousse cake was 27.8. As salmonellosis is infrequent in the general population (and even in hospital) this odds ratio can be taken as a relative risk estimate, i.e. the risk of developing illness was much higher among persons who ate chocolate mousse cake than among those who did not.

[1] Source: Reproduced with permission of the publisher, from Grein et al., 1997.

Dose response

A dose response is present if the risk of illness increases with increasing amount or duration of exposure. For example, if individuals who ate two portions of a stew were more likely to become ill than people who ate only one portion, this would suggest a "dose response". Finding a dose response supports the hypothesis that a particular exposure caused illness.

Looking for a dose response is particularly important in outbreaks where cases and the comparison group (i.e. controls in case–control studies and unaffected persons in cohort studies) were exposed to the same risk factors. When the entire study population has been exposed to the same risk factors, demonstrating a dose response can be particularly helpful in assessing a situation.

Careful attention to study design is important to ensure that dose response can be evaluated. The first and most important step in looking for a dose response is to include questions about exposure levels in the questionnaire (e.g. how often or how much of a food was eaten). Once data on exposure levels have been collected, odds ratios (in case-control studies) or relative risks (in cohort studies) are calculated for each level of exposure and compared with the unexposed group or the group with the lowest exposure (the "reference" group). Statistical tests such as the chi-square test for trend can be employed to assess the statistical significance of the dose response. Table 7 gives an example of a dose-response calculation for a case control study, in which people eating more than 12 oysters were much more likely to become ill than people eating 7 to 12 oysters, who in turn were more likely to become ill than those eating fewer than 7 oysters.

Table 7. **Number of oysters eaten among oyster-eating patients and controls, Hepatitis A outbreak, Florida, 1988[a]**

Number of raw oysters eaten	**Cases** (*n* = 51)		**Controls** (*n* = 33)		**Odds ratio**
	number	**percentage**	**number**	**percentage**	
1 to 6	6	12	18	55	1.0 (reference)
7 to 12	20	39	11	33	5.5
>12	25	49	4	12	18.8

[a] Source: Reproduced with permission of the publisher, from Desenclos et al., 1991.

Chi-square for trend 20.0, $p < 0.001$
This chi-square value indicates that there is less than a 1 in 1000 chance that the increased odds of becoming ill after eating a larger quantity of oysters could be due to chance alone.

Table 8 gives an example of a similar calculation for a cohort study in which illness was increasingly likely among persons eating more éclairs.

Table 8. **Number of éclairs eaten among sport day attendees, Thailand, 1995**[a]

Pieces of éclair eaten	Number ill	Total number	Attack rate	Relative risk
0	15	285	5.3	1.0 (reference)
0.5 to 1	51	105	48.6	9.2
2 to 4	299	524	57.1	10.7
>4	105	171	61.4	11.6

[a] Source: Thaikruea et al., 1995.

Additional information on these and other topics pertaining to epidemiological and statistical aspects of investigating outbreaks is available free of charge on the internet (WHO, 2002; Dicker, 1992).

Addressing additional research issues

Outbreaks provide unique opportunities to address scientific questions above and beyond the immediate requirements of the investigations. While the rapid control of an outbreak must remain the primary objective for the investigator, additional research questions or collection of additional data related to the pathogen or to the food under investigation may be addressed without jeopardizing this objective. Outbreak investigations can be an important opportunity to learn about a pathogen, the emergence of drug resistance, and other important aspects of the epidemiology of foodborne disease.

Data derived from epidemiological studies can be used in risk assessment, a process of evaluating known or potential adverse health effects resulting from human exposure to foodborne hazards. Risk assessments for foodborne pathogens have become an important tool for responding to increasing scientific, legal and political demands in the area of food safety. Epidemiological data derived from foodborne disease outbreaks can be valuable in risk assessments for foodborne pathogens, particularly if data collection follows a standardized protocol. For the type of data useful in risk assessment of a particular pathogen, see Annex 6.

4.3 Environmental and food investigations

General

Environmental investigations (often also referred to as food or sanitary investigations) are conducted in parallel with epidemiological and laboratory investigations to find out how and why an outbreak occurred and, most importantly, to institute corrective action to avoid similar occurrences in the future. The specific objectives of an environmental investigation during a foodborne disease outbreak include:

- identifying the source, mode and extent of the food contamination;
- assessing the likelihood that pathogens survived processes designed to kill them or to reduce their numbers;
- assessing the potential for growth of pathogens during food processing, handling or storage;
- identifying and implementing corrective interventions.

Because environmental investigations will differ according to the nature and size of the outbreak, the type of establishments involved, the resources available, local priorities, political and legal concerns, and many other factors, only general aspects can be outlined in this manual.

An environmental investigation performed in the context of a foodborne disease outbreak differs significantly from a routine regulatory inspection carried out to identify regulatory violations. Outbreak-related environmental investigations should be guided by data as it becomes available from other components of a multi-disciplinary investigation. Such investigations should endeavour to clarify the actual conditions at the time the suspected foods were prepared (i.e. before the outbreak) rather than simply observe the current conditions. Each suspect food item that has been (or could be) implicated in the outbreak should be thoroughly investigated.

Examples of records that may be useful in an investigation include:

- menus, recipes or product formulations;
- processing records;
- purchasing and inventory records;
- shipping records and other documentation relating to the source of an implicated product;
- hazard analysis and critical control points (HACCP) plans and records;
- records of corrective action;
- flow diagrams;
- floor plans of the establishment;
- complaint records;
- cleaning records;
- food laboratory testing results;
- past inspection records;
- personnel records (including who was working when, and absenteeism).

The amount of physical evidence may diminish rapidly with time after an outbreak has been identified, and associated food investigations should therefore be carried out as soon as possible. In a small, well-defined outbreak (e.g. a point-source outbreak originating in a restaurant), the site of the outbreak may be easily identified, and an environmental investigation can be launched promptly. In more complex outbreak investigations, in which there may be delays in linking cases to a particular food establishment or event, the food investigation may be particularly challenging – or even impossible.

Investigation of food establishments

During a foodborne disease outbreak, investigation of a food establishment will often require:

- interviewing managers;
- interviewing any employees who may have had a role in the processing or preparation of suspected foods;
- a review of employee records (to determine whether some were out ill during the period of interest);
- a review of the overall operations and hygiene;
- a specific assessment of procedures undergone by a suspect food;
- food and environmental sampling;
- a review of food worker health and hygiene, including specimens for analysis;
- an assessment of the water system and supply;

- measurement of temperatures, pH and water activity (a_w) with appropriate equipment.

Investigations should be guided by what is already known about an outbreak from epidemiological and laboratory investigations and about known reservoirs for the suspected agent. If a food has been incriminated epidemiologically, efforts should focus on how this particular food became contaminated. If laboratory investigations have identified a pathogen, efforts may focus on foods and conditions known to be associated with the particular pathogen (see Section 6). Food investigations that lack this kind of clear focus can be expensive, time-consuming and of limited value. The following questions may help to focus an efficient food investigation:

- What are the known reservoirs or common sources of the suspected pathogen?
- What type of environment does it survive in?
- Where and how could the food have been contaminated?
- What environmental conditions support the growth and spread of the suspected pathogen?
- Where are the opportunities for cross-contamination, survival or growth of the pathogen in this environment or establishment?

One of the goals of an environmental investigation is to identify "contributing factors" – the factors that probably played a role in the occurrence of the outbreak. These are often classified into factors related to contamination, proliferation or amplification of a pathogen, and survival of a pathogen (Bryan, Guzewich & Todd, 1997).

Investigation of a suspect food

When the role of a suspect food is investigated, the complete processing and preparation history should be reviewed, including sources and ingredients, persons who handled the specific foods, the procedures and equipment used, potential sources of contamination, and time-and-temperature conditions to which foods were exposed.

Product description

The suspect food should be fully described in terms of:

- all raw materials and ingredients used (menus, recipes, formulations);
- sources of the ingredients;
- physical and chemical characteristics, including pH, water activity (a_w);
- use of returned, reworked or leftover foods in processing;
- intended use (e.g. home use, catering, for immediate consumption, for vulnerable groups).

Observation of procedures from receipt to finish

Observations must cover the entire range of procedures, focusing on actual processes and work practices and including cleaning methods, schedules, personal hygiene of food-handlers and other relevant information. The temperature history (temperature and duration) of the suspect food should be recorded as completely as possible, including the conditions in which the food was stored, transported, prepared, cooked, heat-processed, held warm, chilled or re-heated. Observation of food-handling practices may be valuable for small-scale operations and in the domestic setting as well as in commercial operations.

Interviewing food-handlers

All food-handlers who were directly involved in producing, preparing or handling suspect foods should be interviewed. Information should be obtained about the exact flow of the

suspect food, its condition when received by each food-handler, the manner in which it was prepared or handled, and any unusual circumstances or practices prevailing during the relevant period. Recent illnesses of food-handlers (before, during or after the date of the outbreak exposure) and times of absence from work should also be noted. Specimens for microbial analysis should be obtained from any food-handlers who are ill. If any employee is found to be infected with the agent of concern, it is essential to determine whether he or she is a potential source of the problem or is infected because of having eaten the same food. At every step of the process, data should be evaluated with respect to contamination, growth/proliferation and survival factors associated with the suspected pathogen(s).

Employees should be interviewed regarding their observations and recollections of specific days implicated in the outbreak. Examples of such questions are:

- What were each employee's specific duties that day?
- Were there any unusual working conditions that day?
- Were deliveries arriving on time?
- Was all equipment working properly?
- Was anyone out ill?
- Was the establishment short-staffed?
- Were unusual quantities of food being prepared?

Taking appropriate measurements

An effort should be made to estimate food-processing conditions at the time the implicated foods were produced. Product temperatures during processing and storage and time sequences of operations should be measured and recorded as appropriate. This includes:

- time and temperature conditions to which suspect foods were exposed;
- water activity (a_w), water content and pH of suspect foods;
- size of containers used in procedures, depth of food in containers, etc.

Again, attempting to understand actual conditions at the time that implicated foods were prepared is paramount.

Drawing a flowchart of the operations

All information and measurements should be entered on a flowchart to facilitate assessment of factors that may have contributed to the outbreak. The flowchart should be based on actual practices at the time of the outbreak and, as applicable, should show:

- exact flow of operations for the suspect food(s);
- name of persons performing operations;
- equipment used;
- results of measurements taken;
- other relevant information.

If practices at the time of the outbreak can no longer be reconstructed, a flowchart of current practices may be useful.

Conducting an outbreak hazard analysis

Hazard analysis in an outbreak situation should address the following questions at each step of the processing of potentially implicated foods:

- Could pathogens have been introduced at any stage?

- Could pathogens already present have been able to grow at any stage?
- Could pathogens have survived processes designed to kill them?

This analysis also include observation of the food-handling environment, assessing such factors as the location and availability of sinks and appropriate hand-washing facilities, and determining whether separate areas are maintained for the preparation of raw and ready-to-eat foods.

Food and environmental sampling

If laboratory facilities are available, appropriate food and environmental samples should be taken as early as possible since the amount of physical evidence will diminish with time. The laboratory should be alerted in advance of sample collection and can provide sampling materials appropriate to the type and quantity of specimens to be collected, their storage, packing and transport.

Food samples

Laboratory analysis of foods for microbial or chemical contamination is time- and resource-intensive and liable to a number of sampling and handling errors. Targeted sampling and laboratory analysis of foods should be directed by epidemiological and environmental investigations. If an implicated food has not been identified at the time of sampling, a large number of specimens may be collected and stored for subsequent laboratory testing as additional information becomes available.

Food samples that may be appropriate for collection and testing include:

- ingredients used to prepare implicated foods;
- leftover foods from a suspect meal;
- foods from a menu that has been implicated epidemiologically;
- foods known to be associated with the pathogen in question;
- foods in an environment that may have permitted the survival or growth of microorganisms.

If a packaged food item is suspected of being involved in an outbreak, it is particularly important to collect unopened packages of that food – ideally, from the same lot. This can help to establish whether the food was contaminated before its receipt at the site of preparation. If no foods are left from a suspect meal, samples of items that were prepared subsequently but in a similar manner may be collected instead, although findings from these tests must be interpreted with care. Any ingredients and raw items that are still available should also be sampled. Storage areas should be checked for items that may have been overlooked; even food retrieved from garbage containers may provide information useful in an investigation.

The circumstances in which samples were collected, the names of the suppliers and distributors, and coding information on packaged foods should be recorded so that the distribution channels of the product can be determined if necessary.

Environmental samples

The purpose of collecting environmental samples is to trace the sources of, and evaluate the extent of contamination that may have led to, the outbreak. Samples may be taken from work surfaces, food contact surfaces of equipment, containers, and other surfaces such as

refrigerators, door handles, etc. Environmental samples may also include clinical specimens (such as faecal specimens, blood or nasal swabs) from food workers and water used for food processing.

Raw poultry, pork, beef and other meats are often contaminated with *Salmonella*, *Campylobacter jejuni, Yersinia enterocolitica*, *Clostridium perfringens*, *Staphylococcus aureus*, *Escherichia coli* O157 and other pathogens by the time they come into kitchens. If any of these agents is suspected in an outbreak, meat scraps, drippings on refrigerator floors and deposits on saws or other equipment can be helpful in tracing the source of contamination. Swabs can also be taken from tables, cutting boards, grinders, slicing machines and other utensils that had contact with the suspect food. However, as these pathogens are often present in such raw products, their detection does not automatically imply that they were the cause of the outbreak.

Food-handlers

Food-handlers can be a source of foodborne contamination. Stool specimens or rectal swabs may be collected from food-handlers for laboratory analysis to identify potential carriers or sources of contamination. Toxin-producing strains of *S. aureus* are carried in the nostrils, on the skin and occasionally in the faeces of many healthy persons. If *S. aureus* intoxication is suspected, the nasopharynx of food-handlers can be swabbed. Swabs should also be taken from skin lesions (pimples, boils, infected cuts, burns etc) on unclothed areas of the body. Arrangements should be made for workers to be examined by a medical practitioner as appropriate. If hepatitis A virus (HAV) is suspected, blood from food-handlers can be tested for IgM antibodies against HAV, which are an indication of acute infection (Heymann, 2004).

If ill food-handlers are identified, an immediate decision is needed on whether to exclude those people from work until their symptoms have resolved or until additional investigations have been completed. Local jurisdictions may have different policies and rules regarding exclusion of food-handlers, and different criteria for allowing them to return to work, although guidelines have been established (Heymann, 2004, and Section 6.3).

Food traceback

If a food investigation fails to identify a source of contamination at the place of preparation (e.g. infected food-handler or cross-contamination), attention should be drawn to the possibility that contamination may have occurred before the food or ingredient arrived at the establishment (Box 4, page 42). The simultaneous occurrence of multiple outbreaks due to the same pathogen at different sites is often evidence of primary contamination. It is generally recognized that many raw foods may commonly be contaminated (primary contamination). Primary contamination may be more or less ubiquitous (e.g. *Bacillus cereus* in grain) or so common (e.g. *Salmonella* in poultry) that food safety measures will rely on subsequent procedures such as thorough cooking to ensure that food is fit for consumption. In such instances, investigation of the place of primary contamination will depend on the available resources, priorities and the epidemiological situation with regard to the outbreak.

BOX 4. **Factors contributing to contamination of foods**

- Raw foods may be contaminated at their source with S*almonella*, *Campylobacter*, *Clostridium perfringens*, *Yersinia enterocolitica*, *Listeria monocytogenes*, *Staphylococcus aureus* or other pathogens. In some regions, raw fish are often contaminated with *Vibrio parahaemolyticus* and non-O1 *Vibrio cholerae*. Rice and other grains often harbour *Bacillus cereus*, and herbs and spices may harbour *C. perfringens.*
- Foods were obtained from unsafe sources (shellfish, raw milk, raw eggs, mushrooms, etc.).
- Non-potable water was used in food preparation.
- Infected persons (e.g. nasal carriers of *Staphylococcus aureus*, persons in the incubatory phase of hepatitis A, persons infected with norovirus and intestinal carriers of Shigella); contaminated foods that were not subsequently heat-processed.
- Contaminants were spread, by worker's hands, cleaning cloths or equipment, from raw foods of animal origin to cooked foods or to foods that were not subjected to further heat treatment.
- Equipment (slicers, grinders, cutting boards, knives, storage containers) was not properly cleaned.
- Contaminated food or ingredients were eaten raw or insufficiently heat-processed.
- High-acid foods were stored in containers or conveyed through pipelines that contained toxic metals (antimony, copper, cadmium, lead, zinc), causing leaking or migration of the toxic substance into the food.
- Poisonous substances such as pesticides reached foods as a result of carelessness, accidents or improper storage or because they had been mistaken as food ingredients.
- Substances were added to foods in excess of culinary needs (e.g. monosodium glutamate) or processing needs (e.g. sodium nitrite).
- Food became contaminated during storage, e.g. through exposure to leaking or overflowing sewage.
- Contaminants penetrated cans or packages through seam defects or breaks.
- Food was contaminated by sewage during growth or production.

Factors affecting survival

- Food was cooked or heat-processed for an insufficient time or at an inadequate temperature.
- Previously cooked food was reheated for an insufficient time or at an inadequate temperature.
- Food was inadequately acidified.

Factors affecting microbial growth

- Cooked food was left at room temperature for an excessive time.
- Food was improperly cooled (e.g. stored in large pots or other large containers in refrigerator).
- Hot food was stored at a temperature that permitted multiplication of bacteria.
- Fermentation (and thus acid formation) was inadequate or slow.
- Inadequate concentrations of curing salts were added or curing time was too short.
- Low- and intermediate-moisture foods had elevated water activity, or there was condensation on these foods.
- By inhibiting competing organisms and providing favourable conditions (e.g. vacuum packing), the environment selectively permitted certain pathogens to multiply.

Other situations in which tracing contamination to raw foods may be important and should be considered include:

- The pathogen is uncommon, newly emerging or re-emerging or causes serious disease (e.g. *E. coli* O157).
- It can be expected that foods will be eaten raw or lightly heated (e.g. shellfish, fresh vegetables, shell eggs).
- Little is known about a pathogen and there is a need to advance knowledge about its ecology.
- Unlicensed or illegally sold foods were involved.
- It is suspected that foods were adulterated.
- The source of contamination is unusual.
- A new or unusual vehicle is involved.

In such situations, a "traceback", or tracing of the implicated food backwards through its distribution and production channels to its place of origin, is commonly performed. The purposes of such tracebacks include:

- identifying the source and distribution of foods in order to alert the public and remove the contaminated product from the marketplace;
- comparing the distribution of illnesses and distribution of product in order to strengthen an epidemiological association (sometimes referred to as an "epi" traceback);
- determining the potential route or source of contamination by evaluating common distribution sites, processors or growers.

Food tracebacks are often resource-intensive investigations requiring the coordination of many investigators from different agencies and organizations, often spread across different jurisdictions. Such investigations frequently require the review of detailed data on dates, quantities, sources and conditions of foods received, collection of original shipping containers and labels or other documentation, and information on lot numbers, facilities involved, production dates and the like. Traceback investigations can result in irreparable damage to food firms. It is therefore critical that each part of the investigation (epidemiological, laboratory and environmental) is thorough, complete and accurate.

An investigation at a farm or dairy will follow the same principles as the investigation of a food establishment. However, depending on the type of food product or animal involved, specific knowledge and skills may be needed to carry out the actual investigations. Most commonly, veterinarians, agriculturists, microbiologists and water supply experts will conduct these investigations in collaboration with epidemiologists.

Traceback investigations may lead to the identification of an ongoing public health threat and a consequent need to take appropriate actions, such as recall of foods, closing of a facility, confiscation of foods, or warning consumers of a potential risk. Investigators should be prepared to coordinate activities closely with other appropriate agencies and organizations to ensure a prompt and effective response as necessary.

4.4 Laboratory investigations

General

Most outbreaks of foodborne disease are microbiological in origin and their investigation will usually require a microbiology laboratory. Outbreaks caused by chemically contaminated

food also occur, although they are much less common than microbiological events. Symptoms resulting from both microbiological and chemical contamination can be similar and may be difficult to distinguish, even by laboratory tests. While the general principles of investigation apply to both types of incident, it is important to involve a chemical laboratory from the beginning if a chemical cause seems likely.

The role of the *clinical laboratory* in foodborne disease outbreak investigations includes:

- ensuring that appropriate clinical specimens are collected;
- arranging appropriate laboratory investigations of clinical samples;
- working with other members of the investigation team to identify and characterize the pathogen involved in the outbreak.

The role of the *food laboratory* in foodborne disease outbreak investigations includes:

- advising on appropriate samples to be taken from food;
- performing appropriate laboratory investigations of the food to identify the suspect pathogens, toxins or chemicals;
- advising on further sampling when a specific agent is found in the food (e.g. guiding collection of clinical specimens from food-handlers);
- working with the clinical laboratory to arrange for typing or additional characterization of organisms (e.g. serotyping, phage typing, molecular subtyping, antibiograms) as appropriate;
- supporting epidemiological and environmental investigations in detecting the pathogen in the implicated food and understanding how the outbreak occurred.

Microbiological analyses

In any outbreak of suspected foodborne disease, a microbiologist should be consulted as soon as possible. This person should be a member of the OCT.

Clinical samples

Diagnosis of most infectious diseases can be confirmed only if the etiological agent is isolated and identified from ill persons. This is particularly important when the clinical diagnosis is difficult to make because signs and symptoms are nonspecific, as is the case with many foodborne diseases. Faecal samples are the most commonly collected specimens; others include vomitus, urine, blood and clinical specimens (e.g. swabs from rectum, nostrils, skin or nasopharynx) obtained from food-handlers during the food investigations. If a disease has already been diagnosed, specimens should be collected according to Section 6.2. If a disease has not yet been diagnosed, specimen collection should be informed by clinical and epidemiological observations. Information on the collection, storage and transport of clinical specimens is provided in Annex 9.

If there is doubt about appropriate methods for collection, preservation (including selection of appropriate collection material) and shipment of specimens, guidance should be sought from the clinical laboratory. An indication should be given of how many samples are likely to be sent for analysis and whether the laboratory has sufficient resources to deal with them.

Clinical specimens should be taken from ill persons as soon as possible. Whenever possible, they should be taken from individuals who have not received antibiotic treatment for their illness. In large outbreaks, specimens should be obtained from at least 10 to 20 individuals (ideally 15 to 20% of all cases) who manifest illness typical of the outbreak and from some

exposed, but not ill, persons. Once the diagnosis has been confirmed, there is usually no need to obtain additional samples if individuals manifest characteristic symptoms. In smaller outbreaks, specimens should be collected from as many cases as practicable.

Specimens should be collected from persons who have been interviewed so that a link can be made between the laboratory and the epidemiological investigations. A unique identifier on the laboratory request form and the questionnaire will allow linkage of laboratory results with epidemiological information.

All containers should be labelled with a waterproof marking pen before or immediately after collection with the patient's name, identification, date and time of collection, and any other information required by the laboratory.

Molecular typing

Recent advances in laboratory methods have contributed substantially to improvements in the detection and investigation of foodborne disease outbreaks. Molecular microbiology technology has markedly changed the nature of many acute disease epidemiology investigations. Polymerase chain reaction (PCR) technology is increasingly being used for the rapid identification of pathogens and in many cases allows determination of subtypes that previously required time-consuming and resource-intensive methods.

Pulsed-field gel electrophoresis (PFGE) can provide "DNA fingerprints" of bacterial isolates; if the PFGE patterns of clinical and food specimens are the same, the investigators have additional evidence that the suspected food item is implicated in the event. PFGE can also help investigators to include related cases and exclude concurrent cases that are epidemiologically unrelated to an outbreak. Such subtyping can be particularly useful when a pathogen implicated in an outbreak is very common and its presence in related specimens (e.g. cases, food and farm animals) may be purely coincidental.

Genetic sequencing technology has become more readily available and has been useful for assessing the relatedness of various pathogens involved in outbreaks of foodborne and waterborne disease. For example, sequencing of hepatitis A viruses collected during three large outbreaks associated with green onions demonstrated that similar virus strains caused all three outbreaks and were related to hepatitis A strains commonly isolated from patients living in the region where the green onions were grown. Sequencing of noroviruses is also becoming increasingly useful in identifying relatedness among potential outbreak-associated viruses.

Many subtyping and molecular microbiology tests are available only at specialized reference laboratories, and may require coordination with the primary laboratory involved in an outbreak investigation.

Chemical investigations

The features of important chemical foodborne illnesses are summarized in Section 6.2. In acute chemical exposures, most toxins or their metabolites are rapidly cleared from easily accessible specimens such as blood; prompt collection and shipment of specimens is therefore of critical importance.

When collecting samples for chemical analyses it is important to closely collaborate with the analytical laboratory, make arrangements in advance for chemical samples to be analysed and

to seek advice about what specimens should be collected and how. The types of specimens to be collected will depend on the suspected chemicals (Annex 9). In an emergency where it is impossible to contact the laboratory, biological specimens (whole blood, serum, urine, vomitus) should be collected as soon as possible, sealed in a clean container and sent to the laboratory promptly. Substances from the ambient air, the collector's skin or clothes, or interfering substances in collection and storage supplies may be concentrated and measured along with the specimens, yielding inaccurate results. Because care must be taken to avoid cross-contamination, contaminant-free materials (such as specialized collection containers) may be provided by the laboratory to ensure that extraneous contamination is kept to a minimum. Consultation with the testing laboratory is important in accurately interpreting results.

Section 5
Control measures

5.1 General

The primary goal of outbreak investigations is to control ongoing public health threats and to prevent future outbreaks. Ideally, control measures should be guided by the results of these investigations but as this may delay the prevention of further cases it is often unacceptable from a public health perspective. At the same time, specific interventions – such as recalling a food product or closing food premises – can have serious economic and legal consequences and must be based on accurate information. Thus the implementation of control measures is often a balancing act between the responsibility to prevent further cases and the need to protect the credibility of an institution.

5.2 Control of source

Once investigations have identified an association between a particular food or food premises and transmission of the suspected pathogen, measures should be taken to control the source. Steps may include:

- removing implicated foods from the market (food recall, food seizure);
- modifying a food production or preparation process;
- closing food premises or prohibiting the sale or use of foods.

