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Risk Communication: Epidemiology

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Key Points

- To define epidemiology in food safety
- To demonstrate the use of epidemiology in traceback analysis

Abstract

Epidemiology is part of medical science that deals with the origin and spread of disease in a population. It is an important tool to control outbreaks, such as the Covid-19 pandemic. Epidemiology can be applied to any form of human illness and provides useful information to prevent spread of disease. Food safety benefits from epidemiological analysis to determine the origin of a food safety outbreak and the source of contaminants in the food chain. While epidemiology is a mature science, recent molecular methods are providing more detailed information than previously. These are providing a much greater depth of understanding that is enabling new control measures to assist in controlling food safety.

Introduction

Interest in epidemiology has never been higher than it is today. This is largely due to Covid-19 and the international awareness of the importance of tracing the source of infections. Epidemiology has always been important in the medical sector to trace the source of illnesses; however, it takes a major international crisis for the general public to be aware of the importance of epidemiology. Being able to identify the source of an infection is important in the development of long-term solutions. With many illnesses, treatment can be achieved with antibiotics. However, this is not an ideal solution due to the human suffering and costs involved in dealing with human illness. There are additional concerns with the overuse of antibiotics where other methods of control or prevention are possible. Prevention is better than a cure and this is where epidemiological data can help.

In the food industry, illness is often hard to trace. This is due to a combination of factors including lack of reporting of illnesses and a lack of information regarding the potential food source. Foods consumed may not be recalled by the patient and even if they can recall their meals, obtaining samples for traceback analysis is often not possible as the food has since been consumed or discarded. Additional concerns occur due to seasonal and geographic factors, demographics and cultural influences (e.g., specific types of foods consumed).

Where outbreaks involve many people, the chance of identifying the source improves and there are many more opportunities to obtain meaningful data. Some of this data can be location where there is a focus of illness in a particular town or a particular restaurant. In some cases, there may be an association with or a particular food type that has been consumed by a large proportion of the people in the outbreak. This can lead to a particular food outlet or manufacturer as the root cause of the problem. Some outbreaks may be seasonal or limited to a particular demographic in the population that can provide a clue as to a particular food source that has a seasonal or demographic based occurrence. Epidemiology involves the analysis of all this information to produce a likely scenario that can be used to put preventative measures in place. Some of this data may not be what you would expect. For example, an outbreak of colihaemorrhagic *E. coli* in Europe, involving over 2000 people was traced to bean sprouts through observing photographs that patients had taken of their meals (Payne, 2011).

Epidemiological tracing of human food safety problems can be incredibly complex when you consider the range of potential microbiological, chemical, and sometimes physical causes of food illness. In addition, there is variation in the sensitivity of individuals to a particular cause and variation in the potency of microbial or chemical contaminants. Environmental factors need to be considered. These include climate (there are more food safety issues in summer months), and the social setting, such as an age care

facility or childcare center. The foodborne illness may result from a contaminated product from a food manufacturing plant or from abuse or miss handling in the food chain during transportation and preparation of a meal. Factors such as the health of workers in the food industry need to be considered.

Epidemiology has always been