Closing food premises

If site inspections reveal a situation that poses a continuing health risk to consumers, it may be advisable to close the premises until the problem has been solved. This may be done with the agreement of the business or be enforced by law (closing order). Once premises have been closed they should be monitored by the responsible authorities and remain closed until appropriate authorities approve their reopening. The criteria for reopening of establishments may vary by jurisdiction and may involve input from various agencies involved in the investigation and control of the outbreak.

Removing implicated foods from the market

The objective of food recall and food seizure is to remove implicated foods as efficiently, rapidly and completely as possible from the market.

A **food recall** is undertaken by any business responsible for the manufacture, wholesale, distribution or retailing of the suspect food – from large corporations or partnerships to family-owned businesses – and may be initiated by the business itself or undertaken at the request of an appropriate health authority. **Food seizure** is the process by which an appropriate authority removes a food product from the market if the business does not comply with the request to recall. In most cases, businesses will comply with such a request to protect themselves from private lawsuits and damaged reputation where appropriate consumer protection legislation exists. Government regulatory agencies will often have an active role in removing implicated foods from distribution. In many situations, company recalls of products are carried out voluntarily at the suggestion of government authorities.

General

The longer the time that passes between a food appearing on the market and it being identified as a potential source, the less likely is recovery of that food.

The shelf-life of a food product will affect how much of it will be recovered. Most establishments ship fresh products (fresh meat, poultry, milk, etc.) to distributors on the day that they produce it, and distributors will quickly pass it on to hotels, institutions, retail stores and restaurants. The product is generally consumed within 3 to 7 days of production and the likelihood of recovery is poor.

Frozen or shelf-stable food products (e.g. cans, dried foods, packaged foods) are more likely to be recovered as there is less urgency to move them through the system. Thus, if these types of product are recalled, there is a good possibility that they will still be with distributors or retailers or on the consumers' shelves.

Procedure

Once investigations implicate a suspect food, a decision is needed on whether that food should be removed from the market. This decision may rest with agencies represented on the OCT or involve other bodies concerned with food safety. Such authorities must decide:

- whether the information available justifies removal of the food from the market;
- whether the product is still on the market;
- whether the product is likely to be in the homes of the consumer even though sold out at retail level;
- whether there is an ongoing risk to the consumer;
- how likely it is that the product can be recovered.

Authorities (such as the OCT) may be faced with presumptive findings that would justify a recall but without corroborative evidence. In such situations, a decision must be based on all factors in the particular case. For example, if a canned food product has been implicated as one of several potential sources in a botulism outbreak, all efforts would be made to retrieve the cans in circulation, including those in the hands of consumers, even at the risk of being wrong. It is vital that all information and decisions related to the need to remove an implicated food from the market are adequately documented.

Once the appropriate authorities have decided to recall a food product, they should:

- communicate with, and ensure the cooperation of the business(es), involved in the recall;
- directly advise local health authorities of the recall and any enforcement action required;
- ensure appropriate public notification;
- monitor the progress and effectiveness of the recall;
- ensure that corrective actions are taken by the recalling business.

The recalling business is usually responsible for conducting the actual recall. The extent of recall will depend on the potential risk to the consumer. A business may conduct a recall to the level of the retailer or, if public health is seriously jeopardized, to the level of the individual consumer. Means of notification will depend on the urgency of the situation and may include press releases, faxes, letters, telephone calls, and announcements on radio or television.

Efficient recall of a widely distributed product requires that a manufacturer can identify a product by production date or lot number and that distribution records for finished products are maintained for a period of time that exceeds the shelf-life of the product.

Communication with the public

Although the business may have already issued a press release, the OCT or food safety committee itself may decide to notify the public. Ideally, this should be done on the same day that the decision is taken to recall a food product. Information to the public should include:

- actions that consumers should take to prevent further exposure and illness;
- name and brand of the food product (including labelling) being recalled;
- the nature of the problem, the reason for recall of the product, and information about how the problem was discovered;
- name and location of the producing establishment and point of contact;
- locations where the product is likely to be found;
- numbers, amounts, and distribution;
- a description of common symptoms of the illness associated with the suspected pathogen or contaminant;
- appropriate food-handling information for consumers;
- actions that consumers should take if illness occurs.

Sometimes important new information becomes available after the initial release is published. This may necessitate a correction or update, or a complete revision and simultaneous removal from circulation of the first release.

Issuing a press release is of little use when consumers have not seen the product package or cannot identify the product directly, as in the case of products shipped to restaurants and large institutions. Efforts then should concentrate on issuing general food safety advice to the public.

Post-recall reporting by the business

After implementation of a food recall, the business should provide the food safety committee or other appropriate authorities with interim and final reports about the recall, which should contain the following information:

- copy of recall notice, letters to customers, retailers, etc;
- circumstances leading to recall;
- action taken by the business;
- extent of distribution of the batch of food that was recalled;
- result of recall (percentage of stock recovered or accounted for);
- method of disposal or reprocessing of recovered stock;
- difficulties experienced during recall;
- action proposed for the future to prevent a recurrence of the problem.

The interim and final reports thus give information about the effectiveness of the recall: if they are unsatisfactory, or evidence of corrective action is inadequate, further recall action may need to be considered.

Modifying a food production/preparation process

Once food investigations identify faults in production or preparation processes that may have contributed to the outbreak, corrective action must be taken immediately to avoid recurrences. Examples of corrective actions are modification of a recipe or of a process, reorganization of working practices, change in storage temperatures, or modification of instructions to consumers.

5.3 Control of transmission

Public advice

If a contaminated food product cannot be controlled at its source, steps need to be taken to eliminate or minimize the opportunities for further transmission of the pathogen. Depending on the situation, appropriate public advice may be issued during a period of hazard, for example:

- boiling of microbiologically contaminated water or avoidance of chemically contaminated water;
- advice on proper preparation of foods (see Annex 10, WHO Five Keys to Safer Food);
- advice to dispose of foods;
- emphasizing personal hygiene measures.

Exclusion of infected persons from work and school

The risk of infection being spread by infected individuals depends on their clinical picture and their standards of hygiene. People with diarrhoea are far more likely to spread infection than asymptomatic individuals with subclinical illness.

Decisions about exclusion from work must be made by health authorities in accordance with local laws and regulations. In general, the following groups with diarrhoea or vomiting should stay away from work or school until they are no longer infectious:

- food-handlers whose duties involve touching unwrapped foods to be consumed raw or without further cooking or other forms of treatment;
- people who have direct contact with highly susceptible patients or persons in whom gastrointestinal infection would have particularly serious consequences (e.g. the young, the elderly, the immunocompromised);
- children aged under 5 years;
- older children and adults with doubtful personal hygiene or with unsatisfactory toilet, hand-washing or hand-drying facilities at home, work or school.

Even if clinically well, no person with any of the following conditions should handle unpackaged food:

- excretor of *Salmonella typhi* or *Salmonella paratyphi*;
- excretor of the etiological agents of cholera, amoebic dysentery or bacillary dysentery;
- hepatitis A or hepatitis E and all other forms of acute hepatitis until diagnosed as other than hepatitis A or hepatitis E;
- *Taenia solium* (pork tapeworm) infection;
- tuberculosis (in the infectious state).

More specific exclusion criteria are provided in Section 6.3. Otherwise, clinically healthy persons who are asymptomatic excretors of enteric pathogens and have good hygiene pose a minimal risk and do not need to be excluded from work or school.

If an ill food-handler was implicated in an outbreak, recommendations should be made for preventing such problems in the future, such as ensuring that mechanisms are in place for routine screening to prevent ill persons from working.

Advice on personal hygiene

Advice on personal hygiene should be issued to all individuals with gastrointestinal disease and should include the following:

- Avoid preparing food for other people until free from diarrhoea or vomiting.
- Thoroughly wash hands after defecation, urination and before meals. Thorough hand-washing with soap in warm running water and drying is the most important factor in preventing the spread of enteric diseases.
- Use your own separate towels to dry hands. Institutions, particularly schools, should use liquid soaps and disposable towels or hand-dryers.
- Clean toilet seats, flush handles, hand-basin taps and toilet door handles with disinfectant after use. If young children are infected, these cleaning procedures must be undertaken on their behalf. Similar arrangements may also be necessary in schools and residential institutions (if temporary exclusion is not possible).
- If employed in food preparation activities, scrub your nails with soap and a brush.

Infection control precautions

Infection control precautions for hospitalized and institutionalized persons with infectious diarrhoea (in particular, easily transmissible infections such as *Salmonella typhi*, *Shigella*, etc.) include:

- isolation of patients (e.g. in a private room with separate toilet if possible);
- barrier-nursing precautions;
- strict control of the disposal or decontamination of contaminated clothing and bedding;
- strict observation of personal hygiene measures (see above).

Protecting risk groups

Certain groups are at particularly high risk of severe illness and poor outcomes after exposure to a foodborne disease. Safe food-handling practices, including strict adherence to thorough hand-washing, should be particularly emphasized to such people. Specific advice for risk groups may be considered in some circumstances. Examples include advice to:

- pregnant women against consumption of unpasteurized milk, unpasteurized cheeses, and other foods potentially contaminated with *Listeria*;
- immunocompromised persons, such as those with HIV/AIDS, to avoid eating unpasteurized milk products, raw fish, etc;
- persons with underlying liver disease to avoid consumption of raw oysters and other food that may transmit *Vibrio* bacteria;
- persons with underlying chronic viral hepatitis B or C or other liver disease to be vaccinated against hepatitis A if appropriate;
- personnel of day-care centres about receiving vaccination or immunoglobulin during a hepatitis A outbreak in the institution (although this is more likely to protect against secondary spread than against foodborne transmission).

5.4 End of outbreak

Review of outbreak

The OCT should formally decide when an outbreak is over and issue a statement to this effect.

A structured review should follow all outbreaks for which an OCT is convened and should include a formal debriefing meeting with all parties involved in the investigation. The aims of debriefing are to:

- ensure that control measures for the outbreak are effective;
- identify long-term and structural control measures and plan their implementation;
- assess whether further scientific studies should be conducted;
- clarify resource needs, structural changes or training needs to optimize future outbreak response;
- identify factors that compromised the investigations and seek solutions;
- change current guidelines and develop new materials as required;
- discuss legal issues that may have arisen;
- arrange for completion of the final outbreak report.

A "brainstorming" session, held in an open and positive environment, may produce additional valuable suggestions and ideas not addressed during the formal debriefing. Consideration should be given to using an external facilitator for the review sessions.

Outbreak report

An interim report should be made available by the OCT 2 to 4 weeks after the end of the investigations, followed by a written final report. The final report should be comprehensive, protect confidentiality and be circulated to appropriate individuals and authorities. The report should follow the usual scientific format of an outbreak investigation report (see Annex 6) and include a statement about the effectiveness of the investigation, the control measures taken and recommendations for the future.

In addition, a summary report should be completed and forwarded to the appropriate authorities at national level for collation, analysis (see Annex 6) and, when appropriate, reporting to the international level (e.g. SalmNet, EnterNet, WHO, etc.).

Future studies, research

Further studies may be conducted after completion of the initial investigations, particularly if new or unusual pathogens were involved or additional information for risk assessment of a particular pathogen is required. The need to catch up on routine work delayed by the outbreak investigation often makes it difficult to conduct such follow-up studies. Nevertheless, it is important that these opportunities be considered following each outbreak – either by OCT members themselves or by others who may be in a better position to do this. Details of the outbreak may also be published in an international journal in order to inform the scientific community at large.

Economic evaluations of outbreaks and associated control efforts can be important in assessing the cost-effectiveness of outbreak investigations and food safety measures. Foodborne outbreaks will incur costs to:

- health care providers (diagnostic and curative services);

- the population (medication, time missed from school or work, reduced activity as a consequence of long-term sequelae, death);
- the food industry (closure, adverse publicity, recall, litigation);
- agencies, laboratories and other persons and organizations involved in the investigation, response and control activities.

Costs associated with outbreaks can be enormous, and quantifying them may help to increase the commitment of the food industry and other agencies to food safety.

Section 6

Features of important foodborne diseases

6.1 Foodborne pathogens, toxins and chemicals of public health importance

It has to be noted that the following is not a complete list of all foodborne diseases, and investigators need to be aware of the possibility of other or newly emerging foodborne hazards. Detailed microbiological, epidemiological and clinical information about these organisms is provided in Section 6.3 (marked below with an asterisk).

Pathogenic bacteria

*Aeromonas hydrophila**
*Bacillus cereus**
Brucella spp*
Campylobacter spp*
*Clostridium botulinum**
*Clostridium perfringens**
Escherichia coli spp*
- enterotoxigenic *E. coli* (ETEC)
- enteropathogenic *E. coli* (EPEC)
- enterohaemorrhagic *E. coli* (EHEC)
- enteroinvasive *E. coli* (EIEC)

*Listeria monocytogenes**
Mycobacterium bovis
Salmonella typhi and *S. paratyphi**
Salmonella (non-*typhi*) spp*
Shigella spp*
*Staphylococcus aureus**
Vibrio cholerae O1*
*Vibrio parahaemolyticus**
*Vibrio vulnificus**
*Yersinia enterocolitica**

Viruses

Hepatitis A virus*
Hepatitis E virus
Small, round, structured viruses (SRSVs), including norovirus
Poliovirus*
Rotavirus

Protozoa

Cryptosporidium spp*
*Entamoeba histolytica**
*Giardia lamblia**
*Toxoplasma gondii**
Cyclospora cayetanensis

Trematodes

*Clonorchis sinensis**
*Fasciola hepatica**
Fasciolopsis buski
*Opisthorchis felineus**
*Opisthorchis viverrini**
*Paragonimus westermani**

Cestodes

Diphyllobothrium spp
*Echinococcus s*pp
Taenia solium and *T. saginatum**

Nematodes

Anisakis spp*
*Ascaris lumbricoides** and *Trichuris trichiura*
*Trichinella spiralis**
Trichuris trichiura

Natural toxins

Marine biotoxins
- ciguatera poisoning
- shellfish toxins (paralytic, neurotoxic, diarrhoeal, amnesic)
- scombroid poisoning/histamine
- tetrodotoxin (pufferfish)

Mushroom toxins
Mycotoxins (e.g. aflatoxins)
Plant toxicants
Pyrrolizidine alkaloids
Phytohaemagglutinin (red kidney bean poisoning)
Grayanotoxin (honey intoxication)

Chemicals

Pesticides (organophosphates, antimony)
Toxic metals (cadmium, copper, lead, mercury, tin)
Polychlorinated biphenyls
Radionuclides
Fluoride
Zinc
Nitrites (food preservatives)
Sodium hydroxide
Monosodium glutamate

6.2 Major foodborne hazards: predominant clinical features

Approximate time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Appropriate samples from cases (food-handlers)
Upper gastrointestinal tract symptoms (nausea, vomiting) occur first or predominate			
Less than 1 hour	Nausea, vomiting, unusual taste, burning of mouth.	Metallic salts	Vomit, urine, blood, stool
1–2 hours	Nausea, vomiting, cyanosis, headache, dizziness, dyspnoea, trembling, weakness, loss of consciousness.	Nitrites	Blood
1–6 (mean 2–4) hours	Nausea, vomiting, retching, diarrhoea, abdominal pain, prostration.	*Staphylococcus aureus* and its enterotoxins	Stool, vomit, (swabs from nostril, skin lesions)
8–16 hours (2–4 hours if emesis predominant)	Vomiting, abdominal cramps, diarrhoea, nausea.	*Bacillus cereus*	Rectal swab, stool
6–24 hours	Nausea, vomiting, diarrhoea, thirst, dilation of pupils, collapse, coma.	Mycotoxins (*Amanita* sp. fungi)	Urine, blood (SGOT, SGPT), vomit
12–48 (median 36) hours	Nausea, vomiting, watery non-bloody diarrhoea, dehydration.	Norovirus	Stool
Sore throat and respiratory symptoms occur			
12–72 hours	Sore throat, fever, nausea, vomiting, rhinorrhoea, sometimes a rash.	*Streptococcus pyogenes*	Rectal swab, stool
2–5 days	Inflamed throat and nose, spreading greyish exudate, fever, chills, sore throat, malaise, dysphagia, oedema of cervical lymph node.	*Corynebacterium diphtheriae*	Swabs of skin lesions, nose, oropharynx, blood for toxin testing

Approximate time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Appropriate samples from cases (food-handlers)
Lower gastrointestinal tract symptoms (abdominal cramps, diarrhoea) occur first or predominate			
2–36 (mean 6–12) hours	Abdominal cramps, diarrhoea, putrefactive diarrhoea (*Clostridium perfringens*), sometimes nausea and vomiting.	*Clostridium perfringens, Bacillus cereus, Streptococcus faecalis, S. faecium*	Rectal swabs, stool
6–96 hours (usually 1–3 days)	Fever, abdominal cramps, diarrhoea, vomiting, headache.	*Salmonella* spp, *Shigella*, *Aeromonas*, enteropathogenic *E. coli*	Rectal swabs, stool
6 hours to 5 days	Abdominal cramps, diarrhoea, vomiting, fever, malaise, nausea, headache, dehydration. Sometimes bloody or mucoid diarrhoea, cutaneous lesions associated with *Vibrio vulnificus*.	*Vibrio cholerae* (O1 and non-O1), *V. vulnificus*, *V. fluvialis, V. parahaemolyticus*	Stool
1–10 (median 3–4) days	Diarrhoea (often bloody), abdominal pain, nausea, vomiting, malaise, fever (uncommon with *E. coli* O157).	Enterohaemorrhagic *E. coli* (including *E. coli* O157), *Campylobacter*	Stool, rectal swabs
3–5 days	Fever, vomiting, watery non-inflammatory diarrhoea.	Rotavirus, astrovirus, enteric adenovirus	Stool, vomit
3–7 days	Fever, diarrhoea, abdominal pain. Can mimic acute appendicitis.	*Yersinia enterocolitica*	Stool
1–6 weeks	Mucoid diarrhoea (fatty stools) abdominal pain, flatulence, weight loss.	*Giardia lamblia*	Stool
1 to several weeks	Abdominal pain, diarrhoea, constipation, headache, drowsiness, ulcers, variable – often asymptomatic.	*Entamoeba histolytica*	Stool
3–6 months	Nervousness, insomnia, hunger pains, anorexia, weight loss, abdominal pain, sometimes gastroenteritis.	*Taenia saginata, T. solium*	Stool, rectal swab

Approximate time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Appropriate samples from cases (food-handlers)
	Neurological symptoms (visual disturbances, vertigo, tingling, paralysis)		
Less than 1 hour	Neurological and/or gastrointestinal symptoms.	Shellfish toxin (see final section of this table)	Gastric washing
	Gastroenteritis, nervousness, blurred vision, chest pain, cyanosis, twitching, convulsions.	Organic phosphate	Blood, urine, fat biopsy
	Excessive salivation, perspiration, gastroenteritis, irregular pulse, pupils constricted, asthmatic breathing.	Muscaria-type mushrooms	Vomit
	Tingling and numbness, dizziness, pallor, gastric haemorrhage, and desquamation of skin, fixed gaze, loss of reflexes, twitching, paralysis.	Tetradon (tetrodotoxin) toxins	
1–6 hours	Tingling and numbness, gastroenteritis, temperature reversal, dizziness, dry mouth, muscular aches, dilated pupils, blurred vision, paralysis.	Ciguatera toxin	
	Nausea, vomiting, tingling, dizziness, weakness, anorexia, weight loss, confusion.	Chlorinated hydrocarbons (insecticides, pesticides)	Blood, urine, stool, gastric washing
2 hours to 6 days, usually 12–36 hours	Vertigo, double or blurred vision, loss of light reflex, difficulty in swallowing, speaking and breathing, dry mouth, weakness, respiratory paralysis. Characteristic syndrome is descending, bilateral flaccid paralysis, starting with cranial nerves and with preserved sensorium.	*Clostridium botulinum* and its neurotoxins	Blood, stool, gastric washing
More than 72 hours	Numbness, weakness of legs, spastic paralysis, impairment of vision, blindness, coma.	Organic mercury	Urine, blood, hair
	Gastroenteritis, leg pain, ungainly high-stepping gait, foot and wrist drop.	Triorthocresyl phosphate (oil substitute)	Muscle tissue

Approximate time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Appropriate samples from cases (food-handlers)
	Allergic symptoms (facial flushing, itching)		
Less than 1 hour	Headache, dizziness, nausea, vomiting, peppery taste in mouth, burning of throat, facial swelling and flushing, stomach pain, itching of skin.	Histamine (scombroid)	Vomit
	Numbness around mouth, tingling sensation, flushing, dizziness, headache, nausea.	Monosodium glutamate	
	Flushing, sensation of warmth, itching, abdominal pain, puffing of face and knees.	Nicotinic acid (food additive, preservative)	
	Generalized infection symptoms (fever, chills, malaise, prostration, aches, swollen lymph nodes)		
4–28 (mean 9) days	Gastroenteritis, fever, oedema around eyes, perspiration, muscular pain, chills, prostration, laboured breathing.	*Trichinella spiralis*	Serum, muscle tissue (biopsy)
7–28 (mean 14) days	Malaise, headache, fever, cough, nausea, vomiting, constipation, abdominal pain, chills, rose spots, bloody stools.	*Salmonella typhi*	Rectal swab, stool
10–13 days	Fever, headache, myalgia, rash.	*Toxoplasma gondii*	Lymph node biopsy, blood
Varying periods (depends on specific illness)	Fever, chills, headache, arthralgia, prostration, malaise, swollen lymph nodes and other specific symptoms of disease in question.	*Bacillus anthracis, Brucella melitensis, B. abortus, B. suis, Coxiella burnetii, Francisella tularensis, Listeria monocytogenes, Mycobacterium tuberculosis, Mycobacterium* spp, *Pasteurella multocida, Streptobacillus moniliformis, Campylobacter jejuni, Leptospira* spp	

Approximate time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Appropriate samples from cases (food-handlers)
	Gastrointestinal and/or neurological symptoms		
0.5–2 hours	Tingling, burning, numbness, drowsiness, incoherent speech, respiratory paralysis.	Paralytic shellfish poisoning (PSP) (saxitoxins) – mussels, clams	Gastric washing
2–5 minutes to 3–4 hours	Reversal of hot and cold sensation, tingling; numbness of lips, tongue and throat; muscle aches, dizziness, diarrhoea, vomiting.	Neurotoxic shellfish poisoning (NSP) (brevetoxins)	Gastric washing
30 minutes to 2–3 hours	Nausea, vomiting, diarrhoea, abdominal pain, chills, fever.	Diarrhoeal shellfish poisoning (DSP) (dinophysis toxin, okadaic acid, pectenotoxin, yessotoxin)	Gastric washing
24 hours (gastrointestinal) to 48 hours (neurological)	Vomiting, diarrhoea, abdominal pain, confusion, memory loss, disorientation, seizure, coma.	Amnesic shellfish poisoning (ASP) (domoic acid)	Gastric washing

6.3 Major foodborne diseases: epidemiology and methods of control and prevention

The **incidence** of foodborne diseases, based on available data, is rated as:

+	≤1 case per 100 000 population
++	>1 to 100 cases per 100 000
+++	>100 cases per 100 000.

The completeness of reporting varies substantially by jurisdiction, and it is probable that most diseases are significantly underreported.

Disease-specific exclusion criteria are mentioned as appropriate under *Specific control measures* in the tables that follow. Reference is made to risk groups according to the following classification:

- Group I: food-handlers whose work involves touching unwrapped foods that will be consumed raw or without further cooking or other treatment.
- Group II: persons with direct contact with highly susceptible patients, or persons in whom gastrointestinal infection would have particularly serious consequences (e.g. the young, the elderly, the ill).
- Group III: children aged under 5 years.
- Group IV: older children and adults with doubtful personal hygiene or with unsatisfactory toilet, hand-washing or hand-drying facilities at home, work or school.

These classifications are for general guidance only; laws and regulations may vary considerably with jurisdiction.

Name of illness	***Aeromonas* enteritis**
Etiological agent	Bacterium: *Aeromonas hydrophila*.
Characteristics of agent	Gram-negative, motile, non-spore-forming, facultatively anaerobic, straight or curved rod. No growth in 4–5% salt or at pH <6. Optimum temperature 28 °C but growth may occur at temperatures as low as 4 °C. Many strains have the ability to grow over a pH range of 4–10 under otherwise optimum conditions.
Incubation period	24–48 hours.
Symptoms	Watery stools, abdominal cramps, mild fever, vomiting.
Sequelae	Bronchopneumonia, cholecystitis.
Duration	Days to weeks.
Reservoir/source	Common in aquatic environments, sewage.
Mode of transmission and associated foods	Seafood (fish, shrimp, oysters), snails, drinking-water; isolated from a wide range of foods.
Specific control measures	*Industrial:* Treatment and disinfection of water supplies; food irradiation; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Thorough cooking of food; proper storage of ready-to-eat foods
Occurrence	Worldwide. Sporadic outbreaks have been reported from Africa, Australia, Europe, Japan and North America. Incidence unknown.
Other comments	Opportunistic pathogen.

Name of illness	**Amoebiasis (amoebic dysentery)**
Etiological agent	Protozoa: *Entamoeba histolytica*.
Characteristics of agent	Amoeboid, aerotolerant anaerobe that survives in the environment in an encysted form. Cysts remain viable and infective in faeces for several days, in soil for at least 8 days at 28−34 °C (and for >1 month at 10 °C). Relatively resistant to chlorine.
Incubation period	2−4 weeks (range several days to several months).
Symptoms	Sever bloody diarrhoea, stomach pains, fever and vomiting. Most infections remain symptomless.
Sequelae	Liver abscess.
Duration	Weeks to months.
Reservoir/source	Mainly humans, but also dogs and rats. The organism is also found in nightsoil and sewage used for irrigation.
Mode of transmission and associated foods	Transmission occurs mainly through the ingestion of faecally contaminated food and water containing cysts. Cysts are excreted in large numbers (up to 5 x 10^7 cysts per day) by an infected individual. Illness is spread by faecal−oral route, person-to-person contact or faecally contaminated food and water. Foods involved include fruit and vegetables and drinking-water.
Specific control measures	*Industrial:* Filtration and disinfection of water supply; hygienic disposal of sewage water; treatment of irrigation water; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Boiling of water when safe water is not available; thorough washing of fruits and vegetables; thorough cooking of food; thorough hand-washing.
Occurrence	Worldwide, particularly in young adults. Incidence in industrialized countries +, in developing countries with poor sanitation ++.
Other comments	

Name of illness	**Anisakiasis**
Etiological agent	Helminth, nematode: *Anisakis* spp.
Characteristics of agent	Slender, threadlike nematode, measuring 1.5–1.6 cm in length and 0.1 cm in diameter.
Incubation period	Several hours; intestinal symptoms after several days or weeks.
Symptoms	The motile larvae burrow into the stomach wall producing acute ulceration and nausea, vomiting and epigastric pain, sometimes with haematemesis. They migrate and attach themselves to the oropharynx, causing coughing; in the small intestine they cause eosinophilic abscesses.
Sequelae	Chronic abdominal pain, abdominal mass.
Duration	Usually resolves within 2 weeks, rarely persists months to years.
Reservoir/source	Sea mammals (for *Anisakis* spp. that are parasitic to man).
Mode of transmission and associated foods	Consumption of the muscles of some saltwater fish that have been inadequately processed. Foods involved include raw fish dishes (e.g. sushi, sashimi, herring, cebiche).
Specific control measures	*Industrial:* Irradiation; heat treatment, freezing, candling, cleaning (evisceration) of fish as soon as possible after they are caught (will prevent post-mortem migration of infective larvae from the mesenteries of the fish to muscles); thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Cleaning of fish; thorough cooking before consumption; freezing (–23 °C for 7 days).
Occurrence	Mainly in countries where consumption of raw or inadequately processed fish is common, e.g. northern Europe, Japan, Latin America. More than 12 000 cases have been reported in Japan. Cases have also been reported in other parts of the world as eating habits change with immigration.
Other comments	Symptoms mimic those of appendicitis.

Name of illness	**Ascariasis**
Etiological agent	Helminth, nematode: *Ascaris lumbricoides.*
Characteristics of agent	Large nematode (roundworm) infecting the small intestine. Adult males measure 15–31 cm x 2–4 mm, females 20–40 cm x 3–6mm. Eggs undergo embryonation in the soil; after 2–3 weeks they become infective and may remain viable for several months or even years in favourable soils. The larvae emerge from the egg in the duodenum, penetrate the intestinal wall and reach heart and lungs via the blood. Larvae grow and develop in the lungs; 9–10 days after infection they break out of the pulmonary capillaries into the alveoli and migrate through the bronchial tubes and trachea of the pharynx where they are swallowed, reaching the intestine 14–20 days after infection. In the intestine they develop into adults and begin laying eggs 40–60 days after ingestion of the embryonated eggs. The life cycle is complete after 8 weeks.
Incubation period	First appearance of eggs in stools 60–70 days following ingestion of the eggs. Symptoms of larval ascariasis appear occur 4–16 days after infection.
Symptoms	Generally asymptomatic. Gastrointestinal discomfort, colic and vomiting; fever; observation of live worms in stools. Some patients may have pulmonary symptoms or neurological disorders during migration of the larvae.
Sequelae	A heavy worm infestation may cause nutritional deficiency; other complications, sometimes fatal, include obstruction of the bowel by a bolus of worms (observed particularly in children), obstruction of the bile duct or pancreatic duct.
Duration	Adult worms can live 12 months or more.
Reservoir/source	Humans; soil and vegetation on which faecal matter containing eggs have been deposited.
Mode of transmission and associated foods	Ingestion of infective eggs from soil contaminated with faeces or of contaminated vegetables and water.
Specific control measures	Use of toilet facilities; safe excreta disposal; protection of food from dirt and soil; thorough washing of produce. Food dropped on the floor should not be eaten without washing or cooking, particularly in endemic areas. Thermal processing, good hygiene practices during production and processing.
Occurrence	Worldwide. Incidence + to +++ depending on region. High prevalence (>50%) in humid and tropical countries.
Other comments	In endemic areas highest prevalence is among children aged 3–8 years.

Name of illness	***Bacillus cereus* gastroenteritis** a) Diarrhoeal syndrome. b) Emetic syndrome.
Etiological agent	Bacterial toxin: *Bacillus cereus*. a) Diarrhoeal toxin causing toxico-infection due to production of heat-labile toxins either in the gut or in food. b) Emetic toxin causing intoxication due to heat-stable toxin produced in food.
Characteristics of agent	Gram-positive, facultatively anaerobic, motile rod that produces heat-resistant spores; generally mesophilic, grows at 10−50 °C (optimum temperature 28−37 °C), pH 4.3−9.3 and water activity (a_w) >0.92. Spores are moderately heat-resistant and survive freezing and drying. Some strains require heat activation for spores to germinate and outgrow.
Incubation period	a) Diarrhoeal syndrome: 8−16 hours. b) Emetic syndrome: 1−5 hours.
Symptoms	a) Diarrhoeal syndrome: acute diarrhoea, nausea and abdominal pain. b) Emetic syndrome: acute nausea, vomiting and abdominal pain and sometimes diarrhoea.
Sequelae	Rare with toxin-mediated gastrointestinal disease; invasive disease can have protean manifestations.
Duration	a) Diarrhoeal syndrome: 24−36 hours. b) Emetic syndrome: 24−36 hours.
Reservoir/source	Widely distributed in nature (soil).
Mode of transmission and associated foods	Ingestion of food that has been stored at ambient temperatures after cooking, permitting the growth of bacterial spores and toxin production. Many outbreaks (particularly those of the emetic syndrome) are associated with cooked or fried rice that has been kept at ambient temperature. Foods involved include starchy products such as boiled or fried rice, spices, dried foods, milk, dairy products, vegetable dishes, and sauces.
Specific control measures	Food service establishment/household: Effective temperature control to prevent spore germination and growth. Food storage at >70 °C or <10 °C until use unless other factors (pH, a_w) prevent growth. When refrigeration facilities are not available, cook only quantities required for immediate consumption. Toxins associated with emetic syndrome are heat-resistant and reheating, including stir-frying, will not destroy them. Good hygiene practices during production and processing.
Occurrence	Worldwide. Incidence ++/+++.

Name of illness	**Botulism**
Etiological agent	Bacterial toxin: *Clostridium botulinum*.
Characteristics of agent	Gram-positive, spore-forming, anaerobic, motile rods that produce seven potent neurotoxins A–G; only A, B, E and, infrequently, F have been associated with disease (*Clostridium botulinum*). Toxins are potentially lethal in very small doses, binding to the neuromuscular junction, blocking nerve transmission and causing flaccid paralysis. Proteolytic strains of *C. botulinum* producing toxin types A, B and F are mesophilic, growing at 10–50 °C. Non-proteolytic strains producing toxin types B, E and F are psychrotrophic and grow at temperatures as low as 3.3 °C. Minimum a_w for growth is 0.93–0.94 and minimum pH 4.6 (proteolytic strains) or 5.0 (non-proteolytic strains). Toxins are heat-labile and can be destroyed by adequate heat treatment (boiling for 15 minutes). Spores are resistant to normal cooking temperatures and survive drying and freezing.
Incubation period	12–36 hours (range several hours to 8 days).
Symptoms	Vomiting, abdominal pain, fatigue, muscle weakness, headache, dizziness, ocular disturbance (blurred or double vision, dilated pupils, unreactive to light), constipation, dry mouth and difficulty in swallowing and speaking, and ultimately paralysis and respiratory or heart failure.
Sequelae	Paralysis of breathing causes death unless mechanical ventilation is provided. Case mortality rate is 5–10% in developing countries.
Duration	From several days to 8 months.
Reservoir/source	Soil, marine and freshwater sediments; intestinal tracts of fish, animals, birds and insects.
Mode of transmission and associated foods	Ingestion of toxin pre-formed in food. This may occur when raw or under-processed foods are stored in anaerobic conditions that allow growth of the organism. Most outbreaks are due to faulty preservation of food (particularly in homes or cottage industries), e.g. canning, fermentation, curing, smoking, or acid or oil preservation. Examples of foods involved include vegetables, condiments (e.g. pepper), fish and fish products (type E), meat and meat products. Several outbreaks have occurred as a result of consumption of uneviscerated fish, garlic in oil and baked potatoes. Honey is a common vehicle of transmission of infant botulism.
Specific control measures	Toxin destroyed by boiling – spores require a much higher temperature. *Industrial:* Heat sterilization; use of nitrites in pasteurized meat; thermal processing, good hygiene practices during production and processing. *Food service establishment/household*: Acid-preservation of food at low pH (<4.6); thorough cooking of home-canned food (boil and stir for 15 minutes); refrigerated storage of food, particularly vacuum-packed, fresh or lightly cured/smoked food. *Consumers* should avoid giving honey or foods containing honey to infants; discard swollen cans.
Occurrence	Worldwide; particularly frequent among Alaskan populations. Incidence +.
Other comments	Case–fatality ratio in industrialized countries 5–10%.

Name of illness	**Brucellosis (undulant fever)**
Etiological agent	Bacteria: a) *Brucella abortus*. b) *Brucella melitensis.* c) *Brucella suis.*
Characteristics of agent	Gram-negative, aerobic, non-spore-forming, short, oval, non-motile rods that grow optimally at 37 °C and pH 6.6−7.4; heat-labile.
Incubation period	Variable; several days to several weeks/months.
Symptoms	Continuous, intermittent or irregular fever, lassitude, sweat, headache, chills, constipation, arthralgias, generalized aching, weight loss, anorexia.
Sequelae	Bouts of fever, osteoarticular complications in 20−60% of cases, sacroiliitis, genitourinary complications (including orchitis, epididymitis, sexual impotence), cardiovascular and neurological conditions, insomnia, depression.
Duration	Weeks.
Reservoir/source	a) *Brucella abortus*: cows. b) *Brucella melitensis*: sheep and goats. c) *Brucella suis*: pigs.
Mode of transmission and associated foods	Contracted principally from close association with infected animals and therefore an occupational disease of farmers, herdsmen, veterinarians and slaughterhouse workers. Can also be contracted by consumption of milk (usually goat's or sheep's milk) and products made from unpasteurized milk (e.g. fresh goat's cheese).
Specific control measures	*Industrial*: Heat treatment of milk (pasteurization or sterilization); use of pasteurized milk for cheese production, ageing cheese for at least 90 days; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Heat treatment of milk (boiling). *Other:* Vaccination of animals; eradication of diseased animals (testing and slaughtering). *Consumers* should avoid consumption of raw milk and cheese made with raw milk.
Occurrence	Worldwide, with the exception of parts of northern Europe where it occurs rarely. Incidence in North America is decreasing (currently annual incidence in USA <120 cases). Prevalent in eastern Mediterranean areas, southern Europe, north and east Africa, central and southern Asia (India), Mexico, Central and South America. Incidence + /++, depending on region.
Other comments	Disease often unrecognized and unreported. Susceptible to antibiotic treatment. Case–fatality ratio up to 2% if disease untreated.

Name of illness	**Campylobacteriosis**
Etiological agent	Bacteria: *Campylobacter jejuni* and *Campylobacter coli*.
Characteristics of agent	Gram-negative, non-spore-forming, curved or spiral, motile rods that are sensitive to oxygen (grow best at low oxygen levels in presence of carbon dioxide). Optimum pH 6.5−7.5, optimum temperature 42−45 °C, no growth below 28−30 °C. Very sensitive to heat, salt, reduced pH levels (<6.5) and dry conditions. The organism survives better in cold conditions than at ambient temperatures.
Incubation period	Typically 2−5 days (range 1−11 days).
Symptoms	Fever, severe abdominal pain, nausea and diarrhoea which can vary from slight to profuse and watery, sometimes containing blood or mucus.
Sequelae	Occur in 2−10% of cases and include reactive arthritis, Guillain-Barré syndrome, haemolytic uraemic syndrome, meningitis, pancreatitis, cholecystitis, colitis, endocarditis, erythema nodosum.
Duration	Up to 10 days; excretion of the organism can continue for 2−3 weeks.
Reservoir/source	Domestic animals (cats, dogs), livestock (pigs, cattle, sheep), birds (poultry), polluted water.
Mode of transmission and associated foods	Principally through ingestion of contaminated food. Main food sources are raw milk and raw or undercooked poultry. Spread to other foods by cross-contamination or contamination with untreated water; contact with animals and birds. Other sources of transmission are contact with live animals (pets and farm animals). Person-to-person transmission occurs during the infectious period that ranges from several days to several weeks. Foods involved include raw milk, poultry, beef, pork and drinking-water.
Specific control measures	*Industrial*: Heat treatment (pasteurization/sterilization of milk); hygienic slaughter and processing procedures; irradiation of meat and poultry; treatment of water; good hygiene practices during production and processing. *Food service establishment/household*: Heat treatment of milk (boiling); thorough cooking of all meat; washing of salads; prevention of cross-contamination of contact surfaces; personal hygiene in food preparation (hand-washing after contact with animals); keeping pets away from food-handling areas. *Consumers* should avoid eating raw or partially-cooked poultry or drinking raw milk.
Occurrence	Worldwide. One of the most frequently reported foodborne diseases in industrialized countries; a major cause of infant and traveller's diarrhoea in developing countries. *Campylobacter* spp. cause 10–15% of cases of diarrhoeal disease in children seen at treatment centres. Incidence in industrialized countries ++, in developing countries +++.
Other comments	Many infections are asymptomatic. Infected individuals not treated with antibiotics may excrete the organisms for as long as 2−7 weeks. Infection is sometimes misdiagnosed as appendicitis. Sporadic cases occur more frequently in warmer months. Case–fatality ratio in industrialized countries about 0.05%. Infants and young children are the most susceptible.

Name of illness	**Cholera**
Etiological agent	Bacterial toxin: *Vibrio cholerae* O1 and O139. *V. cholerae* O1 includes two biotypes – classical and El Tor – each of which includes organisms of Ogawa, Inaba (and rarely) Hikojima serotypes.
Characteristics of agent	Gram-negative, facultatively anaerobic, motile, non-spore-forming rods that grow at 18–42 °C (optimum 37 °C), pH 6–11 (optimum 7.6), a_w 0.97. Growth is stimulated by salinity levels of around 3% but prevented by levels of 6%. Organism is resistant to freezing but sensitive to heat and acid. May survive for some days on fruit and vegetables. *V. cholerae* is non-invasive and diarrhoea is mediated by cholera toxin formed in the gut (toxico-infection).
Incubation period	1–3 days.
Symptoms	Profuse watery diarrhoea, which can lead to severe dehydration, collapse and death within a few hours unless lost fluid and salt are replaced; abdominal pain and vomiting.
Sequelae	Chronic biliary infection is rare but can last for years, with intermittent shedding.
Duration	Up to 7 days
Reservoir/source	Humans. *V. cholerae* is often found in aquatic environments and is part of the normal flora in brackish water and estuaries.
Mode of transmission and associated foods	Food and water contaminated through contact with faecal matter or infected food handlers. Contamination of vegetables may occur through sewage or wastewater used for irrigation. Person-to-person transmission through the faecal–oral route is also an important mode of transmission. Foods involved include seafood, vegetables, cooked rice and ice.
Specific control measures	*Industrial*: Safe disposal of excreta and sewage/wastewater; treatment of drinking-water (e.g. chlorination, irradiation); heat treatment of foods (e.g. canning); high pressure treatment; good hygiene practices during production and processing. *Food service establishment/household*: Personal hygiene (hand-washing with soap and water); thorough cooking of food and careful washing of fruit and vegetables; boiling drinking-water when safe water is not available. *Consumers* should avoid eating raw seafood. Oral vaccines have recently become available in some countries. Although no country or territory currently requires vaccination against cholera as a condition for entry, local authorities may require documentation of vaccination.
Occurrence	Africa, Asia, parts of Europe and Latin America. In most industrialized countries, reported cholera cases are imported by travellers or occur as a result of imported food.
Other comments	In endemic areas, cholera occurs mainly in children because of lack of prior immunity; during epidemics, children and adults are equally susceptible. Case–fatality ratio <1% with adequate treatment but may exceed 50% in untreated cases. Incidence in industrialized countries rare and most cases are imported. Incidence in Africa, Central and South America incidence +/++, in other parts of the world +.

Name of illness	**Clonorchiasis**
Etiological agent	Helminth, trematode (flatworm): *Clonorchis sinensis*, the Chinese (or Oriental) liver fluke.
Characteristics of agent	Flattened worm, 10–25 mm long, 3–5 mm wide, usually spatula-shaped, yellow-brown in colour (owing to bile staining); has an oral and a ventral sucker and is a hermaphrodite. Eggs measure 20–30 µm x 15–17 µm, are operculate and are among the smallest trematode eggs to occur in man.
Incubation period	Varies with the number of worms present. Symptoms begin with the entry of immature flukes into the biliary system one month after encysted larvae (metacercariae) are ingested.
Symptoms	Most patients are asymptomatic but may have eosinophilia. Gradual onset of discomfort in the right upper quadrant, anorexia, indigestion, abdominal pain or distension and irregular bowel movement. Patients with heavy infection experience weakness, weight loss, epigastric discomfort, abdominal fullness, diarrhoea, anaemia, oedema. In later stages, jaundice, portal hypertension, ascites and upper gastrointestinal bleeding occur.
Sequelae	Hepatomegaly, rarely splenomegaly, recurrent pyogenic cholangitis and pancreatitis, cholangiocarcinoma. Repeated or heavy infection during childhood has been reported to cause dwarfism with retarded sexual development.
Duration	An acute illness occasionally develops 2–3 weeks after initial exposure. Adult worms can live many years.
Reservoir/source	Snails are the first intermediate host. Some 40 species of river fish serve as the second intermediate host. Humans, dogs, cats and many other species of fish-eating mammals are definitive hosts.
Mode of transmission and associated foods	People are infected by eating raw or under-processed freshwater fish containing encysted larvae (metacercariae). During digestion, the larvae are freed from the cysts and migrate via the common bile duct to biliary radicles. Eggs deposited in the bile passages are evacuated in faeces. Eggs in faeces contain fully developed miracidia; when ingested by a susceptible operculate snail, they hatch in its intestine, penetrate the tissues and asexually generate larvae (cercariae) that migrate into the water. On contact with a second intermediate host, the cercariae penetrate the host and encyst, usually in muscle, occasionally on the underside of scales. The complete life cycle from person to snail to fish to person requires at least 3 months.
Specific control measures	*Industrial*: Safe disposal of excreta and sewage/wastewater to prevent contamination of rivers; treatment of wastewater used for aquaculture; irradiation of freshwater fish; freezing; heat treatment (e.g. canning); good hygiene practices during production and processing. *Food service establishment/household:* Thorough cooking of freshwater fish. *Consumers* should avoid consumption of raw or undercooked freshwater fish. *Other:* Control of snails with molluscicides where feasible; drug treatment of the population to reduce the reservoir of infection; elimination of stray dogs and cats.
Occurrence	Incidence ++/+++ in endemic part of western Pacific (China, Japan, Korean peninsula, Malaysia, Viet Nam). In Europe (eastern part of Russian Federation) ++.
Other comments	About one-third of chronic infections are asymptomatic.

Name of illness	***Clostridium perfringens* enteritis**
Etiological agent	Bacterium: *Clostridium perfringens* (also known as *Clostridium welchii*) producing toxico-infection.
Characteristics of agent	Gram-positive, non-motile, anaerobic, spore-forming rod that grows at 12−50 °C (very slow growth below 20 °C, extremely rapid growth at optimum temperature of 43−47 °C). Optimum pH 6−7 but growth will occur at pH as low as 5. Lowest a_w supporting growth 0.95.
Incubation period	8−24 hours.
Symptoms	Abdominal pain, diarrhoea, rarely vomiting and fever.
Sequelae	Food poisoning is usually self-limited.
Duration	1−2 days.
Reservoir/source	Soil, sewage, dust, faeces of animals and humans, animal-origin feedstuffs.
Mode of transmission and associated foods	Illness usually caused by cooked meat and poultry dishes subject to time/temperature abuse. Dishes are often left for too long at ambient temperature to cool down before storage, or cooled inadequately. This allows spores that survive the cooking process to germinate and grow, producing large numbers of vegetative cells. If a dish is not reheated sufficiently before consumption, the vegetative cells can cause illness. Foods involved include meat and poultry (boiled, stewed or casseroled).
Specific control measures	*Food service establishment/household*: Adequate cooling and cool storage of cooked products. Meat-based sauces and large pieces of meat should be cooled to <10 °C within 23 hours; thorough reheating of stored food before consumption; preparation of quantities as required when no refrigeration is available; thermal processing; good hygiene practices during production and processing.
Occurrence	Worldwide. Incidence ++/ +++.
Other comments	Case–fatality ratio in industrialized countries <0.1%.

Name of illness	**Cryptosporidiosis**
Etiological agent	Protozoa: *Cryptosporidium parvum.*
Characteristics of agent	The organism has a complex life cycle that can take place in a single animal host. It produces oocysts (diameter 4–6 µm) which are very resistant to chlorination but killed by conventional cooking procedures.
Incubation period	2–4 days.
Symptoms	Persistent diarrhoea, nausea, vomiting and abdominal pain, sometimes accompanied by an influenza-like illness with fever.
Sequelae	Illness more serious in immunocompromised individuals, particularly AIDS patients, leading to severe nutrient malabsorption and weight loss.
Duration	Several days to 3 weeks.
Reservoir/source	Humans, wild and domestic animals, e.g. cattle.
Mode of transmission and associated foods	Spread through the faecal–oral route, person-to-person contact or consumption of faecally contaminated food and water, bathing in contaminated pools. Foods involved include raw milk, drinking-water and apple cider.
Specific control measures	*Industrial:* Pasteurization/sterilization of milk; filtration and disinfection of water; sanitary disposal of excreta, sewage and wastewater; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Boiling of water when safe water is not available; boiling of milk; thorough cooking of food; thorough hand-washing.
Occurrence	Worldwide. Cryptosporidiosis is one of the leading causes of diarrhoeal disease in infants and young children, accounting for 5–15 % of diarrhoeal disease cases in children seen at treatment centres. Incidence +++, in industrialized countries (often in day-care centres) ++.
Other comments	Children under the age of 5 years are at higher risk of infection. Immunocompromised individuals may suffer from longer and more severe infection; may be fatal in AIDS patients.

Name of illness	***Escherichia coli* infection**
Etiological agent	Bacteria: a) enteropathogenic *E. coli* (EPEC). b) enterotoxigenic *E. coli* (ETEC), producing a heat-labile (LT) and a heat-stable (ST) enterotoxin. c) enteroinvasive *E. coli* (EIEC). d) enterohaemorrhagic *E. coli* (EHEC) or verocytotoxin-producing *E. coli* (VTEC), also referred to as Shiga-toxin producing *E. coli* (STEC), of which the most commonly recognized is *E. coli* O157.
Characteristics of agent	Gram-negative, non-spore-forming, facultatively anaerobic rods of family Enterobacteriaceae. Typically mesophilic grow from 7–10 °C up to 50 °C (optimum 37 °C). Minimum a_w for growth 0.95, pH 4.4–8.5. Most *E. coli* strains are harmless inhabitants of the gut of humans and other warm-blooded animals. Strains mentioned above may cause disease. EHEC is more acid-resistant than other *E. coli* strains.
Incubation period	a) EPEC: 1–6 days; as short as 12–36 hours. b) ETEC: 1–3 days; as short as 10–12 hours. c) EIEC: 1–3 days; as short as 10–18 hours. d) EHEC: 3–8 days, median of 4 days.
Symptoms	a) EPEC adheres to the mucosa and changes its absorption capacity, causing vomiting, diarrhoea, abdominal pain and fever. b) ETEC mediates its effects by enterotoxins. Symptoms include diarrhoea (ranging from mild to a severe, cholera-like syndrome), abdominal cramps and vomiting, sometimes leading to dehydration and shock. c) EIEC causes inflammatory disease of the mucosa and submucosa by invading and multiplying in the epithelial cells of the colon. Symptoms include fever, severe abdominal pain, vomiting and watery diarrhoea (in <10% of cases stools may become bloody and contain mucus). d) EHEC causes abdominal cramps and watery diarrhoea that may develop into bloody diarrhoea (haemorrhagic colitis). Fever and vomiting may also occur.
Sequelae	EPEC, ETEC, EIEC infections are an underlying factor of malnutrition in infants and children in developing countries. EHEC infections may result in life-threatening complications such as haemolytic uraemic syndrome (HUS) in up to 10% of patients, particularly young children and the elderly. HUS is characterized by acute renal failure, haemolytic anaemia and thrombocytopenia. Other sequelae include erythema nodosum and thrombotic thrombocytopenic purpura.
Duration	a) EPEC: days to weeks. b) ETEC: up to 5 days. c) EIEC: days to weeks. d) EHEC: days to weeks.
Reservoir/source	Humans are the main reservoir for EPEC, ETEC, EIEC; cattle for EHEC.

Mode of transmission and associated foods	a–c) EPEC, ETEC, EIEC: consumption of food and water contaminated with faecal matter. Time/temperature abuse of such foods increases risk of illness. Up to 25% of infections in infants and young children in developing countries are due to *E. coli*, in particular ETEC and EPEC (10–20% and 1–5% of cases at treatment centres, respectively). ETEC is a major cause of traveller's diarrhoea in developing countries. d) EHEC is transmitted mainly through consumption of foods such as raw or undercooked ground-meat products and raw milk from infected animals. Faecal contamination of water and other foods, as well as cross-contamination during food preparation, will also lead to infection. Foods involved include ground (minced) meat, raw milk, and vegetables. Secondary transmission (person-to-person) may also occur during the period of excretion of the pathogen which is less than a week for adults but up to 3 weeks in one-third of affected children.
Specific control measures	*Industrial*: Treatment of drinking water; effective sewage disposal system and treatment of irrigation water; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Specific control measures based on prevention of direct and indirect contamination of food and water with faecal matter; thorough cooking and reheating of food; good personal hygiene. **For EHEC infection**, control measures include: *Industrial*: Irradiation of meat, or thorough heat processing of meat; pasteurization/sterilization of milk; treatment of wastewater used for irrigation. *Food service establishment/household*: Thorough cooking of meat; boiling of milk or use of pasteurized milk; hand-washing before preparation of food. *Consumers* should avoid eating raw or partially cooked meat and poultry and drinking raw milk. *Exclusion from work/school*: Until 48 hours after first normal stool for cases not in risk groups. For cases in risk groups 1–4 and for contacts in risk groups 3–4 until microbiological clearance obtained (2 negative faecal samples taken at intervals >48 hours).
Occurrence	Worldwide. Incidence in developing countries +++.
Other comments	Case–fatality ratio for EPEC, ETEC, EIEC infections in industrialized countries <0.1%, for EHEC infection about 2%. Case–fatality ratio of *E. coli* infections in infants and children much higher in developing countries. Children and the elderly are particularly vulnerable and may suffer more severely. Most cases of EHEC infections are reported in summer.

Name of illness	**Fascioliasis**
Etiological agent	Helminths, trematodes (flatworms): *Fasciola hepatica* and *F. gigantica*.
Characteristics of agent	*Fasciola hepatica:* large fluke (23–30 mm x 15 mm), pale grey in colour with dark borders, leaf-shaped with a distinct cephalic cone at the anterior end. Eggs are usually 130–150 µm x 63–90 µm with inconspicuous operculum, shell irregularity at the opercular end, non-embryonated. *Fasciola gigantica* is bigger than *F. hepatica*, measures up to 7 cm in length and has a more attenuated shape. Eggs measure 150–190 µm x 70–90 µm.
Incubation period	4–6 weeks.
Symptoms	Fever, sweating, abdominal pain, dizziness, cough, bronchial asthma, urticaria. Acute infection in children is associated with right upper quadrant pain or generalized abdominal pain, fever and anaemia and can be fatal. Ectopic infections are common in humans.
Sequelae	Necrotic lesions; inflammatory, adenomatous and fibrotic changes in the bile duct, biliary stasis, atrophy of the liver and periportal cirrhosis, cholecystitis and cholelithiasis.
Duration	Symptoms corresponding to hepatic migration can last 4 months or longer. Chronic fascioliasis is usually subclinical but adult flukes can live 10 years.
Reservoir/source	Snails are the intermediate host. Sheep, cattle and humans are the definitive hosts.
Mode of transmission and associated foods	Infection in humans is acquired by consuming aquatic plants such as raw watercress (*Nasturtium officinale*) bearing metacercariae. After ingestion the infective metacercariae excyst and the larvae pass through the intestinal wall to the abdominal cavity, enter the liver and, after development, the bile ducts where they begin laying eggs 3–4 months after initial exposure. The eggs are carried by the bile into the intestine and evacuated with the faeces. The eggs mature and develop into miracidia (motile ciliated larvae) within a few weeks. The miracidia penetrate snails (intermediate host), and produce free-swimming cercariae. Under favourable conditions the cercariae may begin to emerge from the snails in 6 weeks and encyst on vegetation (metacercariae).
Specific control measures	*Industrial:* Safe disposal of excreta and sewage/wastewater; drug treatment of livestock against the parasite; prevention of animal access to commercial watercress beds and control of water used to irrigate the beds; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Thorough cooking of food. *Consumers* should avoid consumption of raw watercress. *Others:* Control of snails with molluscicides where feasible; drug treatment of the population to reduce the reservoir of infection.
Occurrence	Africa (Egypt, Ethiopia), Americas (Bolivia, Ecuador, Peru), Asia (Islamic Republic of Iran), Europe (France, Portugal, Spain), Western Pacific (China). Incidence ++ to +++ depending on country.
Other comments	

Name of illness	**Giardiasis**
Etiological agent	Protozoa: *Giardia lamblia.*
Characteristics of agent	Flagellate with environmentally resistant cyst stage as well as a vegetative trophozoite stage. Cysts are oval and 7−14 µm long, resistant to the chlorination process used in most water-treatment systems but killed by conventional cooking procedures. Once ingested, cysts release the active trophozoite which adheres to the gut wall.
Incubation period	7–10 days (range 4–25 days).
Symptoms	Diarrhoea (which may be chronic and relapsing), abdominal cramps, fatigue, weight loss, anorexia and nausea. Symptoms may be caused by a protein toxin.
Sequelae	Cholangitis, dystrophy, joint symptoms, lymphoid hyperplasia.
Duration	Weeks to years.
Reservoir/source	Humans and animals.
Mode of transmission and associated foods	Infected individuals excrete *Giardia* cysts in large numbers. Illness is spread by faecal–oral route, person-to-person contact or faecally contaminated food and water. Cysts have been isolated from lettuces and fruits such as strawberries. Infection also associated with drinking-water from surface waters and shallow wells. Foods involved include water, home-canned salmon and noodle salad.
Specific control measures	*Industrial*: Filtration and disinfection of water supply; sanitary disposal of excreta and sewage water; treatment of irrigation water; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Boiling of water when safe water is not available; thorough washing of fruit and vegetables; thorough cooking of foods; thorough hand-washing. *Consumers*, and more specifically campers, should avoid drinking surface water unless it has been boiled or filtered.
Occurrence	Worldwide. Incidence in industrialized countries ++, in developing countries with poor sanitation +++.
Other comments	Number of asymptomatic carriers high. Children are affected more frequently than adults. Tourists are particularly at risk. Illness is prolonged and more serious in immunocompromised individuals, particularly AIDS patients.

Name of illness	**Hepatitis A**
Etiological agent	Hepatitis A virus.
Characteristics of agent	Small round virus, member of Picornaviridae, around 28 nm in diameter, containing single-stranded RNA. Multiplies in the gut epithelium before being carried by the blood to the liver. In the later part of incubation, the virus is shed in the faeces. Relatively acid-resistant.
Incubation period	25–28 days (range 2–6 weeks).
Symptoms	Loss of appetite, fever, malaise, abdominal discomfort, nausea and vomiting, followed by symptoms of liver damage (passage of dark urine, pale stools, jaundice).
Sequelae	Acute liver failure, particularly in older persons.
Duration	Varies with clinical severity: recovery within a few weeks when mild, several months when severe.
Reservoir/source	Humans (sewage and contaminated water).
Mode of transmission and associated foods	Spread by faecal–oral route, primarily person-to-person. Can also be transmitted through food and water as a result of sewage contamination or infected food-handlers. Risk of transmission is greatest during the second half of the incubation period until a few days after the appearance of jaundice. Foods involved include shellfish, raw fruit and vegetables, bakery products.
Specific control measures	*Industrial*: Treatment of water supply; safe sewage disposal. *Food service establishment/household*: Good personal hygiene, particularly thorough hand-washing with soap and water before handling foods and abstinence from handling food when infected; thorough cooking of shellfish; thermal processing; good hygiene practices during production and processing. An effective vaccine is available and vaccination of professional food-handlers and travellers should be considered. Immune-serum globulin is effective in preventing illness if administered within 14 days of exposure to hepatitis A, and can be used for pre-exposure prophylaxis in travellers who cannot be vaccinated. *Exclusion from work/school:* All cases (including those in risk groups 1–4) for 7 days after onset of jaundice and/or symptoms.
Occurrence	Worldwide. Incidence ++.
Other comments	There may be asymptomatic carriers. Infection in adults is more severe than in children in whom infection often asymptomatic and confers immunity. Case-fatality ratio about 0.3% but may be higher in adults over 50 years of age.

Name of illness	**Listeriosis**
Etiological agent	Bacterium: *Listeria monocytogenes.*
Characteristics of agent	Gram-positive, non-spore-forming, facultatively anaerobic rod. Psychrotrophic; grows at 3–42 °C (optimum 30–35 °C), pH 5.0–9.0 (minimum 4.4), a_w >0.92. The bacteria are able to grow in the presence of 10% salt.
Incubation period	Days to several weeks.
Symptoms	Influenza-like symptoms such as fever, headache and occasionally gastrointestinal symptoms.
Sequelae	Meningoencephalitis and/or septicaemia in newborns and adults and abortion in pregnant women. The onset of meningoencephalitis (rare in pregnant women) may be sudden with fever, intense headaches, nausea, vomiting and signs of meningeal irritation. Delirium and coma may appear early; occasionally there is collapse and shock.
Duration	Days to weeks.
Reservoir/source	Water, soil, sewage, decaying vegetables, silage and faeces of numerous wild and domestic animals. Other sources may be infected animals and people.
Mode of transmission and associated foods	A substantial proportion of cases of listeriosis are foodborne. Foods involved include raw milk, soft cheese, meat-based paste, jellied pork tongue, raw vegetables and coleslaw.
Specific control measures	*Industrial:* Heat treatment of milk (pasteurization, sterilization) with measures to ensure that processing contamination risks are reduced. For ready-to-eat, high-risk processed foods, reduction of all cross-contamination risks after processing; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Use of pasteurized or heat-treated (boiling) milk and products made from pasteurized or heat-treated milk; refrigeration of perishable foods and consumption within a short space of time. Pre-cooked refrigerated foods should be thoroughly reheated before consumption. Avoidance of certain high-risk foods, e.g. soft cheese, ready-to-eat meat such as pâté and raw milk and raw milk products during pregnancy. *Consumers*, particularly pregnant women and other vulnerable individuals, should avoid eating raw foods of animal origin, e.g. raw meat, raw milk. Pregnant women should also avoid foods that support growth of *Listeria*, e.g. soft cheese, pre-prepared salad, cold, smoked or raw seafood, pâté.
Occurrence	Incidence +. Most cases have been reported from Europe, North America and the Pacific islands.
Other comments	The most severe form of illness occurs in fetuses and neonates, the elderly and those who are immunocompromised. About one-third of clinical cases occur in the newborn. In adults, infection occurs mainly in those aged 40 or over. Transplacental fetal infection may lead to abortion or stillbirth. Asymptomatic infection may occur at all ages. Infected individuals shed the organisms in their stools for several months. Case–fatality ratio up to 30%, and up to 70% in patients without adequate treatment. Pregnant women and fetuses, the elderly and immunocompromised individuals, are the most susceptible. Systemic illness with a long incubation period is the most common manifestation, but acute outbreaks of diarrhoeal illness with a 2-day incubation period have been reported among healthy persons.

Name of illness	**Opisthorchiasis**
Etiological agent	Helminths, trematodes (flatworms): *Opisthorchis viverrini* and *O. felineus* (liver flukes).
Characteristics of agent	Morphological features similar to *Clonorchis sinensis*. Measures 8–11 mm x 1.5–2 mm. Eggs measure 30 µm x 12 µm and are more slender than those of *C. sinensis*. Organism lives in the intrahepatic bile ducts and pancreas and has been also found in the lungs.
Incubation period	*Opisthorchis felineus*: 2–4 weeks, very occasionally 1 week.
Symptoms	Fever, abdominal pain, dizziness, urticaria. Chronic cases may lead to diarrhoea, flatulence, fatty food intolerance, epigastric and right upper quadrant pain, jaundice, fever, hepatomegaly, lassitude, anorexia, and in some cases emaciation and oedema.
Sequelae	Cholecystitis, cholangitis, liver abscess and gallstones. Cholangiocarcinoma is associated with *O. viverrini* infection and perhaps also with *O. felineus*.
Duration	Infection can be chronic without treatment.
Reservoir/source	The first intermediate host is the freshwater snail; several fish species act as the second intermediate host. Humans, dogs, cats and other mammals that eat fish or fish waste are definitive hosts.
Mode of transmission and associated foods	The life cycle of *Opisthorchis* is similar to that of *C. sinensis.* Foods involved include raw or under-processed freshwater fish.
Specific control measures	*Industrial:* Safe disposal of excreta and sewage/wastewater; treatment of wastewater used for aquaculture; irradiation of freshwater fish; freezing; heat treatment e.g. canning; good hygiene practices during production and processing. *Food service establishment/household:* Thorough cooking of freshwater fish. Consumers should avoid consumption of raw or undercooked freshwater fish. *Others:* Control of snails with molluscicides where feasible; drug treatment of the population to reduce the reservoir of infection; elimination of stray dogs and cats.
Occurrence	*Opisthorchis viverrini:* Cambodia, Lao People's Democratic Republic, Thailand. *Opisthorchis felineus*: Europe (Baltic states, eastern Germany, Kazakhstan, Poland, Russian Federation, Ukraine), Asia (India. Japan, Thailand). Incidence in eastern European countries ++, in Asian countries +++.
Other comments	

Name of illness	**Paragonimiasis**
Etiological agent	Helminths, trematodes (flatworms): *Paragonimus westermani* (lung fluke).
Characteristics of agent	Reddish brown hermaphrodite, 10–12 mm long, 5–7 mm wide, linear to spherical shape. Golden brown, thick-shelled eggs, 80–120 µm, non-embryonated in faeces or in sputum, with prominent operculum. The shell is thickened at the opercular end.
Incubation period	Acute stage: several days to several weeks. Chronic stage: pulmonary symptoms begin after 3 months.
Symptoms	Early stages usually asymptomatic. Heavy infections may lead to fever, fatigue, generalized myalgia and abdominal pain with eosinophilia.
Sequelae	Pleuropulmonary paragonimiasis causes chronic coughing, thoracic pain, blood-stained viscous sputum. Severe infections produce tuberculosis-like symptoms. Systemic symptoms include fatigue, fever, myalgia, chest pain and dyspnoea. Ectopic paragonimiasis (extrapulmonary lesion): migration of the worm through the brain can cause cerebral haemorrhage, oedema or meningitis. Abdominal paragonimiasis results in abdominal pain and diarrhoea with blood and mucus when the intestinal mucosa is ulcerated.
Duration	Infection can be chronic without treatment. Adult worms can live 20 years.
Reservoir/source	Freshwater snails are the first intermediate host, crabs and crayfish the second intermediate hosts. Humans, dogs, pigs and other wild and domestic animals are definitive hosts.
Mode of transmission and associated foods	The definitive hosts are infected through consumption of raw, inadequately cooked or otherwise under-processed freshwater crustaceans (crabs and crayfish) or by cross-contaminated other foods or utensils. Following ingestion, the metacercariae excyst in the duodenum of the host and the larvae penetrate the intestinal wall and migrate beneath the peritoneum where they remain for 5–7 days. Over a period of about 2–3 weeks following infection, the immature worms penetrate the diaphragm, enter the pleural cavity and then move into the lung parenchyma where they mature. At this stage, eggs may be present in the sputum without the host showing any symptoms. During the initial stage of lung infection, adult worms migrate through the tissues and cause focal haemorrhagic pneumonia. After 12 weeks, the worms in the lung parenchyma typically provoke a granulomatous reaction that gradually proceeds to development of fibrotic encapsulation. Extrapulmonary lesions are caused by worms that reach, and develop in, ectopic foci.
Specific control measures	*Industrial:* Safe disposal of excreta and sewage/wastewater to prevent contamination of rivers; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Thorough cooking of crabs and crayfish, and hygienic handling of these foods. *Consumers* should avoid consumption of raw or undercooked crabs and crayfish. *Others:* Control of snails with molluscicides where feasible; drug treatment of the population to reduce the reservoir of infection; elimination of stray dogs and cats.
Occurrence	Africa (Cameroon, Nigeria), Americas (Ecuador, Peru), Asia (China, Japan, Korean peninsula, Lao People's Democratic Republic, Philippines, Thailand). Incidence in these countries +++.
Other comments	

Name of illness	**Poliomyelitis**
Etiological agent	Poliovirus.
Characteristics of agent	Small round virus, member of Picornaviridae, contains single-stranded RNA, withstands pH 3–5. Virus infects gastrointestinal tract, spreads to the regional lymph nodes and, in a minority of cases, to the nervous system.
Incubation period	3–14 days.
Symptoms	Poliomyelitis may be a transient viraemia characterized by fever and malaise. In a minority of cases it may progress to a second stage of persistent viraemia in which virus invades the central nervous system causing varying degrees of paralysis. More severe illness is characterized by severe muscle pain and stiffness of the neck and back, with or without flaccid paralysis. Flaccid paralysis occurs in <1% of poliovirus infections, most often in the legs, sometimes in the arms. Paralysis of the muscles used in respiration and/or swallowing is life-threatening. The infection is usually asymptomatic in young children and confers immunity but is more severe in older children and young adults.
Sequelae	Permanent paralysis.
Duration	Maximum extent of paralysis generally reached within 3–4 days. Paralysis persisting longer than 60 days is likely to be permanent.
Reservoir/source	Humans, most frequently asymptomatic persons.
Mode of transmission and associated foods	Principally person-to-person transmission by faecal–oral route. Food and drinking-water are potential vehicles for transmission where hygiene standards are low. In some instances, milk and other foodstuffs contaminated with faeces have been vehicles for transmission.
Specific control measures	Vaccination. **Food-specific control measures:** *Industrial*: Treatment of drinking-water; effective sewage disposal system; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Safe food preparation practices, including careful hand-washing with soap and water; thorough cooking and reheating of food before consumption and thorough washing of all fruits and vegetables.
Occurrence	Poliomyelitis has been almost entirely eliminated in industrialized countries and the Americas by effective immunization. Incidence in developing countries +/++ depending on immunization coverage.
Other comments	Risk of transmission greatest several days before and after onset of symptoms. Infants and children under 5 years of age most frequently affected. Immunization of the elderly is recommended, particularly when travelling abroad.

Name of illness	**Salmonellosis**
Etiological agent	Bacteria: non-typhoid *Salmonella* serotypes.
Characteristics of agent	Gram-negative, mesophilic, facultatively anaerobic, motile, non-spore-forming rod. Grows at 5−47 °C (optimum 37 °C), at pH >4.0 and a_w >0.95.
Incubation period	6–48 hours, occasionally up to 4 days.
Symptoms	The principal symptoms are fever, headache, nausea, vomiting, abdominal pain and diarrhoea.
Sequelae	Reactive arthritis, septicaemia, aortitis, cholecystitis, colitis, meningitis, myocarditis, osteomyelitis, pancreatitis, Reiter disease, rheumatoid syndromes.
Duration	Several days to 1 week, sometimes up to 3 weeks.
Reservoir/source	Wide range of domestic and wild animals including poultry, pigs, cattle, rodents, pets such as iguanas, tortoises, turtles, chicks, dogs and cats. Also humans, i.e. patients and convalescent carriers.
Mode of transmission and associated foods	Main route of transmission is by ingestion of the organisms in food (milk, meat, poultry, eggs) derived from infected food animals. Food can also be contaminated by infected food-handlers, pets and pests, or by cross-contamination as a result of poor hygiene. Contamination of food and water from the faeces of an infected animal or person may also occur. Problems caused by initial contamination may be exacerbated by prolonged storage at temperatures at which the organism may grow. Direct person-to-person transmission may also occur during the course of the infection. Foods involved include unpasteurized milk, raw eggs, poultry, meat, spices, salads and chocolate.
Specific control measures	*Industrial*: Effective heat-processing of foods of animal origin including pasteurization of milk and eggs; irradiation of meat and poultry thermal processing; good hygiene practices during production and processing; vaccination of egg-producing flocks. *Food service establishment/household:* Safe food preparation practices, including thorough cooking and reheating of food and boiling of milk; adequate refrigeration; prevention of cross-contamination; cleaning and disinfection of food preparation surfaces; exclusion of pets and other animals from food-handling areas. *Consumers*, particularly vulnerable groups, should avoid raw and undercooked meat and poultry, raw milk, raw eggs and foods containing raw eggs.
Occurrence	Worldwide. Incidence ++ /+++. Drastic increase in incidence of salmonellosis, particularly due to *S. enteritidis*, has occurred during the past two decades in Europe, North America and some other countries. In Europe and North America, contaminated eggs and poultry have been the major source of infection.
Other comments	General susceptibility is increased by achlorhydria, antacid therapy, immunosuppressive therapy and other debilitating conditions, including malnutrition. Severity of illness is related to serotype, the number of organisms ingested and host factors. Case–fatality ratio <1% in industrialized countries. Symptomless excretion of the organism can continue for several weeks or, in some cases, months. Strains of *Salmonella* resistant to many commonly available antimicrobial agents are increasingly being reported and may complicate therapy. Testing isolates for antimicrobial susceptibility can be important.

Name of illness	**Shigellosis (bacillary dysentery)**
Etiological agent	Bacteria: *Shigella dysenteriae, S. flexneri, S. boydii, S. sonnei.*
Characteristics of agent	Gram-negative, non-motile, non-spore-forming, facultatively anaerobic rods. Typically mesophilic, grow at 10−45 °C (optimum 37 °C). Optimum pH 6−8, no survival at pH below 4.5, minimum a_w 0.97.
Incubation period	1−3 days, up to 1 week for *S. dysenteriae.*
Symptoms	Abdominal pain, vomiting, fever, diarrhoea ranging from watery (*S. sonnei*) to dysenteric with bloody stools, mucus and pus (*S. dysenteriae* and, to a lesser extent *S. flexneri* and *S .boydii*).
Sequelae	Occur in 2−3% of cases and include haemolytic uraemic syndrome, erythema nodosum, Reiter disease, splenic abscesses, synovitis.
Duration	Several days to several weeks.
Reservoir/source	Humans.
Mode of transmission and associated foods	Food and water contaminated with faecal matter. Person-to-person transmission through the faecal–oral route is an important mode of transmission. Food can be contaminated by food-handlers with poor personal hygiene or by use of sewage/wastewater for fertilization. Foods involved include uncooked foods that have received extensive handling, such as mixed salads and vegetables, water and raw milk.
Specific control measures	*Industrial*: Treatment of drinking water; effective sewage disposal system; thermal processing; good hygiene practices during production and processing. *Food service establishment/household*: Safe food preparation practices, including careful hand-washing with soap and water; thorough cooking and reheating of food before consumption; disinfection of food preparation surfaces; thorough washing of all fruits and vegetables. *Exclusion from work/school:* Groups 1, 2 and 4 should not handle food or provide child or patient care until two successive stool specimens (collected at least 24 hours apart and no less than 48 hours after cessation of antimicrobials) are free of *Shigella*.
Occurrence	Worldwide; higher prevalence in developing countries. Shigellosis is a major cause of diarrhoea in infants and children under the age of 5 years and accounts for 5–15% of diarrhoeal disease cases seen at treatment centres. *S. dysenteriae* type 1 has been responsible for large epidemics of severe dysentery in central America and recently in Central Africa and southern Asia. Incidence + to +++ depending on degree of development.
Other comments	In developing countries, *S. flexneri* is the most common cause of shigellosis. *S. dysenteriae* type 1, occurring in epidemics, causes most severe disease. In industrialized countries, *S. sonnei* is the most common species and milder illness is the norm. The disease is more severe in young children than in adults (in whom many infections may be asymptomatic). The elderly and those suffering from malnutrition are particularly susceptible and may develop severe symptoms or even die. Travellers are particularly at risk. Case–fatality ratio in industrialized countries <0.1%.

Name of illness	***Staphylococcus aureus* intoxication**
Etiological agent	Bacterial toxin: *Staphylococcus aureus*.
Characteristics of agent	Gram-positive, non-motile, non-spore-forming, facultatively anaerobic coccus. Grows at 7–48 °C (optimum 37 °C), pH 4.0−9.3 (optimum 7.0–7.5); the pH range over which enterotoxin is produced is narrower, with little toxin production below pH 6.0. While bacterial growth will still occur at a_w 0.83, toxin production does not occur below 0.86: this is the most resistant bacterial pathogen with regard to reduced a_w. The toxin that causes intoxication is formed in the food, is relatively heat-stable and can survive boiling for >1 hour. It is therefore possible for well-cooked food to cause illness without containing viable organisms.
Incubation period	2−6 hours.
Symptoms	Intoxication, sometimes of abrupt and violent onset. Severe nausea, cramps, vomiting and prostration, sometimes accompanied by diarrhoea.
Sequelae	Toxin-mediated gastroenteritis is generally self-limited.
Duration	About 2 days.
Reservoir/source	Humans (skin, nose, throat). *S. aureus* is carried by about 25–40 % of the healthy population.
Mode of transmission and associated foods	Consumption of foods containing the toxin. Foods are contaminated by food-handlers. If storage conditions are inadequate, the bacteria may multiply to produce toxin. Intoxication is often associated with cooked food, e.g. meat, in which competitive bacteria have been destroyed. Foods involved include prepared foods subject to handling in their preparation (ham, chicken and egg salads, cream-filled products, ice cream, cheese).
Specific control measures	*Food service establishment/household:* Exclusion from work of food-handlers with visibly infected skin lesions (boils, cuts, etc); nasal carriers do not need to be excluded unless implicated as the source of an outbreak. Scrupulous personal hygiene; prevention of time–temperature abuse in handling cooked/ready-to-eat foods; thermal processing, good hygiene practices during production and processing.
Occurrence	Worldwide. Estimated incidence varies between ++ and +++ depending on conditions of food hygiene.
Other comments	Case–fatality ratio <0.02%.

Name of illness	**Taeniasis (and cysticercosis)**
Etiological agent	Helminths, cestodes: *Taenia solium* (pork tapeworm). *Taenia saginata* (beef tapeworm).
Characteristics of agent	*T. solium* causes both intestinal infection with adult worms and somatic infection with eggs (cysticercosis). When eggs or proglottids of *T. solium* are swallowed, the eggs hatch in the small intestine and the larvae migrate to subcutaneous tissue, striated muscle, and other tissues and vital organs of the body where they form cysts. The adult worm comprises the scolex, 1 mm in diameter and armed with two rows of hooks and four suckers, and the strobila, ranging in length from 1.8 to 4 m. *T. saginata* causes only intestinal infection with adult worms. The adult worm comprises the scolex, 1–2 mm in diameter and equipped with four suckers, the neck, and the strobila, which ranges in length from 35 mm to 6 m.
Incubation period	For cysticercosis, few days to decades. Eggs appear in the stools 8–12 weeks after infection with *T. solium*, 10–14 weeks after infection with *T. saginata*.
Symptoms	Nervousness, insomnia, anorexia, weight loss, abdominal pain and digestive disturbance. Cysticercosis of the brain may cause epileptiform seizures, signs of intracranial hypertension or psychiatric disturbance and may be fatal.
Sequelae	Severe health consequences occur when larvae localize in the eye, the central nervous system or the heart.
Duration	Worms can survive 30 years in the intestine.
Reservoir/source	Humans; pigs and cattle are the intermediate hosts for *T. solium* and *T. saginata*.
Mode of transmission and associated foods	Taeniasis is caused by consumption of raw or undercooked beef (*Taenia saginata*) or pork (*Taenia solium*) containing cysticerci. Gravid proglottids of the parasite are excreted in faeces. Eggs within the segments are infective. When viable eggs are ingested by cattle or pigs they develop into cysticerci. Cysticercosis is caused by ingestion of *T. solium* eggs by the faecal–oral route, person-to-person contact, auto-infection (unwashed hands) or consumption of contaminated foods, e.g. vegetables.
Specific control measures	*Industrial:* Prevention of faecal contamination of soil, water and animal food through safe disposal of sewage; avoidance of sewage water for irrigation use. Irradiation, heat treatment and freezing kills the cysticerci; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Thorough cooking of meat. *Other*: Early diagnosis and treatment to prevent cysticercosis.
Occurrence	Worldwide. Most common in Africa, Latin America, eastern Europe and south-east Asia. Incidence + to ++ in high-prevalence areas.
Other comments	*T. saginata* eggs infect only cattle, *T. solium* eggs only pigs and humans. Eggs of both species are disseminated in the environment as long as the worm remains in the intestine, sometimes for more than 30 years. Eggs may remain viable in the environment for months.

Name of illness	**Toxoplasmosis and congenital toxoplasmosis**
Etiological agent	Protozoa: *Toxoplasma gondii*.
Characteristics of agent	Coccidian protozoa of family Sarcocystidae; complex life cycle.
Incubation period	5–23 days.
Symptoms	Infections often asymptomatic or present as acute disease with lymphadenopathy and lymphocytosis persisting for days or weeks.
Sequelae	During pregnancy, transplacental infection may cause abortion or stillbirth, chorioretinitis, brain damage. In immunocompromised individuals, infection may cause cerebritis, chorioretinitis, pneumonia, myocarditis, rash and death. Cerebral toxoplasmosis is a particular threat for AIDS patients.
Duration	Symptoms of acute infection may persist days or weeks. Cysts remaining in tissue can reactivate if the immune system becomes compromised.
Reservoir/source	Cats and other felines; intermediate hosts are sheep, goats, rodents, pigs, cattle and birds, all of which may carry an infective stage of *T. gondii* encysted in tissue, e.g. muscle or brain. Cysts remain viable for long periods, perhaps for the entire life of the animal.
Mode of transmission and associated foods	Infections occur through ingestion of oocysts. Children may acquire the infection by playing in sand polluted with cat excreta. Oocysts shed by cats can sporulate and become infective 1–5 days later and may remain infective in water or soil for a year. Infection may also be acquired by eating raw or undercooked meat containing the cysts or food and water contaminated with feline faeces. Transplacental infection may occur when the infection is acquired during pregnancy. Foods involved include raw or undercooked meat, vegetables and goat's milk.
Specific control measures	*Industrial:* Irradiation of meat; thermal processing; good hygiene practices during production and processing. *Food service establishments, household:* Thorough cooking of meat; careful washing of fruits and vegetables; good personal hygiene (particularly after contact with cats and before food preparation); safe disposal of cat faeces. *Consumers*, particularly pregnant women if not immune, should be advised to avoid raw or undercooked meat, wash vegetables carefully and wash hands after contact with cats.
Occurrence	Worldwide. Incidence + to ++.
Other comments	*T. gondii* cysts remain in the tissue and may be reactivated if the immune system becomes compromised. In immunosuppressed individuals, the infection may be fulminant and fatal.

Name of illness	**Trichinellosis (trichiniasis, trichinosis)**
Etiological agent	Helminth, nematode: *Trichinella spiralis*.
Characteristics of agent	White intestinal nematode (roundworm), visible to the naked eye. Transmissible form is the larval cyst (approximately 0.4 mm x 0.25 mm) found mainly in pork muscle. In the initial phase of trichinellosis, the larvae ingested with the meat develop rapidly into adults in the epithelium of the intestine. Female worms produce larvae which penetrate the lymphatics or venules and are disseminated via the blood throughout the body. The larvae become encapsulated in the skeletal muscle.
Incubation period	Initial phase: several days. Systemic symptoms: 8–21days.
Symptoms	Infection can range from asymptomatic to fulminating and fatal disease, depending on the number of larvae ingested. Symptoms during the initial invasion are nausea, vomiting, diarrhoea and fever. During the phase of parasite dissemination to the tissues, there may be rheumatic manifestations, muscle soreness and oedema of the upper eyelids, sometimes followed by subconjunctival, sublingual and retinal haemorrhages, pain and photophobia. Thirst, profuse sweating, chills, weakness, prostration and rapidly increasing eosinophilia may follow shortly after the ocular symptoms.
Sequelae	Cardiac and neurological complications may appear after 3–6 weeks; in severe cases myocardial failure may lead to death.
Duration	2 weeks to 3 months.
Reservoir/source	Pigs, dogs, cats, rats, horses and other mammals of man's domestic environment.
Mode of transmission and associated foods	Ingestion of raw or undercooked meat (pork, horse) containing the encysted larvae. Foods involved include pork, horse, wild boar, game.
Specific control measures	*Industrial:* Meat irradiation, freezing, heating, curing; good hygiene practices during production and processing. *Food service establishment/household:* Thorough cooking of meat, freezing (–15 °C for 30 days). Hunters should cook all game thoroughly.
Occurrence	Worldwide, predominantly in countries where pork or game is eaten. Incidence + to ++ in high-prevalence areas.
Other comments	

Name of illness	**Typhoid fever, paratyphoid fever**
Etiological agent	Bacteria: *Salmonella typhi* and *Salmonella paratyphi* types A–C.
Characteristics of agent	As for non-typhoid Salmonellae, except that a higher pH (>4.9) is required for growth.
Incubation period	10–20 days (range 3 days to 8 weeks).
Symptoms	Systemic infections characterized by high fever, abdominal pains, headache, vomiting, diarrhoea followed by constipation, rashes and other symptoms of generalized infection.
Sequelae	Haemolytic anaemia.
Duration	Several weeks to months.
Reservoir/source	Humans.
Mode of transmission and associated foods	Ingestion of food and water contaminated with faecal matter. Food-handlers carrying the pathogen may be an important source of food contamination. Secondary transmission may also occur. Foods involved include prepared foods, dairy products (e.g. raw milk), meat products, shellfish, vegetables, salads.
Specific control measures	*Industrial*: Treatment of drinking water; effective sewage disposal system; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Safe food preparation practices, including careful hand-washing with soap and water; thorough cooking and reheating of food before consumption; disinfection of food preparation surfaces and thorough washing of all fruits and vegetables. *Exclusion from work/school:* **Cases:** Risk groups 1, 3, 4 until microbiologically cleared. Risk group 2, and those not in risk groups, until clinically well with formed stools. **Contacts**: Risk group 1 until microbiologically cleared. All others with positive faecal specimens should be managed as a case (see above). **Microbiological clearance for cases**: Risk group 1: six consecutive negative stool specimens taken at 2-week intervals starting 2 weeks after the completion of antibiotic treatment. Risk groups 3, 4: three consecutive negative specimens taken at weekly intervals. **Microbiological clearance for contacts in risk groups 1, 3, 4:** three consecutive specimens taken at weekly intervals starting 3 weeks after the last contact with an untreated case.
Occurrence	Incidence in developing countries ++, in industrialized countries +.
Other comments	Excretion of the organism may occur after recovery or by asymptomatic carriers and may be lifelong unless treated. Case–fatality ratio in industrialized countries about 6%.

Name of illness	***Vibrio parahaemolyticus* gastroenteritis**
Etiological agent	Bacterium: *Vibrio parahaemolyticus*.
Characteristics of agent	Characteristics similar to those of *V. cholerae* except that *V. parahaemolyticus* is more halophilic and will grow at salt levels up to 8% and at a minimum a_w of 0.94. Growth is optimal and very fast at 37 °C (doubling time about 10 minutes) but growth also occurs at temperatures as low as 10 °C. *V. parahaemolyticus* can survive in shrimp and crab meat for several minutes at up to 80 °C.
Incubation period	9–25 hours, up to 3 days.
Symptoms	Profuse watery diarrhoea, abdominal pain, vomiting, and fever. A dysenteric syndrome has been reported from some countries, particularly Japan.
Sequelae	Septicaemia.
Duration	Up to 8 days.
Reservoir/source	Natural habitat is coastal seawater and estuarine brackish waters at temperatures >15 °C, marine fish and shellfish.
Mode of transmission and associated foods	Mainly by consumption of raw or undercooked fish and fishery products or cooked foods subject to cross-contamination from raw fish.
Specific control measures	*Food service establishment/household:* Thorough heat treatment of seafood; rapid chilling; prevention of cross-contamination from raw seafood products to other foods or preparation surfaces.
Occurrence	Primarily in western Pacific region, particularly Japan, as well as south-east Asia and the USA. Incidence +/++.
Other comments	Case–fatality ratio in industrialized countries <1%.

Name of illness	***Vibrio vulnificus* infection**
Etiological agent	Bacterium: *Vibrio vulnificus*.
Characteristics of agent	Gram-negative, non-spore-forming rods. Optimum growth temperature 37 °C.
Incubation period	12 hours–3 days.
Symptoms	Profuse diarrhoea with blood in stools. Organism is associated with wound infections and septicaemia which may originate from the gastrointestinal tract or traumatized epithelial surfaces.
Sequelae	Produces septicaemia in persons with chronic liver diseases, alcoholic liver disease, haemochromatosis or immunosuppression. Over 50% of patients with primary septicaemia may die; case–fatality ratio increases to 90% in hypotensive patients.
Duration	Days to weeks.
Reservoir/source	Natural habitat is coastal or estuarine waters.
Mode of transmission and associated foods	All known cases are associated with seafood, particularly raw oysters.
Specific control measures	*Consumers:* Particularly vulnerable groups (the elderly, those with underlying liver disease, the immunosuppressed) should not eat raw seafood; thermal processing; good hygiene practices during production and processing.
Occurrence	Frequent disease (sporadic cases) in Europe, USA and the western Pacific region. Incidence +/++.
Other comments	Case–fatality ratio as high as 40–60%.

Name of illness	**Viral gastroenteritis**
Etiological agent	Many different viruses including adenoviruses, coronaviruses, rotaviruses, parvoviruses, caliciviruses and astroviruses. Those most commonly associated with foodborne outbreaks are described as small, round, structured viruses (SRSVs), which include norovirus (Norwalk virus).
Characteristics of agent	These viruses exhibit a range of biochemical and physical characteristics.
Incubation period	15–50 hours.
Symptoms	Diarrhoea and vomiting, which is often severe and projectile with sudden onset.
Sequelae	Usually self-limited.
Duration	2 days.
Reservoir/source	Humans.
Mode of transmission and associated foods	Gastroenteritis viruses usually spread by faecal–oral route. Food and drinking-water may be contaminated either at source when exposed to sewage/wastewater in the environment or used for irrigation, or by an infected food-handler. Filter-feeding shellfish most common food contaminated at source, but a wide range of different cooked and uncooked foods have been implicated in secondary contamination by food-handlers.
Specific control measures	*Industrial:* Hygienic sewage disposal; treatment of drinking-water; treatment of wastewater used for irrigation; thermal processing; good hygiene practices during production and processing. *Food service establishment/household:* Good personal hygiene (hand-washing with soap and water); abstinence from handling food when ill, especially when diarrhoea and vomiting present. Vaccines against rotavirus are now available.
Occurrence	Worldwide. Incidence for rotavirus ++/+++, others +. Rotavirus infections make up 15–25% of diarrhoeal disease cases identified in children seen at treatment centres in developing countries.
Other comments	

Name of illness	**Yersiniosis**
Etiological agent	Bacterium: *Yersinia enterocolitica*.
Characteristics of agent	Gram-negative, facultatively anaerobic, non-spore-forming rod of family Enterobacteriaceae. Psychrotrophic; grows at 0−44 °C (optimum 29 °C), pH 4.6−9.0 (optimum pH 7−8) and in media containing 5% salt (no growth in media containing 7% salt).
Incubation period	24−36 hours (range 1−11 days).
Symptoms	Abdominal pain, diarrhoea, mild fever, sometimes vomiting.
Sequelae	Occur in 2–3% of cases and include reactive arthritis, Reiter disease, eye complaints, cholangitis, erythema nodosum, septicaemia, hepatic and splenic abscesses, lymphadenitis, pneumonia, spondylitis.
Duration	2−3 days, may continue in a milder form for 1−3 weeks.
Reservoir/source	Many animals; pathogenic strains are most frequently isolated from pigs.
Mode of transmission and associated foods	Illness is transmitted through consumption of pork products (tongue, tonsils, gut), cured or uncured, as well as milk and milk products.
Specific control measures	*Food service establishment/household:* Thorough cooking of pork products; prevention of cross-contamination.
Occurrence	Incidence in Australia and northern Europe +/++, in USA +.
Other comments	Untreated cases may continue to excrete organisms for 2−3 months. The disease is often misdiagnosed as appendicitis. Fatality is rare.

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Annex 1
Glossary

agent
A factor (microorganism, chemical substance, etc) whose presence or excessive presence is essential for the occurrence of disease.

analytical epidemiology
The aspect of epidemiology concerned with the search for health-related causes and effects. Uses comparison groups, which provide baseline data to quantify the relationship between exposures and outcomes and to test hypotheses about causal relationships.

attack rate
Proportion of people becoming ill after a specified exposure.

carrier
A person or animal harbouring a specific infectious agent without showing signs of clinical illness and capable of transmitting the agent to others.

case
An occurrence of illness as defined by investigators.

case definition
A set of diagnostic criteria that must be fulfilled to be regarded as a case of a particular disease. Case definitions can be based on clinical criteria, laboratory criteria or a combination of the two.

case classification
Gradations in the likelihood of being a case (e.g. possible, probable, confirmed). This is particularly useful where early reporting of cases is important and where there are difficulties in making definite diagnoses (e.g. when specialized laboratory tests are required).

case–control study
Observational study in which subjects are enrolled on the basis of presence (cases) or absence (controls) of the disease of interest. Information is collected about earlier exposures and compared between cases and controls.

case–fatality ratio
The proportion of all cases who die because of the disease. The case–fatality ratio will vary according to the case definition used.

cohort study
Observational study in which subjects are enrolled on the basis of presence (exposed) or absence (unexposed) of risk factors. Subjects are followed over time for the development of a disease outcome of interest.

common source outbreak
An outbreak that results from a group of persons being exposed to a common agent. If the group is exposed over a relatively brief period of time (i.e. all cases occur within one incubation period), the common source outbreak is further classified as a point source outbreak.

contamination

Presence of a disease agent on or in food or on any object that may come into contact with food.

control

In a case–control study, comparison group of persons without the disease under investigation.

control point (CP)

Point, step or procedure that controls food safety hazards, including biological, physical and chemical hazards. Generally a receiving or storage point.

critical control point (CCP)

A point, step or procedure in the product-handling process where controls can be applied and a food safety hazard can be prevented, eliminated or reduced to safe levels.

cross-contamination

The transfer of biological, physical or chemical hazards to food products by contact with other raw food products, previously cooked food, dirty contact surfaces or the dirty hands of a food-handler.

demographic information

The "person" characteristics (age, sex, occupation, ethnicity, etc.) of descriptive epidemiology used to characterize the population at risk.

descriptive epidemiology

The aspect of epidemiology concerned with organizing and summarizing health-related data according to time, place and person characteristics.

dose–response effect

The increasing magnitude and/or frequency of an outcome with increasing magnitude of exposure.

endemic

The constant presence of a disease within a given geographical area or population group.

epidemic

The occurrence of cases of an illness clearly in excess of expected rates; often referred to as an outbreak (a more neutral term).

exposure

Contact with an agent in a manner that may cause disease.

food

Any substance, whether processed, semi-processed or raw, that is intended for human consumption, including drink, and any substance that has been used in the manufacture, preparation or treatment of food, but excluding cosmetics, tobacco and substances only used as drugs.

foodborne disease

Any disease of an infectious or toxic nature caused by the consumption of food.

foodborne disease outbreak

The occurrence of two or more cases of a similar foodborne disease resulting from the ingestion of the same food.

foodborne intoxication
Illness caused by ingestion of toxins produced in food by bacteria as a naturally occurring by-product of their metabolic processes.

food hygiene
All conditions and measures necessary to ensure the safety and suitability for consumption of food at all stages of its growth, distribution and preparation.

food safety
Assurance that food will not cause harm to the consumer when it is prepared and/or eaten.

HACCP system
The Hazard Analysis and Critical Control Point (HACCP) system is a scientific and systematic way of enhancing food safety from primary production to final consumption through the identification, evaluation and control of hazards that are significant for food safety.

hazard
A biological, chemical or physical agent in or property of food that may have an adverse health effect.

histogram
A graphic representation of the frequency distribution of a continuous variable. Used in descriptive epidemiology to describe an outbreak over time.

host
A person or animal that can be infected by an infectious agent under natural (as opposed to experimental) conditions.

incidence
Number of new cases in a specified population in a defined period of time, divided by the population at risk.

incubation period
The time interval between the initial contact with an infectious agent and the first appearance of symptoms associated with the infection.

infection
Entry and development or multiplication of an infectious agent in the body of persons or animals.

infectious disease
A clinically manifest disease resulting from an infection (see Infection).

mean, arithmetic
Measure of central location, also referred to as the average. Calculated by adding all the individual values in a group of measurements and dividing it by the number of values in the group.

measure of association
A quantified relationship between exposure and outcome, including relative risk, and odds ratio.

median
Measure of central location that divides a set of data into two equal parts.

notifiable disease

A disease that must, by law or by ministerial decree, be reported to a government authority.

odds ratio

(Also known as cross-product ratio) Measure of association that quantifies the relationship between an exposure and an outcome from an analytical study (most often, a case–control study). Strictly speaking, the odds ratio describes the likelihood of exposure to the risk factor under investigation in both diseased and non-diseased groups.

outbreak

See Epidemic.

prevalence

The number or proportion of cases in a defined population.

propagated outbreak

An outbreak that does not have a common source but instead spreads from person to person.

rate

An expression of the frequency with which an event occurs in a defined population.

relative risk

A comparison of the rate of some health-related event such as illness or death in two groups (where one group is exposed while the other is not exposed to a risk factor).

reservoir of infection

Ecological niche in which a pathogen lives and multiplies and upon which it depends for its survival. Reservoirs include human reservoirs, animal reservoirs and environmental reservoirs.

risk assessment

Scientific evaluation of known or potential adverse health effects resulting from human exposure to foodborne hazards. The risk assessment process involves four steps: hazard identification, hazard characterization, exposure assessment and risk characterization.

source of infection

The person, animal, object or substance from which an infectious agent passes to a host. The source of infection may or may not be part of the reservoir of infection.

surveillance

The systematic collection, analysis, interpretation and dissemination of health data on an ongoing basis, to gain knowledge of the pattern of disease occurrence and potential in a community, in order to control and prevent disease in the community.

toxico-infection

Illness caused by ingestion of an infectious agent that produces a toxin in the body (as opposed to in the food).

vector

An animate intermediary in the indirect transmission of an agent that carries the agent from a reservoir to a susceptible host.

vehicle

An inanimate intermediary (e.g. food) in the indirect transmission of an agent that carries the agent from a reservoir to a susceptible host.

zoonosis

An infectious disease that is transmissible under natural conditions from animals to humans.

Annex 2

Outbreak control meeting: draft agenda[1]

1. **Introduction**
2. **Minutes of last meeting (if applicable)**
3. **Outbreak resume/update**
   - General situation statement
   - Patient(s) report
   - Epidemiological report
   - Microbiological report
   - Environmental health report
   - Other relevant report (veterinarians, toxicologist, etc.)
4. **Management of outbreak**
   - Control measures: patients, general, public health
   - Care of patients: hospital, community
   - Microbiological aspects: specimens and resources
5. **Advice to public and to professionals**
6. **Agree on content of press releases and press arrangements**
7. **Consider arrangements for enquiries from the public**
8. **Obtain contact details of all key personnel within and after hours**
9. **Agree on actions taken**
10. **Date and time of next meeting**

[1] Source: Scottish Home and Health Department, 1996.

Annex 3

Examples of outbreak investigation forms

Initial response form for disease outbreaks

Today's date:	Name of person completing form:
Information on person reporting disease outbreak	
Last name:	First name(s):
Address:	
Telephone number(s):	
Daytime contact details (work address, telephone number):	
Other information (organization, affiliation, request for anonymity):	
Information on disease outbreak	
Description of event:	
Suspected exposure (e.g. event, meal, restaurant visit, food):	
Number of cases suspected:	Geographical area of concern:
Number of persons at risk:	Date of first suspected case:
Date when suspected exposure first occurred:	Date of most recent case:
Is the suspected exposure still occurring?	Yes / No
How was the event first discovered?	

Initial case report form

Case ID:	Today's date:	Name of person completing form:
Information on person affected		
Last name:		First names:
DOB:	Sex: M F	Occupation:
Address, telephone number:		
Daytime contact details (work address, phone):		
Clinical details		
Date & time of onset of symptoms:		Date & time when symptoms stopped:
Predominant symptoms *(severity, duration)*:		
Doctor consulted? *(if yes, provide name and details)*		
Hospital attended? *(if yes, provide name and details)*		
Laboratory specimen taken? *(if yes, provide details)*		
Diagnosis available?		
Suspect food? *(if yes, provide source of food, preparation mode, when consumed)*		
Suspect meal, event, place? (if yes, describe; provide, name, date, address, telephone number)		

Persons attending suspect meal/event	ill/well	Address & telephone number
1		
2		
3		
4		
5		

Other relevant information

Line listing

ID	Name	Age	Sex	Date & time of onset of illness	Major signs and symptoms	Laboratory tests	
						Specimen	Result

Annex 4

Questionnaire design

A questionnaire is a written instrument used to obtain information from study subjects. Developing a questionnaire is the last step in designing a study after all variables of interest have been identified. By first identifying the information that is needed to answer the study objectives, questions will be limited to those needed to obtain the required information. As a general rule questionnaires should be as simple as possible, collect only needed information and be valid. A valid questionnaire is:

- **Relevant** – Does the questionnaire obtain the information it was designed to seek?
- **Complete** – Was all desired relevant information obtained?
- **Accurate** – Can reliance be placed upon the responses to the questions?

Questionnaire methods

Questionnaires can be administered by an interviewer or answered by the respondents themselves (self-administered).

Self-administered questionnaires can be mailed or given in person to the respondents. They are feasible in a literate population if the questions are short and simple. If questions are complex or nested or if significant probing is required, interviewer-administered questionnaires may be preferable. Interviews conducted by interviewers can be personal (face-to-face) or by telephone. Telephone interviews usually yield shorter answers than personal interviews, with respondents tending to favour the first in a list of possible answers.

Self-administered questionnaires offer the following advantages:

- no interviewer bias;
- less time spent on administration;
- easier questioning of larger numbers of people;
- more leisurely, which may permit more careful responding;
- perceived as more anonymous and may therefore yield more accurate data on sensitive issues;
- printed visual aids can be incorporated.

Interviewer-administered questionnaires offer the following advantages:

- respondent literacy not necessary;
- questions and responses can be clarified;
- allows probing for additional information;
- complex and open-ended questions are possible;
- answering of questionnaire by intended person is assured;
- fewer “blanks”;
- participation potentially increased by personal contact.

There should be an introduction to all questionnaires that explain the purpose of the study to interviewees and assure them of confidentiality.

Questions

Questions may be closed-end or open-ended. Closed-end questions allow a limited number of answers, leaving no room for additional information to be volunteered; they require only recognition and a choice from among answer options. Advantages of closed-end questions are greater precision, uniformity, easier recall for the respondent, easier coding and easier analysis than open-ended questions. Because open-ended questions are not pre-categorized, they gather more information but require respondents to have a good recall and to explain their answers. In relation to food consumption, closed-end questions may be preferred to open-ended as most persons cannot spontaneously or accurately recall all foods eaten over a period of several days.

Closed-end question

- Have you eaten any of the following items in the past four days:

  Poultry? Yes / No / Don't know
  Pork? Yes / No / Don't know
  Beef? Yes / No / Don't know
  Lamb? Yes / No / Don't know

Open-ended question

- List the types of meat that you have eaten in the past 4 days.

_____

_____

_____

_____

In the initial stage of an investigation, open-ended questions are likely to be preferred to identify relevant topics and determine the full range of possible answers. Once the exploratory stage has been completed, questionnaires may use predominantly closed-end questions to focus on issues identified as relevant to the investigation.

Checklist of points to consider when drafting questions[1]

- Keep wording informal, conversational and simple.
- Avoid jargon and sophisticated language.
- Keep questions appropriate to educational, social and cultural background of the respondents.
- Avoid long questions (but vary question length).
- Avoid leading questions ("You surely agree with me, that ….
- Avoid negative questions.
- Avoid questions beginning with "Why".
- Avoid hypothetical questions ("Imagine that …").
- Limit each question to a single subject.
- Pay attention to sensitive issues.
- Check the adequacy of the list of responses to closed-end questions.
- Avoid a large proportion of responses being in the "other (specify) ……." category.

[1] Source: Smith, 1991.

Annex 5

Sample questionnaires

Questionnaire

Enquiry into suspected food poisoning at a wedding reception

This questionnaire should be completed by all individuals who took part in the wedding ceremony at Hotel X on Wednesday, 21 August 1996.

Interviewer's name _____ Interviewer's code /___/___/

Date and time of interview _____ at _____
date *time*

Interview number /___/___/

Person interviewed: self ☐ other ☐ (please specify) _____

Section 1 – Personal details

1. Forename _____ Surname _____
2. Sex M ☐ F ☐
3. Age _____ years
4. Home address _____
   _____
5. Home phone no. _____
6. Occupation *(describe what person actually does)*
   _____
   _____
7. Workplace contact
   _____

Section 2 - Clinical details

8. Since Sunday, 18 August, have you had an illness with diarrhoea (three loose motions in 24 hours) or any gastrointestinal upset?

   Yes -1- No -2- **(go to Q25)**

9. When did your symptoms start? _____ at _____

date *time*

10. Did you have any of the following symptoms?
(if symptoms still continuing code 9999)

	Yes	No	DK	Duration
Diarrhoea	1	2	9	_____
Blood in stool	1	2	9	_____
Nausea (feeling sick)	1	2	9	_____
Vomiting (being sick)	1	2	9	_____
Feeling feverish	1	2	9	_____
General aches and pains	1	2	9	_____
Other symptoms (please describe)	1	2	9	_____

_____

_____

_____

_____

11. Were you off work because of this illness? Yes -1- No -2-

12. Did you contact your GP because of this illness?

Yes -1- No -2- **(go to Q16)**

13. Name and address of GP_____

_____

14. Did your GP prescribe any medication? Yes -1- No -2- **(go to Q16)**

15. What medication did your GP prescribe? _____

_____

16. Were you admitted to hospital because of this illness?

Yes -1- No -2- **(go to Q21)**

17. When were you admitted to hospital? _____ at _____

date *time*

18. What hospital were you admitted to? _____

19. What was the name of your doctor? _____

20. How long were you in hospital for? _____

21. Has any member of your family or people you are living with been ill with the same or similar symptoms since Sunday, 18 August?

Yes -1- No -2- **(go to Q23)**

22. Please specify *(ONLY for persons who did not attend the wedding ceremony and for whom no questionnaire will be completed)*

_____

_____

Section 3 – Food history

23. Between Sunday 18 August, and the wedding ceremony on Wednesday, 21 August have you attended any parties, special functions, receptions, or have you been eating in other places than usual?

Yes -1- No -2- **(go to Q25)**

24. Please describe activity, place, date, type of food, etc.

_____

_____

25. During your meal on Wednesday, 21 August, did you eat the following items? *(Please get answer for all items; overlaps between food items allowed)*

	Yes	***No***	***Don't know***
Turkey	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Ham	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Chicken	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Beef	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐

Stuffing	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Quiche	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Cauliflower	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Carrots	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Green salad	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Other salads	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Roast potatoes	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Fried potatoes	☐	☐	☐	
	if yes, specify quantity:			portion ☐ half portion ☐ "a bite" ☐ don't know ☐

Scampi	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Mayonnaise	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Eclair with sauce	☐	☐	☐
	if yes, specify quantity:		portion ☐ half portion ☐ "a bite" ☐ don't know ☐
Other *(specify)*	☐	☐	☐
_____		_____	
_____		_____	

26. Would you like to make any additional comments?

_____

_____

_____

This completes the interview. Thank you very much for your cooperation.

Annex 6

Investigation report forms

Outline of an outbreak investigation report

Cover page

- **Title of report**

  Indicate whether this is a preliminary or a final report. Keep the title short and memorable, but include information on the type of problem under investigation, the location and date.

- **Date of report**

- **Names and affiliations of the main authors and investigators**

Abstract

The abstract should be written after the report has been completed. It should stand alone and contain the most relevant data and conclusions. All data mentioned in the abstract must also appear in the main section of the report. Sentences from the Discussion section can be used verbatim in the abstract.

Report

- **Introduction**

  Statement of the problem and its public health importance.

  Details and time frame regarding initial source of information.

  Reasons for investigating event.

  Type of investigations conducted and agencies involved.

- **Background**

  Generally available information to help the reader interpret epidemiology and data presented in the report (e.g. population size, socioeconomic status of community, ethnicity, etc.).

  If outbreak occurred in a food premises, description of premises (e.g. size of restaurant, usual practices and operations, etc.).

  Description of the problem.

  Sequence of events leading to the study or investigation.

  Brief statement of the working hypothesis.

- **Objectives**

  Specify targets to be achieved by the investigations.

  Keep objectives concise and follow a logical, sequential pattern.

  The objectives may include hypotheses, if any, to be tested.

- **Methods**

  Epidemiology:

  – description of study population
  – type of study conducted
  – case definition
  – procedures for case-ascertainment and selection of controls (if any)
  – methods of data collection, including questionnaire design, administration and contents
  – methods of data analysis.

  Medical laboratory testing:

  – methods of specimen collection and processing
  – name of laboratory carrying out tests
  – laboratory techniques employed and methods of data analysis.

  Food and food testing:

  – description of inspection process
  – methods of food and environmental sampling
  – name of laboratory carrying out tests
  – laboratory techniques employed and methods of data analysis.

- **Results**

  Present all pertinent results from clinical, laboratory, epidemiological and environmental findings.

  Present results in same order as described in the methods section.

  Do not interpret or discuss the data in this section.

  Epidemiology:

  – number of cases, overall attack rate
  – clinical details of illness (symptoms, duration, hospitalization, outcome, etc.)
  – descriptive epidemiology by time (epidemic curve), place and person (age, sex, race, specific characteristics) expressed as rates
  – risk factor exposures
  – further data analysis and data presentation depending on specific studies undertaken (e.g. cohort or case–control study).

  Laboratory (microbiology, chemical, toxicological):

  – number of specimens collected
  – findings by type of laboratory analysis.

  Food investigation and food testing:

  – findings of food inspections
  – results of laboratory tests performed on food and environmental samples.

- **Discussion**

  The discussion is the most important part of the report and should cover:

  – summary of the major findings
  – likely accuracy of the results
  – conclusions with justification for those conclusion and rejection of alternative explanations
  – relationship of these results to other studies and the literature
  – implications of the findings
  – an assessment of control measures
  – needs for future research.

- **Recommendations**

  Initial recommendations and those for future prevention and control should be listed numerically.

- **References**

  Select appropriate references, including reviews in major scientific journals. Follow a standard style of referencing (e.g. Vancouver style), numbering the references in the order in which they appear in the text.

- **Appendices**

  Questionnaires and/or other survey forms
  Appropriate field reports
  Any other relevant documents, including press releases.

Sample report forms from various agencies

Example of an outbreak report form used by the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe

Report of incident

1. Country:	2. Year:	3. Report no.:

4. Place of incident:

City/Town: _____ Province/District: _____

5. Causative agent/type:

Code: ☐☐☐☐☐☐ _____

Phagetype: ☐☐☐ Confirmed: ☐ Presumed: ☐

6. Number of persons:

at risk _____ ill _____ hospitalized _____ died _____

by age groups:

from 0 to 4 years	_____	_____	_____	_____
from 4 to 15 ears	_____	_____	_____	_____
from 15 to 60 years	_____	_____	_____	_____
over 60 years	_____	_____	_____	_____

7. Symptoms:

☐ Nausea ☐ Vomiting ☐ Diarrhoea ☐ Abdominal pain

☐ Fever ☐ Neurological ☐ Cardiovascular ☐ Other (_____)

8. Date of onset of illness:

first person: _ _ / _ _ / _ _ _ _ (day / month / year) last person: _ _ / _ _ / _ _ _ _ (day / month / year)

9. Incubation time and duration of illness: (in hours): ☐ ?

Incubation time: shortest _____ longest _____ median _____

Duration of illness: shortest _____ longest _____ median _____

10. Food/vehicle involved:

Code: ☐☐☐☐☐☐ _____

Confirmation: Laboratory ☐ Epidemiological ☐

Commercial name of product: _____

Producer: _____

11. Methods of marketing, processing, serving:

Marketed: code ☐ Treatment before final preparation: code ☐

Served and eaten: code ☐

12. Place where food was contaminated:

Place: code ☐ Country: code ☐

13. Place and date where food was acquired and eaten:

Date: _ _ / _ _ / _ _ _ _ (day / month / year) Place: code ☐

During transit:

Means of transit: code ☐ from: code ☐ to: code ☐

14. Factors contributing to incident:

(a) Code ☐☐ (b) Code ☐☐

Other

_____

_____

Note: In case more than one factor contributed, list all that are applicable but code only the two major factors.

15. Results of lab. tests:

Testing laboratory: _____

Specimens/samples	No. tested	Positive	Details/comments
Ill people*	_____	_____	_____
Well people*	_____	_____	_____
Food-handlers	_____	_____	_____
Suspect food	_____	_____	_____
Other foods	_____	_____	_____
Environment	_____	_____	_____

* Clinical samples.

Example of an outbreak form used in England and Wales for investigation of general outbreaks of infectious intestinal diseases

OUTBREAK NO. 97\.....

Name: _____ Address: _____

Position: _____ _____

Telephone: _____ LA (Local Authority):

Date: _____ DHA (District Health Authority):

---

1. MODE OF TRANSMISSION (tick one only)

Mainly person to person ☐ Mainly foodborne ☐

Equal or unknown proportion of foodborne and person to person ☐

Other ☐ Specify water, animal contact, etc. _____

Unknown ☐

2. PLACE WHERE OUTBREAK OCCURRED, or if foodborne where food was prepared or served. Tick one only. If foodborne "PREPARED" takes precedence over "SERVED", e.g. if food was prepared in a shop but served in a house, tick "Shop/retailer", if food was prepared at a house and served elsewhere, tick "Private house".

(a) Private house	☐
(b) House/guest house/residential pub	☐ Specify _____
(c) Restaurant/café	☐ Specify ethnicity _____
(d) Pub/bar	☐
(e) Mobile retailer	☐ Specify market trader, chip van, etc. ___
(f) Armed services camp	☐ Specify army, navy, etc. _____
(g) Canteen	☐ Specify work, college _____
(h) Shop/retailer	☐ Specify baker, butcher, etc. _____
(i) Hospital	☐ Specify general, geriatric, EMI _____
(j) Residential institution	☐ Specify nursing/residential home _____
(k) School	☐ Specify nursery, junior, etc. _____
(l) Other	☐ Specify _____

3. NAME AND ADDRESS OF PLACE _____

_____ Postcode (if known)_____

4. WAS THE OUTBREAK AT A FUNCTION? Yes ☐ No ☐ Date of function __/__ /_____

5. WAS PATHOGEN/TOXIN IDENTIFIED? Yes ☐ No ☐

If YES give: Organism/toxin_____ Serotype_____ Phage type____

If NO: Specify organism suspected_____

6. LABORATORY where tests performed: State first and reference labs, even if microbiology was negative

☐ _____ ☐ _____

First lab Reference lab

7. TOTAL NUMBER AFFECTED (diarrhoea and/or vomiting +/– any other symptom) _____

TOTAL NUMBER AT RISK _____

Number admitted to hospital _____ Number known to have died _____

8. LABORATORY RESULTS

NUMBER OF PEOPLE	AFFECTED PEOPLE		WELL PEOPLE	
	TESTED	POSITIVE	TESTED	POSITIVE
8a. *HOSPITAL OR RESIDENTIAL OUTBREAKS ONLY categories (i) and (j) in question 2*				
Residential/patients				
Staff				
Total				
8b. *ALL OTHER OUTBREAKS*				
Non-food-handlers				
Food handlers				
Total				

9. DATE OF ONSET: First known __ / __ / _____ Last known __ / __ / _____

10. SUSPECT FOOD VEHICLE ASSOCIATED WITH ILLNESS: only list specific vehicle for which there is microbiological, statistical or other convincing association with illness.

VEHICLE	EVIDENCE (tick)		
	Microbiological	Statistical association	

11. FAULTS THOUGHT TO HAVE CONTRIBUTED TO OUTBREAK:

Infected food-handler ☐ Give details _____

Inadequate heat treatment ☐ Give details _____

Cross contamination ☐ Give details _____

Storage too long/too warm ☐ Give details _____

Other ☐ Give details _____

Environmental Health Department's inspection rating of premises (if available) (A–F): _____

Foodborne disease outbreak report form from Centers for Disease Control and Prevention, USA

Electronic
Foodborne
Outbreak
Reporting
System

INVESTIGATION OF A FOODBORNE OUTBREAK

This form is used to report foodborne disease outbreak investigations to CDC. It is also used to report *Salmonella enteritidis* and *E. coli* O157:H7 outbreak investigations involving any mode of transmission. A foodborne outbreak is defined as the occurrence of two or more cases of a similar illness resulting from the ingestion of a common food in the United States. This form has 6 parts. Part 1 asks for the minimum or basic information needed and must be completed for the investigation to be counted in the CDC annual summary. Part 2 asks for additional information for any foodborne outbreak, while Parts 3–6 ask for information concerning specific vehicles or etiologies. Please complete as much of all parts as possible.

CDC Use Only
__-_____

State Use Only
_____

Part 1: Basic information

1. Report type

A.
☐ Please check if this is a final report

B.
☐ Please check if data does not support a FOODBORNE outbreak

2. Number of cases

Lab-confirmed cases_____(A)
Including _____ secondary cases

Probable cases_____(B)
Including _____ secondary cases

Estimated total ill_____
(if greater than sum A + B)

3. Dates

Please enter as many dates as possible

Date first case became ill
__ __/__ __/__ __ __ __
Month Day Year

Date last case became ill
__ __/__ __/__ __ __ __
Month Day Year

Date first known exposure
__ __/__ __/__ __ ____
Month Day Year

Date last known exposure
__ __/__ __/__ __ __ __
Month Day Year

4. Location of exposure

Reporting state _____

If multiple states involved:
☐ Exposure occurred in multiple states
☐ Exposure occurred in single state, but cases resided in multiple states
Other states: _____
_____
_____

Reporting county_____

If multiple counties involved:
☐ Exposure occurred in multiple counties
☐ Exposure occurred in one county, but cases resided in multiple counties
Other counties: _____
_____
_____

5. Approximate percentage of cases in each age group

<1 year _____% 20–49 yrs _____%
1–4 yrs _____% ≥50 yrs _____%
5–19 yrs _____% Unknown _____%

6. Sex
(estimated percentage of the total cases)

Male _____%

Female _____%

7. Investigation methods (check all that apply)

☐ Interviews of only cases
☐ Food preparation review
☐ Investigation at factory or production plant
☐ Investigation at original source (farm, marine estuary, etc.)
☐ Environment / food sample cultures
☐ Food product traceback
☐ Case–control study
☐ Cohort study

8. Implicated food(s) (please provide known information)

Name of food e.g. lasagne	**Main ingredient(s)** e.g. pasta, sauce, eggs, beef	**Contaminated ingredient(s)** e.g. eggs	**Reason(s) suspected** (see codes just below) e.g. 4	**Method of preparation** (see attached codes) e.g. M1
1)				
2)				
3)				

☐ Food vehicle undetermined

Reason suspected (list above all that apply)

1. Statistical evidence from epidemiological investigation
2. Laboratory evidence (e.g. identification of agent in food)
3. Compelling supportive information
4. Other data (e.g. same phage type found on farm that supplied eggs)
5. Specific evidence lacking but prior experience makes it likely source

9. Etiology (Name the bacteria, virus, parasite, or toxin. If available, include the serotype and other characteristics such as phage type, virulence factors, and metabolic profile. Confirmation criteria available at http//www.cdc.gov/ncidod/dbmd/outbreak/ or MMWR2000/Vol. 49/SS-1/App. B)

Etiology		Serotype	Other characteristics (e.g. phage type)	Detected in (see codes just below)
1)	☐ Confirmed			
2)	☐ Confirmed			
3)	☐ Confirmed			

☐ Etiology undetermined

Detected in (list above all that apply)

1. Patient specimen(s) **2.** Food specimen(s) **3.** Environment specimen(s) **4.** Food worker specimen(s)

10. Isolate subtype	**State Lab. ID**	**PFGE (PulseNet designation)**	**PFGE (PulseNet designation)**
1)			
2)			
3)			

11. Contributing factors (check all that apply: see attached codes and explanations)

☐ **Contributing factors unknown**

Contamination factor

☐C1 ☐C2 ☐C3 ☐C4 ☐C5 ☐C6 ☐C7 ☐C8 ☐C9 ☐C10 ☐C11 ☐C12 ☐C13 ☐C14 ☐C15 (*describe in Comments)* ☐ N/A

Proliferation/amplification factor (bacterial outbreaks only)

☐P1 ☐P2 ☐P3 ☐P4 ☐P5 ☐P6 ☐P7 ☐P8 ☐P9 ☐P10 ☐P11 ☐P12 (*describe in Comments)* ☐N/A

Survival factor (microbial outbreaks only)

☐S1 ☐S2 ☐S3 ☐S4 ☐S5 (*describe in Comments)* ☐N/A

Was food-worker implicated as the source of contamination? ☐ Yes ☐ No

If yes, please check **only one** of following:

☐ laboratory *and* epidemiologic evidence
☐ epidemiologic evidence (w/o lab confirmation)
☐ lab evidence (w/o epidemiologic evidence)
☐ prior experience makes this the likely source (*please explain in Comments*)

Part 2: Additional information

12. Symptoms, signs and outcomes

Feature	Cases **with outcome/ feature**	Total cases **for whom you have information available**
Healthcare provider visit		
Hospitalization		
Death		
Vomiting		
Diarrhoea		
Bloody stools		
Fever		
Abdominal cramps		
HUS or TTP		
Asymptomatic		
*		
*		
*		

13. Incubation period
(circle appropriate units)

Shortest_____(hours, days)
Longest_____(hours, days)
Median _____(hours, days)

☐ Unknown

14. Duration of Illness (among those who recovered)
(circle appropriate units)

Shortest_____(hours, days)
Longest_____(hours, days)
Median _____(hours, days)

☐ Unknown

* Use the following terms, if appropriate, to describe other common characteristics of cases:

Anaphylaxis
Arthralgia
Bradycardia
Bullous skin lesions
Coma
Cough
Descending paralysis
Diplopia
Flushing
Headache
Hypotension
Itching
Jaundice
Lethargy
Myalgia
Paraesthesia
Septicaemia
Sore throat
Tachycardia
Temperature reversal
Thrombocytopenia
Urticaria
Wheezing

15. If cohort investigation conducted:

Attack rate* = _____ / _____ x 100 = _____%
Exposed and ill / Total number exposed for whom you have illness information

* The attack rate is applied to persons in a cohort who were exposed to the implicated vehicle. The numerator is the number of persons who were exposed and became ill; the denominator is the total number of persons exposed to the implicated vehicle. If the vehicle is unknown, then the attack rate should not be calculated.

16. Location where food was prepared
(check all that apply)

- ☐ Restaurant or deli
- ☐ Day care center
- ☐ School
- ☐ Office setting
- ☐ Workplace cafeteria
- ☐ Banquet facility
- ☐ Picnic
- ☐ Caterer
- ☐ Grocery store
- ☐ Nursing home
- ☐ Prison, jail
- ☐ Private home
- ☐ Workplace, not cafeteria
- ☐ Wedding reception
- ☐ Church, temple, etc.
- ☐ Camp
- ☐ Contaminated food imported into U.S.
- ☐ Hospital
- ☐ Fair, festival, other temporary/ mobile services
- ☐ Commercial product, served without further preparation
- ☐ Unknown or undetermined
- ☐ Other (describe) _____

17. Location of exposure or where food was eaten
(check all that apply)

- ☐ Restaurant or deli
- ☐ Day care center
- ☐ School
- ☐ Office setting
- ☐ Workplace cafeteria
- ☐ Banquet facility
- ☐ Picnic
- ☐ Grocery store
- ☐ Nursing home
- ☐ Prison, jail
- ☐ Private home
- ☐ Workplace, not cafeteria
- ☐ Wedding reception
- ☐ Church, temple, etc.
- ☐ Camp
- ☐ Hospital
- ☐ Fair, festival, temporary/ mobile service
- ☐ Unknown or undetermined
- ☐ Other (describe) _____

18. Trace back

☐ Please check if trace back conducted.

Source to which trace back led: _____

Source (e.g. chicken farm, tomato processing plant)	**Location of source** **State**	**County**	**Comments**

19. Recall

☐ Please check if any food product recalled.

Recall comments

_____
_____
_____
_____

20. Available reports (please attach)

- ☐ Unpublished agency report
- ☐ Epi-Aid report
- ☐ Publication (please reference if not attached)

_____
_____

21. Agency reporting this outbreak

_____

Contact person:

Name _____
Title _____
Phone _____
Fax _____
E-mail _____

22. Remarks

Briefly describe important aspects of the outbreak not covered above (e.g. restaurant closure, immunoglobin administration, economic impact, etc.)

_____
_____
_____
_____
_____

Part 3: School questions

1. Did the outbreak involve a single or multiple schools?

☐ Single
☐ Multiple (*if yes*, number of schools ____)

2. School characteristics (for all involved students in all involved schools)

a) Total approximate enrolment
_____ (number of students)
☐ Unknown or undetermined

b) Grade level(s) (please check all grades affected)
☐ Preschool
☐ Grade school (grades K–12)
Please check all grades affected: ☐ K ☐ 1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ 9th ☐ 10th ☐ 11th ☐ 12th
☐ College/university/technical school
☐ Unknown or undetermined

c) Primary funding of involved school(s)
☐ Public ☐ Private ☐ Unknown or undetermined

3. Describe the preparation of the implicated item:

☐ Heat and serve (item mostly prepared or cooked off-site, reheated on-site)
☐ Served a-la-carte
☐ Serve only (preheated or served cold)
☐ Cooked on-site using primary ingredients
☐ Provided by a food service management company
☐ Provided by a fast food vendor
☐ Provided by a pre-plate company
☐ Part of a club/fundraising event
☐ Made in the classroom
☐ Brought by a student/teacher/parent
☐ Other _____
☐ Unknown or undetermined

4. How many times has the state, county or local health department inspected this school cafeteria or kitchen in the 12 months before the outbreak?*

☐ Once
☐ Twice
☐ More than two times
☐ Not inspected
☐ Unknown or undetermined

*If there are multiple schools involved, please answer according to the most affected school.

5. Does the school have a HACCP plan in place for the school feeding program?*

☐ Yes
☐ No
☐ Unknown or undetermined

*If there are multiple schools involved, please answer according to the most affected school.

6. Was implicated food item provided to the school through the National School Lunch/Breakfast Program?

☐ Yes
☐ No
☐ Unknown or undetermined

***If Yes,* was the implicated food item donated/purchased by :**

☐ USDA through the Commodity Distribution Program
☐ Purchased commercially by the state/school authority
☐ Other_____
☐ Unknown or undetermined

Part 4: Ground beef

1. What percentage of ill persons (for whom information is available) ate ground beef raw or undercooked? _____%

2. Was ground beef case-ready? (Ground beef that comes from a manufacturer packaged for sale and not altered or repackaged by the retailer)
- ☐ Yes
- ☐ No
- ☐ Unknown or undetermined

3. Was the beef ground or reground by the retailer?
- ☐ Yes
- ☐ No
- ☐ Unknown or undetermined

If yes, was anything added to the beef during grinding (e.g. shop trim or any product to alter the fat content)?

_____

Part 5: Mode of transmission
(enterohaemorrhagic *E. coli* or *Salmonella* enteritidis only)

1. Mode of transmission (for greater than 50% of cases)

Select one:
- ☐ Food
- ☐ Person to person
- ☐ Swimming or recreational water
- ☐ Drinking water
- ☐ Contact with animals or their environment
- ☐ Unknown or undetermined

Part 6: Additional egg questions

1. Were eggs (check all that apply):
- ☐ in-shell, un-pasteurized?
- ☐ in-shell, pasteurized?
- ☐ liquid or dry egg product?
- ☐ stored with inadequate refrigeration during or after sale?
- ☐ consumed raw?
- ☐ consumed undercooked?
- ☐ pooled?

2. If eggs traced back to farm, was *Salmonella* enteritidis found on the farm?
- ☐ Yes
- ☐ No
- ☐ Unknown or undetermined

Comment:_____
_____

Contamination factors:[1]

C1 – Toxic substance part of tissue (e.g. ciguatera)
C2 – Poisonous substance intentionally added (e.g. cyanide or phenolphthalein added to cause illness)
C3 – Poisonous or physical substance accidentally/incidentally added (e.g. sanitizer or cleaning compound)
C4 – Addition of excessive quantities of ingredients that are toxic under these situations (e.g. niacin poisoning in bread)
C5 – Toxic container or pipelines (e.g. galvanized containers with acid food, copper pipe with carbonated beverages)
C6 – Raw product/ingredient contaminated by pathogens from animal or environment (e.g. *Salmonella* enteriditis in egg, norovirus in shellfish, *E. coli* in sprouts)
C7 – Ingestion of contaminated raw products (e.g. raw shellfish, produce, eggs)
C8 – Obtaining foods from polluted sources (e.g. shellfish)
C9 – Cross-contamination from raw ingredient of animal origin (e.g. raw poultry on the cutting board)
C10 – Bare-handed contact by handler/worker/preparer (e.g. with ready-to-eat food)
C11 – Glove-handed contact by handler/worker/preparer (e.g. with ready-to-eat food)
C12 – Handling by an infected person or carrier of pathogen (e.g. *Staphylococcus*, *Salmonella*, norovirus
C13 – Inadequate cleaning of processing/preparation equipment/utensils leads to contamination of vehicle (e.g. cutting boards)
C14 – Storage in contaminated environment leads to contamination of vehicle (e.g. store room, refrigerator)
C15 – Other source of contamination (*please describe in Comments*)

Proliferation/amplification factors:[1]

P1 – Allowing foods to remain at room or warm outdoor temperature for several hours (e.g. during preparation or holding for service)
P2 – Slow cooling (e.g. deep containers or large roasts)
P3 – Inadequate cold-holding temperatures (e.g. refrigerator inadequate/not working, iced holding inadequate)
P4 – Preparing foods a half day or more before serving (e.g. banquet preparation a day in advance)
P5 – Prolonged cold storage for several weeks (e.g. permits slow growth of psychrophilic pathogens)
P6 – Insufficient time and/or temperature during hot holding (e.g. malfunctioning equipment, too large a mass of food)
P7 – Insufficient acidification (e.g. home canned foods)
P8 – Insufficiently low water activity (e.g. smoked/salted fish)
P9 – Inadequate thawing of frozen products (e.g. room thawing)
P10 – Anaerobic packaging/modified atmosphere (e.g. vacuum packed fish, salad in gas flushed bag)
P11 – Inadequate fermentation (e.g. processed meat, cheese)
P12 – Other situations that promote or allow microbial growth or toxic production (*please describe in Comments*)

Survival factors:[1]

S1 – Insufficient time and/or temperature during initial cooking/heat processing (e.g. roasted meats/poultry, canned foods, pasteurization)
S2 – Insufficient time and/or temperature during reheating (e.g. sauces, roasts)
S3 – Inadequate acidification (e.g. mayonnaise, tomatoes canned)
S4 – Insufficient thawing, followed by insufficient cooking (e.g. frozen turkey)
S5 – Other process failures that permit the agent to survive (*please describe in Comments*)

Method of preparation:[2]

M1 – Foods eaten raw or lightly cooked (e.g. hard shell clams, sunny side up eggs)
M2 – Solid masses of potentially hazardous foods (e.g. casseroles, lasagna, stuffing)
M3 – Multiple foods (e.g. smorgasbord, buffet)
M4 – Cook/serve foods (e.g. steak, fish fillet)
M5 – Natural toxicant (e.g. poisonous mushrooms, paralytic shellfish poisoning)
M6 – Roasted meat/poultry (e.g. roast beef, roast turkey)
M7 – Salads prepared with one or more cooked ingredients (e.g. macaroni, potato, tuna)
M8 – Liquid or semi-solid mixtures of potentially hazardous foods (e.g. gravy, chili, sauce)
M9 – Chemical contamination (e.g. heavy metal, pesticide)
M10 – Baked goods (e.g. pies, eclairs)
M11 – Commercially processed foods (e.g. canned fruits and vegetables, ice cream)
M12 – Sandwiches (e.g. hot dog, hamburger, Monte Cristo)
M13 – Beverages (e.g. carbonated and non-carbonated, milk)
M14 – Salads with raw ingredients (e.g. green salad, fruit salad)
M15 – Other, does not fit into above categories *(please describe in Comments)*
M16 – Unknown, vehicle was not identified

[1] Bryan FL, Guzewich JJ, Todd ECD. Surveillance of foodborne disease. III. Summary and presentation of data on vehicles and contributory factors: their value and limitations. *Journal of Food Protection*, 1997, 60(6):701–714.
[2] Weingold SE, Guzewich JJ, Fudala JK. Use of foodborne disease data for HACCP risk assessment. *Journal of Food Protection*, 1994, 57(9):820–830.

Annex 7
Statistics

Calculating rates

Rates are the most common way of measuring disease frequency in a population and are calculated as:

$$\frac{\text{number of new cases of disease in population at risk}}{\text{number of persons in population at risk}}$$

The numerator is new cases of disease (or deaths or other health events) during a specified period; the denominator is the population at risk. Rates imply changes over time and the period of time for which the rate has been calculated (e.g. month, year) must be specified. Rates can be expressed per hundreds, per thousands or per millions as convenient.

Rates that are calculated with the total population in an area are known as *crude rates.* Crude rates from different populations cannot be easily compared especially where there are striking differences in, for example, age and sex between populations. Rates may also be calculated using data from specific segments of the population: these are called *specific rates* (e.g. age- or sex-specific – rates for certain age groups and for men or women, respectively).

An *attack rate* is defined as the proportion of those who became ill after a specified exposure. For example, in an outbreak of gastroenteritis with 50 cases among a population at risk of 2500, the attack rate of disease is

$$50/2500 = 0.02 \text{ or}$$
$$= 2/100 \text{ or}$$
$$= 20/1000$$

Specific attack rates are calculated to identify persons in the population who are at a higher risk of becoming ill than others. Examples of commonly used specific attack rates are attack rates by age group, residence, sex or occupation. To identify the potential vehicle in a foodborne disease outbreak, the *food-specific attack rate* is often calculated, which is the attack rate for consumption of a specified food, calculated as

$$\frac{\text{number of cases of disease among people who ate food “X”}}{\text{number of persons who ate food “X”}}$$

To calculate a measure of association between food “X” and illness, a second attack rate must be calculated for those who did not eat food “X”. The two attack rates can then be compared with each other as a relative risk (division) or as a risk difference (subtraction).

Example

After a dinner attended by 100 people, 12 individuals become ill. All 100 people are interviewed about their food consumption at the dinner. The interviews show that 8 of the 12 people who are ill and 25 of the 88 who are healthy ate fish.

	Ill	Well	Total	Attack rate (%)
Ate fish	8	25	33	24.2
Did not eat fish	4	63	67	6.0
Total	12	88	100	

The relative risk for eating fish is 24.2/6.0 or 4. The risk difference is 24.2% – 6% = 18.2%

Median

The median is the midpoint of a series of ordered values. It divides a set of values into two equal parts. To identify the median from individual data:

- Arrange the observations in increasing or decreasing order
- Find the middle rank using the following formula: middle rank = (n + 1)/2.
  - If the number of values is odd, the middle rank falls on one observation.
  - If the number of values is even, the middle rank falls between two observations.
- Identify the value of the median
  - If the middle rank falls on a specific observation, the median is equal to the value of the middle rank.
  - If the middle rank falls between two observations, the median is equal to the average of the values of those observations.

Example 1

To calculate the median for the following observations: 1, 20, 5, 3 and 9:

- Arrange the observations (n = 5) by order of magnitude: 1, 3, 5, 9, 20.
- Identify the middle rank: (5 + 1)/2 = 3.
- The median is the third observation of the ordered series, namely 5.

Example 2

To calculate the median for the following observations: 1, 20, 5, 3, 9, 21:

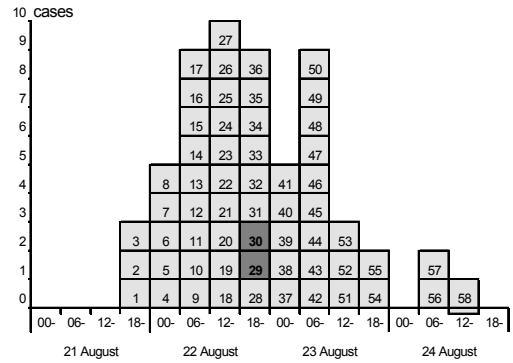
- Arrange the observations (n = 6) by order of magnitude: 1, 3, 5, 9, 20, 21
- Identify the middle rank: (6 + 1)/2 = 3.5.
- The median is the average of the value of the third and fourth observations, namely 5 and 9. Thus the median = (5+9)/2 = 7.

To identify the median from a frequency distribution (e.g. epidemic curve):

- Count the number of observations.
- Identify the middle rank as above.
- If the middle rank falls within a row, the median interval equals the value of the row. If the middle rank falls between two rows, the median interval is the average of the values of the two rows.

Example 3

The epidemic curve shows 58 cases. The middle rank is (58+1)/2 = 29.5. Case numbers 29 and 30 both occur between 18:00 and 24:00 hours on 22 August, which is the median interval.



Statistical significance testing

In the 2x2 table below the attack rate for eating vanilla ice cream is 79.6%, while the attack rate for those who did not eat vanilla ice cream is 14.3%. A test of statistical significance determines the probability that the difference between the two attack rates occurred by chance alone. In other words, the test asks "How likely is it that the 54 exposed and the 21 non-exposed persons would divide into 46 who are ill and 29 who are well purely by chance?" If this probability is very low (arbitrarily, "very low" is defined as 5% or less and expressed as a *p*-value of <0.05) we assume that the differences are real and related in one way or another to eating vanilla ice cream.

	Ill	Well	Total	Attack rate (%)
Ate vanilla ice cream	43	11	54	79.6
Did not eat vanilla ice cream	3	18	21	14.3
Total	46	29	75	61.3

To calculate statistical significance the chi-square (χ^2) test can be used. The principles are illustrated in the following 2x2 tables:

	Ill	Well	Total	*Observed*
Exposed	$O_1 = a$	$O_2 = b$	$n1$	
Non exposed	$O_3 = c$	$O_4 = d$	$n2$	
Total	***n*3**	***n*4**	***N***	

We can calculate the expected numbers of ill and well that would occur if exposure were not related to becoming ill and the division into ill and well were by chance alone:

	Ill	**Well**	**Total**	***Expected***
Exposed	$E1 = \frac{n1n3}{N}$	$E2 = \frac{n1n4}{N}$	$n1$	
Non exposed	$E3 = \frac{n2n3}{N}$	$E4 = \frac{n2n4}{N}$	$n2$	
Total	***n*3**	***n*4**	***N***	

The chi-square tests compare the observed numbers with the expected numbers for each of the four cells using the following formula:

$$\frac{(\text{observed} - \text{expected})^2}{\text{observed}} = \frac{(O_i - E_i)^2}{O_i}$$

$$\chi^2 = \Sigma \frac{(O_i - E_i)^2}{O_i} \qquad (1)$$

An easier way to calculate the χ^2 for a 2x2 table which leads to the same result can be obtained with the following formula:

$$\chi^2 = \frac{N(ad - bc)^2}{n1n2n3n4} \qquad (2)$$

If the expected number (E_i) inside any of the cells is less than 5, the χ^2 needs to be corrected using the following formula:

$$\chi^2_{\text{corrected}} = \frac{N[(ad - bc) - N/2]^2}{n1n2n3n4} \qquad (3)$$

The results for χ^2 are compared with theoretical values for the chi-square distribution (see statistical textbooks for detailed tables). As a rough guide, if the calculated χ^2 value is:

≥10.83, the difference between the two groups is highly significant ($p \leq 0.001$)
≥6.64, the difference between the two groups is strongly significant ($p \leq 0.01$)
≥3.84, the difference between the two groups is significant ($p \leq 0.05$).

If the calculated χ^2 value is <3.84, the difference between the two groups is considered to be not statistically significant ($p > 0.05$).

Calculated example, using formula (2)

	Ill	Well	Total
Ate vanilla ice cream	43	11	54
Did not eat vanilla ice cream	3	18	21
Total	46	29	75

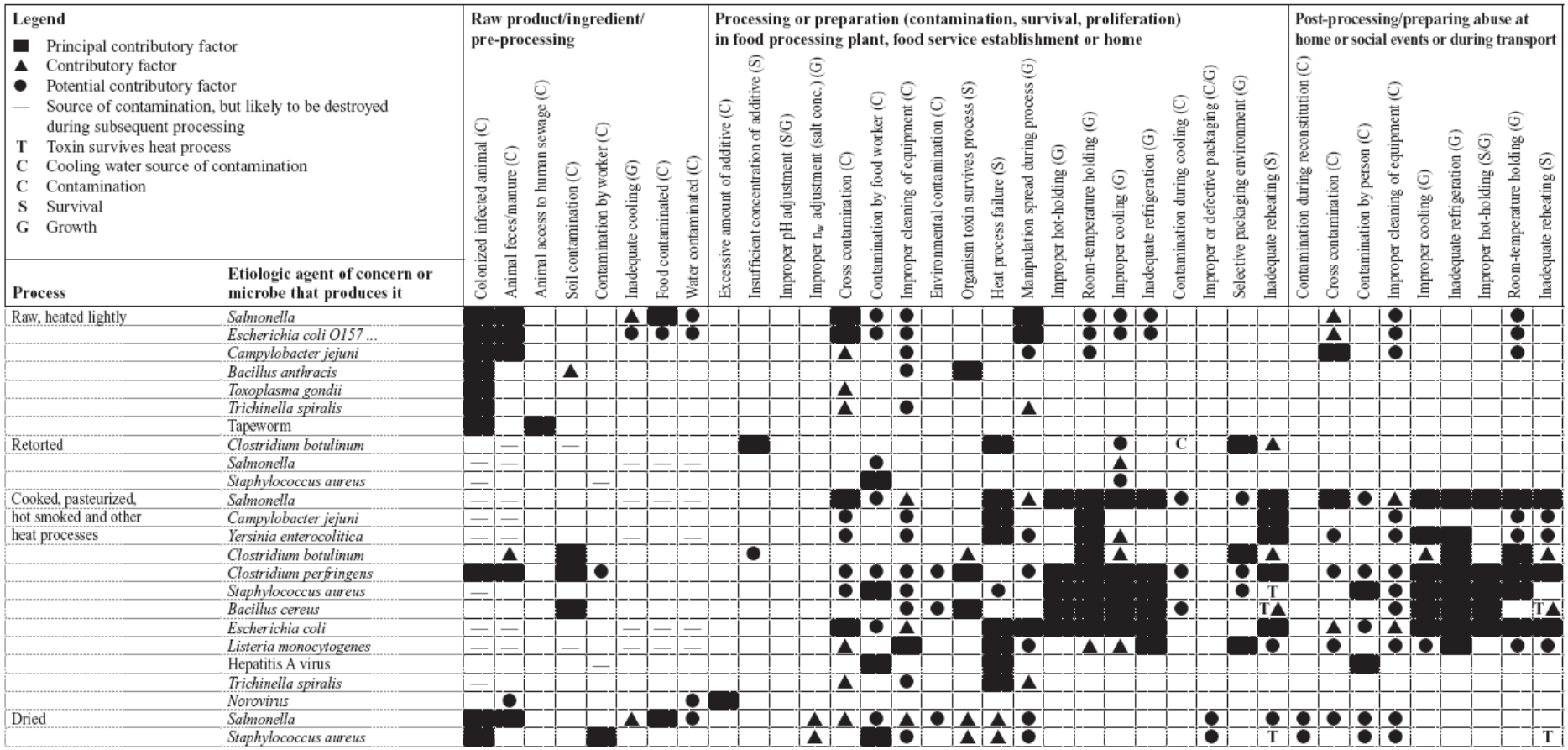
$$\chi^2 = \frac{75(43x18 - 11x3)^2}{54x21x46x29} = 27.2$$

Since the χ^2 value of 27.2 > 10.83, the *p*-value is <0.001. This means that the probability of finding the distribution presented in this 2x2 table by chance alone is small – less than 1/1000. The exact *p*-value as calculated by a computer is 0.0000002. In other words, it can be assumed that vanilla ice cream is strongly associated with the risk of becoming ill.

Annex 8

Situations likely to contribute to foodborne disease outbreaks[2]

Key A. *Situations that likely contributed to outbreaks of foodborne diseases when meat products were implicated as vehicles.*



[2] Source: IAMFES, 1987.

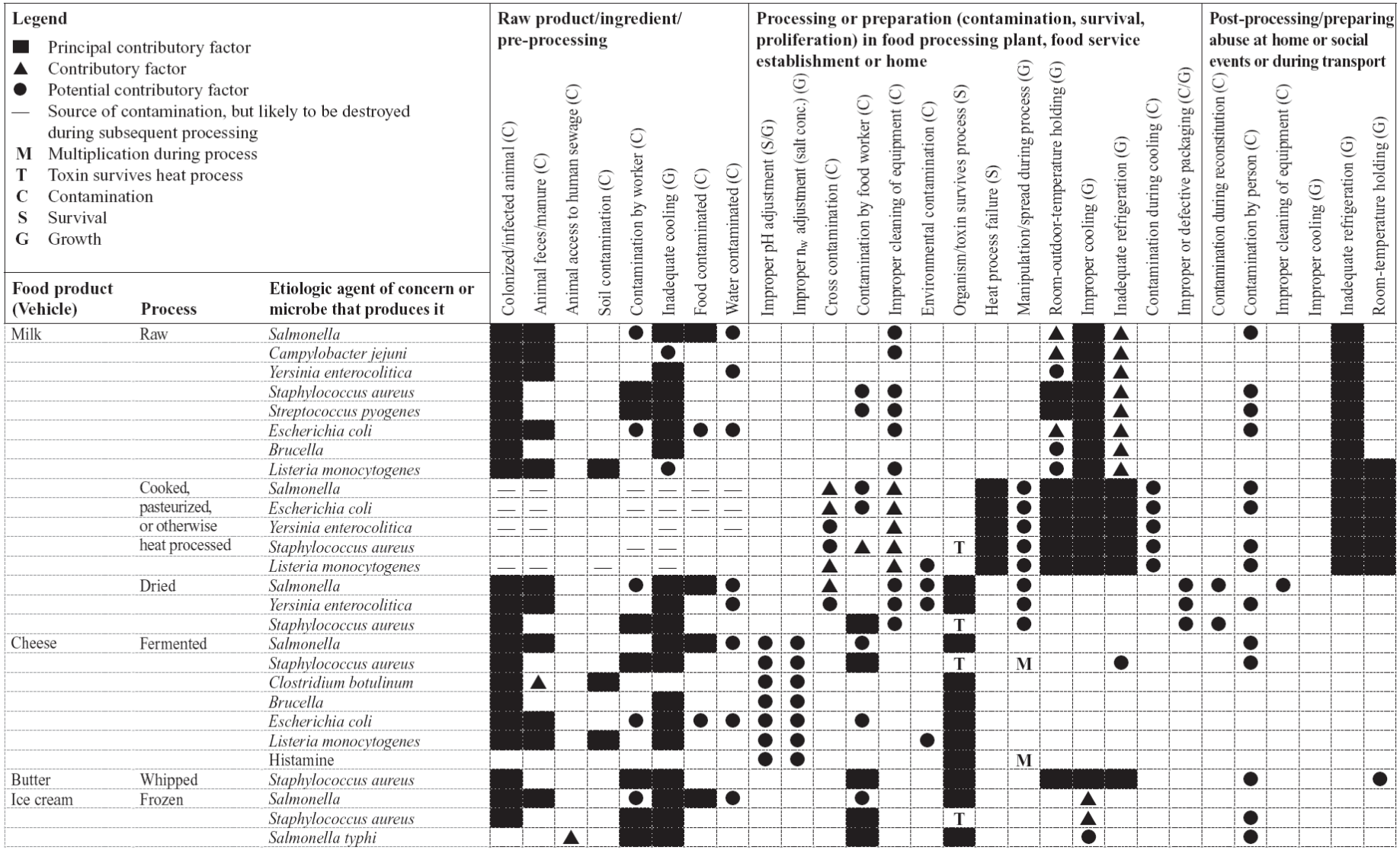
Key B. *Situations that likely contributed to outbreaks of foodborne diseases when poultry, poultry products, or eggs were implicated as vehicles.*

Legend

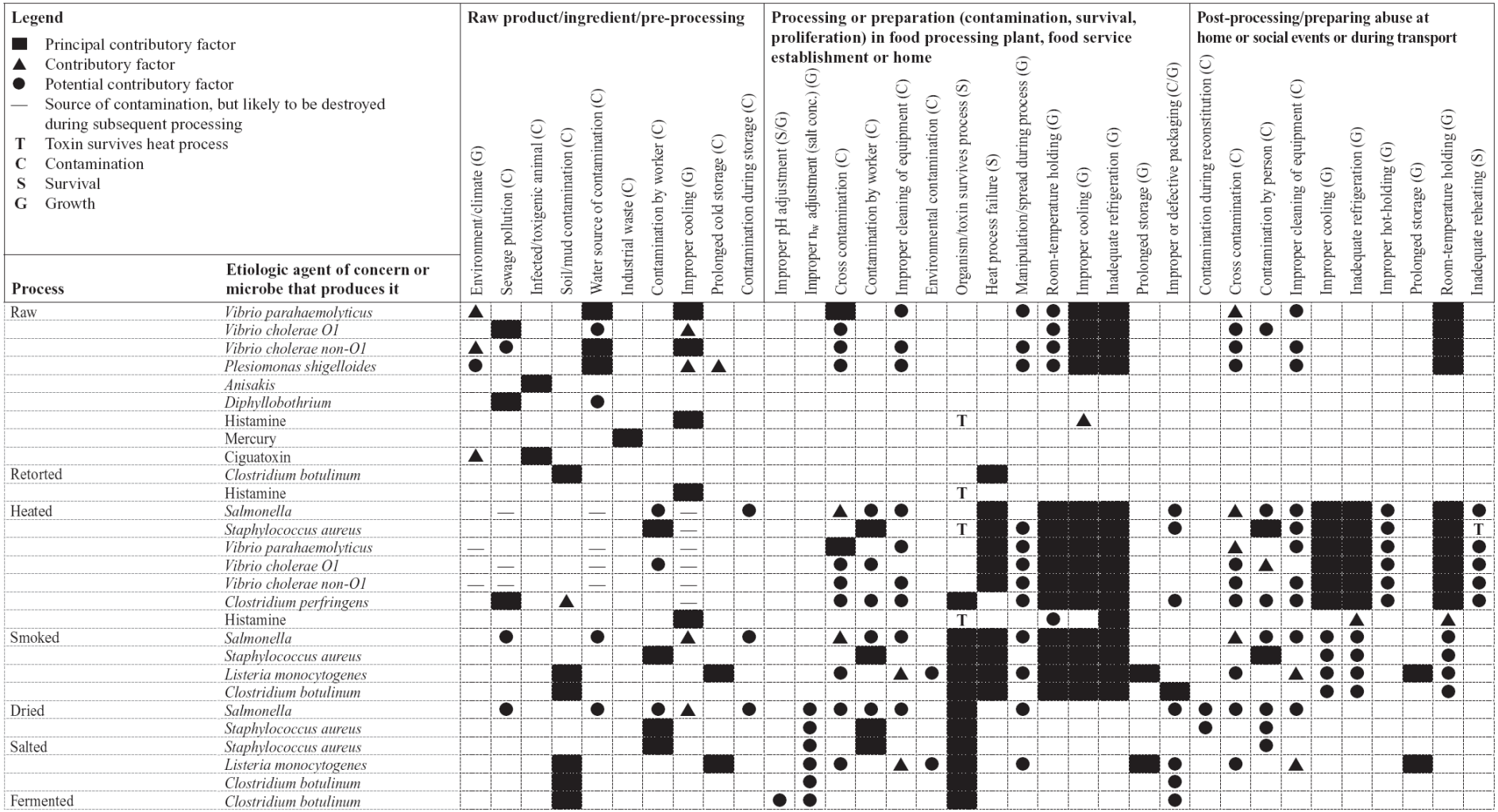
- ■ Principal contributory factor
- ▲ Contributory factor
- ● Potential contributory factor
- — Source of contamination, but likely to be destroyed during subsequent processing
- **T** Toxin survives heat process
- **C** Contamination
- **S** Survival
- **G** Growth

Food product (Vehicle)	Process	Etiologic agent of concern or microbe that produces it	Raw product/ingredient/ pre-processing							Processing or preparation (contamination, survival, proliferation) in food processing plant, food services establishment or home																		Post-processing/preparing abuse at home or social events or during transport								
			Colonized infected animal (C)	Animal feces/manure (C)	Soil contamination (C)	Contamination by worker (C)	Inadequate cooling (G)	Food contaminated (C)	Water contaminated (C)	Excessive amount of additive (C)	Insufficient concentration of additive (S)	Improper pH adjustment (S/G)	Improper n_w adjustment (salt conc.) (G)	Cross contamination (C)	Contamination by food worker (C)	Improper cleaning of equipment (C)	Environmental contamination (C)	Organism/toxin survive process (S)	Heat process failure (S)	Manipulation spread during process (G)	Improper hot-holding (G)	Room temperature holding (G)	Improper cooling (G)	Inadequate refrigeration (G)	Contamination during cooling (C)	Improper or defective packaging (C/G)	Selective packaging environment (G)	Inadequate reheating (S)	Contamination during reconstitution (C)	Cross contamination (C)	Contamination by person (C)	Improper cleaning of equipment (C)	Improper cooling (G)	Inadequate refrigeration (G)	Improper hot-holding (S/G)	Room temperature holding (G)	Inadequate reheating (S)
Poultry	Raw, heated lightly	*Campylobacter jejuni*	■	■										▲		●			■	●		●								■							
	Retorted	*Clostridium botulinum*	—	—	—														■								■	●									●
	Heated	*Salmonella*	—	—			▲	■	●					■	●	▲			■		■	■	■	■	●		●	■		■		▲	■	■	■	■	■
		Campylobacter jejuni	—	—										●		●			■			●					●	■		■		●			●	●
		Listeria monocytogenes	—	—	—		●	●	●					▲		■	●		■	▲		●	●	■	●		■	■		●		●		■	●	●
		Staphylococcus aureus	—			—									■	●		T	■	●	▲	■	■	■				T		●	■	●	■	■	■	■	T
		Clostridium perfringens	■	■		●								●	●	●		■		●	■	■	■	■	●		●	■		●	●	●	■	■	■	■	■
		Salmonella	■	■			▲	■	●					■	■	▲		■		▲						●			●		●	●					
	Dried	*Staphylococcus aureus*				■							●			●	●	T		●						●		T	●		●	●					
	Cured	*Staphylococcus aureus*				■				●	●	●	●			●		T	●	▲		▲	▲	●				T			■	●	■	■	■	■	T
Eggs	Raw/heated lightly	*Salmonella*	■	■		●	●	■						■	●	▲														●			●			
	Heated	*Salmonella*	—	—		—	—	—						■	●	●			■	●	●	■	■	■			●			■	●	●		●			—
		Staphylococcus aureus	—			—									■			T	■		●	■	■	■				T			■	▲	■	■	■	■	T
		Streptococcus pyogenes	—			—									■				■		●	■	■	■				●			■		■	■	■	■	■
	Dried	*Salmonella*	■	■			▲	■	●				●	■	●	●	●	■		▲										●	●	●					T
	Frozen	*Salmonella*	■	■			▲	■	●					■	●	●		■		●		●	▲							●	●	●					■

Key C. *Situations that likely contributed to outbreaks of foodborne diseases when milk or milk products were implicated as vehicles.*



Key D. *Situations that likely contributed to outbreaks of foodborne diseases when fish were implicated as vehicles.*



Key E. *Situations that likely contributed to outbreaks of foodborne diseases when shellfish, crustaceans or marine mammals were implicated as vehicles.*

Legend

- ■ Principal contributory factor
- ▲ Contributory factor
- ● Potential contributory factor
- — Source of contamination, but likely to be destroyed during subsequent processing
- **T** Toxin survives heat process
- **C** Contamination
- **S** Survival
- **G** Growth

Food product (Vehicle)	Process	Etiologic agent of concern or microbe that produces it	Raw product/ingredient/ pre-processing: Environment/climate (G)	Sewage pollution (C)	Infected/toxigenic animal (C)	Soil/mud contamination (C)	Water source of contamination (C)	Industrial waste (C)	Contamination by worker (C)	Improper cooling (G)	Contamination during storage (C)	Processing or preparation (contamination, survival, proliferation) in food processing plant, food service establishment or home: Improper pH adjustment (S/G)	Improper n_w adjustment (salt conc.) (G)	Cross contamination (C)	Contamination by worker (C)	Improper cleaning of equipment (C)	Organism/toxin survives process (S)	Heat process failure (S)	Improper hot-holding (S/G)	Room-outdoor-temperature holding (G)	Improper cooling (G)	Inadequate refrigeration (G)	Inadequate reheating (S)	Post-processing/preparing abuse at home or social events or during transport: Contamination during reconstitution (C)	Cross contamination (C)	Contamination by person (C)	Improper cleaning of equipment (C)	Improper cooling (G)	Inadequate refrigeration (G)	Improper hot-holding (G)	Room-outdoor-temperature holding (G)	Inadequate reheating (S)
Shellfish	Raw	*Salmonella typhi*		■					■	▲					■					●		▲				■			●		■	
		Salmonella		●					●	■	●				●		●			●	●	■			●	●	●		■		■	
		Vibrio cholerae OI		■					■	■					●	●				●	●	▲				●			▲		■	
		Vibrio cholerae non-OI	▲				■			■					▲		●			●	●	■			▲				■		■	
		Vibrio parahaemolyticus	▲				■			■					▲		●			●	■	■			▲				■		■	
		Vibrio vulnificus	▲				■			●										●		●							●		●	
		Hepatitis A virus		■					▲							▲										■						
		Norwalk-like virus		■					▲							▲										■						
		Paralytic shellfish poison (Saxitoxin)	■		■																											
		Amnesic shellfish poison (Domoic acid)	■		■																											
		Mercury						■																								
	Heated	*Salmonella*		●					●		●				●	●			■	●	■	■	■	●		●		●	■	■	●	■	■
		Staphylococcus aureus							●	●						■	●	T	■	●	■	■	■	T			■	●	■	■	●		T
		Vibrio paraphaemolyticus	▲				■			■					■		●		■	●	■	■	■	●		▲		●	■	■	●	■	■
Crustaceans	Heated	*Vibrio paraphaemolyticus*	▲				■			■					■		●		■	●	■	■	■	●		▲		●	■	■	●	■	■
	Dried	*Vibrio paraphaemolyticus*	▲				■			■			●	●		●		■								▲						
		Staphylococcus aureus							●	●			●		■	●	■								●		●					
Marine mammals	Raw	*Salmonella*		●					●	●	●			●	●	●					●	●	■					●	■	■		■	
	Fermented	*Clostridium botulinum*				■				●		▲				■																

Key F. *Situations that likely contributed to outbreaks of foodborne diseases when vegetables were implicated as vehicles.*

Legend

- ■ Principal contributory factor
- ▲ Contributory factor
- ● Potential contributory factor
- — Source of contamination, but likely to be destroyed during subsequent processing
- **T** Toxin survives heat process
- **C** Contamination
- **S** Survival
- **G** Growth

Food product (Vehicle)	Process	Etiologic agent of concern or microbe that produces it	Raw product/ ingredient/ pre-processing: Sewage pollution (C)	Infected animal/manure (C)	Soil contamination (C)	Contamination by worker (C)	Contamination by water (C)	Prolonged cold storage (C)	Processing or preparation (contamination, survival, proliferation) in food processing plant, food service establishment or home: Excessive amount of additive (C)	Abnormally-high n_w (G)	Improper pH adjustment (S/G)	Use of polluted water (C)	Contamination by worker (C)	Improper cleaning of equipment (C)	Organism/toxin survives process (S)	Heat process failure (S)	Improper hot-holding (S/G)	Room-temperature holding (G)	Improper cooling (G)	Inadequate refrigeration (G)	Contamination during cooling (C)	Prolonged storage (G)	Selective packaging environment (G)	Inadequate reheating (S)	Post-processing/preparing abuse at home or social events or during transport: Contamination by person (C)	Improper cleaning of equipment (C)	Improper cooling (G)	Inadequate refrigeration (G)	Improper hot-holding (G)	Prolonged storage (G)	Room-temperature holding (G)	Inadequate reheating (S)
Leafy green (including raw-vegetable salads)	Raw	*Salmonella typhi*	■			■	■					■	■												■			●			●	
		Salmonella	●	■		●	●					●	●	●											●	●		●			●	
		Shigella	■			■	●					●	■												■			●			●	
		Escherichia coli	■	■		●	●					●	●	●											●	●		●			●	
		Listeria monocytogenes		■	■			■				●		▲								■	■					●		■	●	
		Vibrio cholerae	■			●	●					■	●												●			●			●	
		Hepatitis A virus	■			■	●					●	■												■							
		Norwalk-like viruses	■			■	●					●	■												■							
		Giardia lamblia	■	▲		■	●					●	■												■							
		Cyclospora cayetanensis	■			●	●					●	●	●								●								●		
		Sulfites*							■																							
Sprouts	Raw	*Bacillus cereus*			■					■				●				▲														
		Salmonella	●	■		●	●			■		●	●	●				▲														
		Escherichia coli O157	●	■		●	●			■		●	●	●				▲								●	●		●		●	
Tomatoes	Raw	*Salmonella*	●	■		●	●					●	●	●												●			●		●	
Watercress	Raw	*Salmonella*	■	■		●	■						●													●						
Beans/legumes	Heated	*Clostridium perfringens*	■	●	■	●						●	●	●	■	■	■	■	■	■					■	●	●	■	■	■		■	■
		Bacillus cereus			■									●	■	■	■	■	■	■					T▲		●	■	■	■		■	T▲
Potatoes	Heated	*Clostridium botulinum*		●	■									●	■	■	■	■	■	■					●		●	■	■	■		■	●
		Bacillus cereus			■									●	■	■	■	■	■	■					T▲		●	■	■	■		■	T▲
Vegetables, all applicable types	Retorted	*Clostridium botulinum*		—	—						▲				■	■					●		■	●			●					
		Staphylococcus aureus	—			—								■										T	●		●			●		
	Heated	*Bacillus cereus*			■												■	■	■	■							●	■	■	■		■	T▲

*Only affects sensitized persons

Key G. *Situations that likely contributed to outbreaks of foodborne diseases when fruits, nuts, spices, grains or mushrooms were implicated as vehicles.*

Legend

■ Principal contributory factor
▲ Contributory factor
● Potential contributory factor
— Source of contamination, but likely to be destroyed during subsequent processing
C Contamination
S Survival
G Growth

Food product (Vehicle)	Process	Etiologic agent of concern or microbe that produces it	Raw product/ingredient/pre-processing: Spraying close to harvest time (C)	Sewage pollution (C)	Infected animal/manure (C)	Soil contamination (C)	Contamination by worker (C)	Contamination by water (C)	Abnormally-high n_w (G)	Prolonged cold storage (C)	Contamination by vectors (C)	High soil nitrites/nitrates (C)	Processing or preparation (contamination, survival, proliferation) in food processing plant, food service establishment or home: Improper n_w adjustment (salt conc.) (G)	Use of polluted water (C)	Contamination by worker (C)	Improper cleaning of equipment (C)	Organism/toxin survives process (S)	Heat process failure (S)	Manipulation/spread during process (G)	Room-temperature holding (G)	Improper cooling (G)	Inadequate refrigeration (G)	Contamination during cooling (C)	Prolonged storage	Post-processing/preparing abuse at home or social events or during transport: Contamination during reconstitution (C)	Contamination by person (C)	Improper cleaning of equipment (C)	Improper cooling (G)	Inadequate refrigeration (G)	Prolonged storage (G)	Room-temperature holding (G)
Apple cider	Raw	*Escherichia coli*	●	■		●	●								●	▲			●												
		Cryptosporidium	●	■		●	●								●	▲			●												
Berries	Raw	Hepatitis A virus		■			■	●							■											■					
		Cyclospora cayetanensis		■			●	●							●	●			●								●				
Melons	Raw	*Salmonella*		●	■		●	●						●	●	●			■	■	■	●					●	■	▲		■
		Escherichia coli		●	●		●	●						●	●	●			■	■	■	●					●	■	▲		■
		Aldicarb	■																												
Orange juice	Raw	*Salmonella typhi*		●			■	●						●	■	●			●												
		Salmonella		●	■		●	●						●	●	●			●								●				
		Hepatitis A virus		■			■	●						●	■																
Other fruits		*Salmonella*		●	■		●	●						●	●	●			●								●				
		Shigella		■			■	●						●	■											■					●
		Hepatitis A virus		■			■	●						●	■											■					
	Retorted	*Clostridium botulinum*			—	—												■													
Ground/tree nuts	Dried	*Mycotoxins*				●			●	●			●				■							●						●	
Coconuts	Dried	*Salmonella typhi*		■			■	●	●				●	■	■		■		●						●						
		Salmonella		●	■		●	●	●		●		●	■	●	●	■		●						●						
Spices	Dried/Fermented	*Salmonella*		●	■		●	●					●	●	●	●	■		●						●						
Rice	Heated	*Bacillicus cereus*				■											■			■	■	■						■	■		■
Other grains	Dried	*Mycotoxins*				●			●	●			●				■		●					●						●	
		Salmonella		●	■		●	●	●		●		●			●	■		●						●						
Mushrooms	Raw	*Salmonella*		●	■		●								●																
	Retorted	*Clostridium botulinum*				■											■						●								
		Staphylococcus aureus					—								■		T			—											

Annex 9

Procedures and equipment for specimen collection

Clinical specimens

General

Enclose specimens in a secure container and label the container with a waterproof pen. Place this container in a waterproof bag with tissue, towels or other blotting material to absorb any leakage. Put all specimen containers in an insulated box packed with ice or frozen refrigerant packs and deliver them to the laboratory as soon as possible. If sending specimens by post or courier ensure that they are delivered during business hours on a weekday.

Address the package clearly, including the name and telephone number of the receiving laboratory. Write instructions as appropriate, for example *"Medical specimens. Call addressee on arrival. Hold refrigerated."*

Faeces

Collect stool specimens as soon as possible, since delay may impede identification of the causative agent.

Ideally, swabs of fresh stool or rectal swabs should be collected for bacteriological examination, large volumes of diarrhoeal stool (at least 30g) for viral examination, and fresh bulk stool (with preservative) for parasite examination.

Bacteria

Collect at least two rectal swabs or swabs of fresh stools (less than one hour old) from each case:

- If possible refrigerate Cary-Blair transport medium in advance, so that the swabs can be placed into a cool medium.
- Insert swab into Cary-Blair medium to moisten it.
- Insert swab 3–5 cm into rectum and rotate gently.
- Remove swab and examine it to ensure that the cotton tip is stained with faeces.
- Insert swab immediately into tube of transport medium.
- Push the swab to the bottom of the tube.
- Repeat procedure with the second swab and place in same tube as the first.
- Break off top parts of sticks, tighten screw-cap firmly.

If specimens will arrive at the laboratory within the 48 hours after collection, they can be refrigerated at 4 °C. Pathogens can still be recovered from refrigerated samples up to 7 days after collection, although the yield decreases after the first 2 days. During transport, refrigeration for up to 36 hours can be achieved by shipping in a well-insulated box with frozen refrigerant packs or wet ice.

If it is impossible for specimens to reach a laboratory within 2 days, they can be frozen at –20 °C (home-type freezer) although freezing at –70 °C (ultra-low freezer) is preferable. Frozen specimens should be shipped with dry ice, observing the following precautions:

- Protect specimens from direct contact with dry ice, as intense cold can crack the glass tubes.
- Protect specimens from carbon dioxide by sealing screw-caps with tape or by sealing tubes in plastic bags.
- Ensure that container is at least one-third full of dry ice.

Viruses

Obtain a large quantity (as much as possible but at least 10 ml) of diarrhoeal stool that has not been mixed with urine in a clean, dry, leak-proof container. To permit diagnosis of certain viral agents, specimens must be collected during the first 48 hours of illness. Immediately refrigerate the specimen at 4 °C (do not freeze) and send as soon as possible to the laboratory.

Parasites

Obtain fresh bulk-stool that has not been mixed with urine and place in a clean container. Then add preservative solution (10% formalin or 10% polyvinyl alcohol) at a ratio of 1 part stool to 3 parts preservative. If there is a delay in obtaining the preservatives, refrigerate untreated stool specimens at 4 °C (do not freeze) for up to 48 hours. Once preserved, the specimens can be stored and transported at room temperature or refrigerated.

Vomitus

If the person is still vomiting at the time of the investigation, collect vomitus. Let the patient vomit directly into a specimen container that has been thoroughly cleaned and boiled in water. Take the specimen directly to the laboratory. If this is not possible refrigerate (but do not freeze) the specimen.

Serum

In the investigation of foodborne disease outbreaks, serological examination is sometimes useful to detect the development of antibodies as a result of infection.

Blood should be obtained only by a person legally qualified to undertake the procedure; check appropriate laws. If possible, obtain blood specimens from the same patients from whom stool samples were obtained.

Submit two serum specimens – one acute-phase and one convalescent-phase – for each patient thought to have illness caused by viruses or bacteria. Obtain the acute-phase serum specimen as close to the time of onset of illness as possible (at most, within a week after onset of illness). The convalescent-phase serum specimen should be obtained 3 weeks – or, if a viral agent is suspected, 6 weeks – after the onset of illness.

Collect blood specimens from adults (15 ml) and from children (3 ml) in tubes that do not contain anticoagulants. For antibody studies the specimens need not be refrigerated during the day of the collection (unless the weather is extremely hot) but should be kept out of direct sunlight. Centrifuge the blood and send only the serum for analysis. If no centrifuge is available, store the blood specimens in a refrigerator until a clot has formed; then remove the

serum and pipette it into an empty sterile tube. Refrigerate the tubes of spun or unspun serum and ship them refrigerated.

Urine

Clean the area around the urethral orifice with a pad that has been pre-moistened with a 4% tincture of iodine or other appropriate antiseptic. Begin to urinate into the toilet and collect 30ml of midstream urine. The specimen should be refrigerated but not frozen.

Other clinical specimens (food-handlers)

Skin lesions (boils, lesions, abscesses, secretions)

- Clean skin with normal saline or weak disinfectant to prevent contamination of the specimen with saprophytic organisms.
- Apply pressure to the lesion using sterile gauzes and collect specimen on sterile swab, trying to obtain as much secretion as possible.
- If the lesion is closed, disinfect skin and extract specimen using sterile syringe.
- Transport immediately to laboratory at ambient temperature. If this is not possible, the specimen can be left for up to 24 hours, at which time the swab should be placed in a container of ice.

Oropharynx and nostrils

- Collect specimen with a sterile swab and immediately place in transport medium (Stuart's).
- Transport immediately to laboratory at ambient temperature. If this is not possible, the specimen can be left for up to 24 hours, at which time the swab should be placed in a container of ice.

Food and environmental specimens

Equipment

- **Sterile sample containers**

  Disposable plastic bags
  Wide-mouth jars (100–1000 ml) with screw-caps
  Bottles for water samples
  Foil or heavy wrapping paper
  Metal cans with tightly fitting lids

- **Sterile and wrapped instruments for sample collection**

  Spoons, scoops, tongue depressors
  Butcher's knife
  Forceps, tongs, spatula
  Drill bits
  Metal tubes (1.25–2.5 cm in diameter, 30–60 cm in length)
  Pipettes, scissors
  Moore swabs (compact pads of gauze made of 120 x 15 cm strips, tied in the centre with a long, sturdy twin or wire for samples taken from sewers, drains, pipes, etc.)
  Sponges

- **Sterilizing agents**

  95% ethanol
  Propane torch

- **Refrigerants**

  Refrigerant in plastic bags
  Heavy-duty plastic bags or bottles that can be filled with water and frozen
  Heavy-duty plastic bags for ice

- **Food temperature measurement**

  Bayonet-type thermometers (–20 °C to 110 °C), between 13 and 20 cm length
  Bulb thermometer (–20 °C to 110 °C)

- **General**

  Marking pen (waterproof)
  Adhesive tap
  Cotton
  Peptone or buffered distilled water (5 ml in screw-capped tubes)
  Electric drill (if frozen foods to be sampled)
  Distilled water
  Insulated chest or polystyrene box

General

- Collect samples aseptically. Put them into sterile jars or plastic bags to avoid any cross-contamination.
- If samples are to be examined for organophosphate pesticides or heavy metals, plastic containers should not be used. Chemicals from the plastic may leach into the food and interfere with the analysis.
- Obtain samples of approximately 200 grams or 200 ml.
- Take packaged foods to the laboratory in their original containers. Empty containers can be used to identify micro-leaks, or rinsings from these containers can be used to detect pathogens.
- Check original packages or containers for code numbers that can be used to identify the place and time of processing. Include any unopened packages or cans belonging to the same batch.
- Keep all packages not sent for laboratory examination until the end of the investigation.
- Refrigerate samples of perishable foods at 4 °C until they can be examined. Do not freeze food samples as certain pathogens (e.g. Gram-negative bacteria, vegetative forms of *Clostridium perfringens*) die off rapidly when frozen – **but** foods that were frozen when collected should be kept frozen until examined.
- Enrichment broth and dry materials require no refrigeration.

Solid foods or mixture of two foods

- Cut or separate out a portion of food, using a sterile knife or other utensil if necessary. Collect sample aseptically and put into a sterile plastic bag or wide-mouth jar. Collect samples from top centre, and elsewhere, as necessary, refrigerate.

Liquid food or beverages

Stir or shake. Collect samples using one of the following methods:

- Using a sterile utensil, transfer approximately 200 ml into a sterile container; refrigerate.
- Place a long sterile tube into liquid, cover the opening with finger. Transfer liquid to the sterile container; refrigerate.
- Dip a Moore swab in the liquid or into the pipe so that liquid circulates around it. Leave in place for several hours, if possible. Transfer swab to a jar containing enrichment broth. Refrigeration is not usually necessary.
- If the liquid is not too thick, pour 1 to 2 litres through a membrane filter. Transfer the filter pad aseptically to a jar containing enrichment broth. Refrigeration is not usually necessary.

Frozen foods

Keep frozen, using dry ice as necessary. Transport or ship the specimen in an insulated container. Use one of the following methods:

- Send or take small frozen samples to the laboratory, without thawing or opening.
- Break frozen material into pieces using a sterilized hammer and chisel and collect pieces using a sterilized utensil.
- Using a large-diameter sterilized drill, drill from one side at the top of the container diagonally through the centre down to the bottom of the opposite side. Repeat on the other side until sufficient material has been collected.

Raw meat or poultry

Use one of the following methods:

- Using a sterile utensil or sterile glove, place poultry carcass or large piece of meat in a large sterile plastic bag. Add 100–300 ml enrichment broth. Remove sample and seal the bag.
- Wipe a sterile sponge over a large section of the carcass or piece of meat. Place swab in a jar containing enrichment broth.
- Moisten a swab in buffered distilled water or 0.1% peptone water. Wipe the swab over a large section of the carcass or piece of meat. Place swab in enrichment broth.
- Using a sterile glove wipe the carcass or the piece of meat with sterile gauze pads and place the pads in a jar containing enrichment broth.
- Aseptically cut a piece of meat or skin from different parts of the carcass or large piece of meat, or remove part of the carcass. Place at least 200 g of sample in a sterile plastic bag or glass jar; refrigerate.

Dried foods

- Insert a sterile hollow tube near one edge at the top of the container diagonally through the centre down to the bottom of the opposite side.
- Keep the top part of the sample and transfer to sterile container.

- Repeat the procedure on the other side of the container until a sufficiently large sample has been collected.
- Alternatively, use sterile spoon, spatula, tongue depressor or similar utensil to collect sample. Transfer to sterile jar.
- Keep in water- and airtight container.

Scrapings from food equipment, pipes, filters etc.

- Cut or collect sufficient amount of material with a sterile tongue depressor, spatula, spoon or similar utensil and place in sterile bags or wide-mouth jars.
- Refrigerate as required (depending on material, see above).

Environmental swabs

- Moisten swab with 0.1% peptone water or buffered distilled water and wipe over contact surfaces of equipment or environmental surfaces. Place in enrichment broth.
- **Air**: Touch plate or liquid with the device for sampling air, or let airborne particles settle on broth or agar plates obtained from microbiology laboratory. Seal with insulation tape. Refrigerate liquid samples.
- **Water**: Collect water from suspected areas, including from bottles in refrigerators, ice cubes, basins, etc. When taking water from a tap, let the water run for 10 seconds before collecting the sample. To sample water that has not been standing in proximal pipes, let water run for 5 minutes. Place sterile jar under running water and let it fill to 2.5 cm from the top. Collect 1–5 litres. Alternatively, membrane filters can be used. Moore swabs may be used to collect water samples from streams or plumbing; they should be left in place for up to 48 hours and then transferred to sterile jars containing enrichment broth.

Specimen collection for suspected chemical toxicants [3]

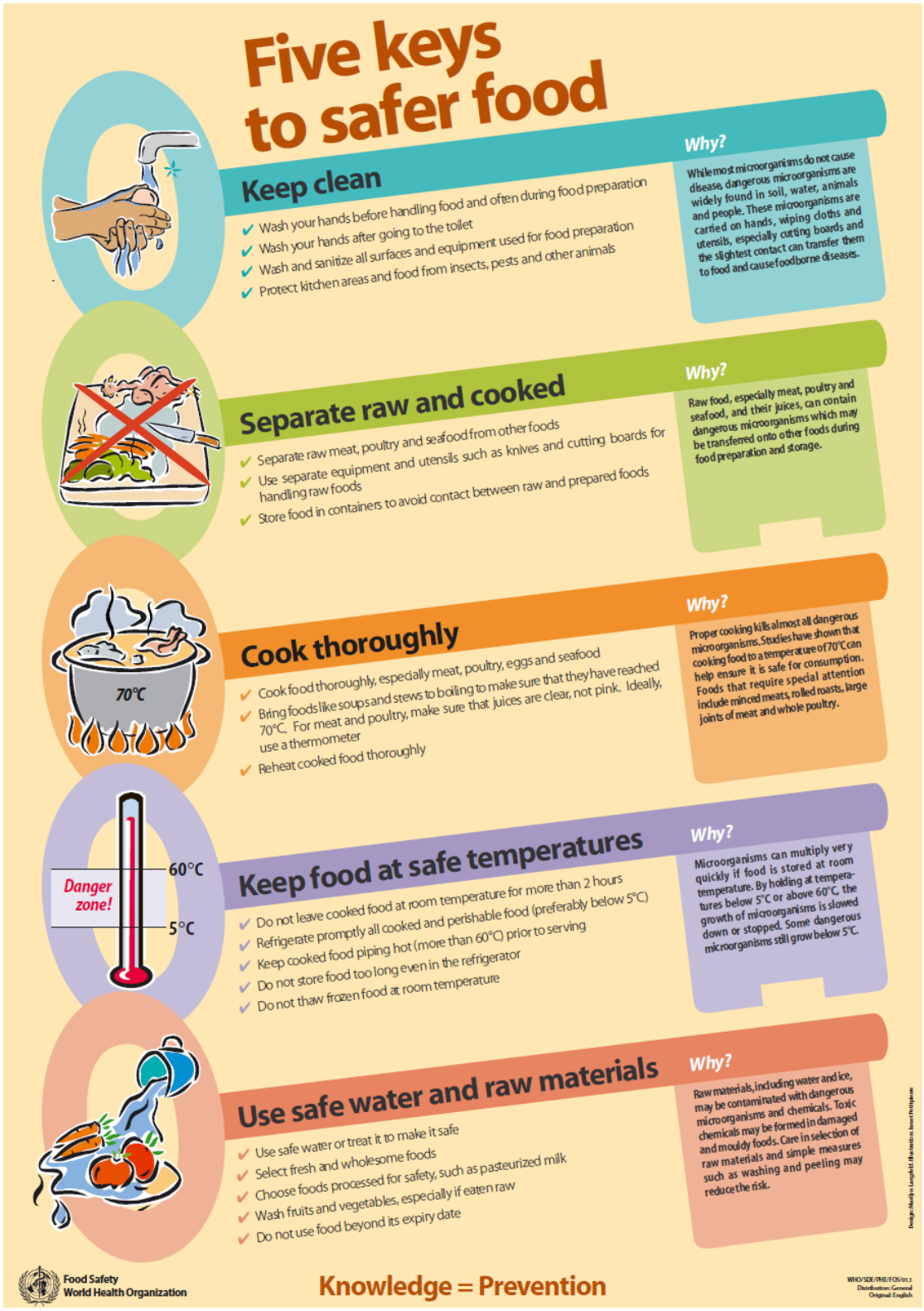
- Avoid contamination at all cost.
- Refrigerate or freeze specimens as rapidly as possible.
- Used only screened collection material if possible. This material has been tested for extraneous contaminants, and is specially washed and packaged. If unscreened material is used, randomly select at least three of each of the containers being used (collection cup, vacutainer, etc), seal them in a clean bag and submit them with the other samples to the laboratory. This may allow evaluation of possible extraneous contaminants from the collection material at hand.
- Urine is the preferred specimen if the suspected toxicant is an inorganic chemical (e.g. lead, arsenic, mercury). Urine should also be collected if the toxicant is unknown. Freeze promptly.

[3] Source: Reproduced with permission of publisher, from Gregg, 2002.

Suspected toxicant	Preferred specimen (in decreasing order)	Adults and children >10 years (children <10 years)
Organic	Serum	Two (one) 10-ml silicon-free vacutainers; freeze
	Urine	50–100 ml (25–50 ml) in prescreened collection cup; store in Wheaton glass bottle, freeze
	Whole blood (usually heparinised)	One–two (one) 10-ml tubes; refrigerate
Inorganic	Urine	50–100 ml (25–50 ml) in prescreened collection cup; (no preservative if frozen promptly)
	Whole blood (usually with EDTA)	One 2–3-ml prescreened container; refrigerate
	Serum	One 7-ml trace elements vacutainer; freeze
Unknown	Serum	Three (one) 10-ml silicon-free vacutainers; freeze
	Urine	50–100 ml (25–50 ml) in prescreened collection cup; store in Wheaton glass bottle, freeze
	Whole blood (EDTA)	One 2–3-ml prescreened container; refrigerate
	Whole blood (heparin)	One 7–10-ml (5-ml) heparin vacutainer; refrigerate
	Tissues, stomach contents	10–50 g, no preservatives; seal in small zip-lock bag, freeze
	Food	As much as possible, place in large ziplock bag, freeze

Annex 10

The WHO Five Keys to Safer Food



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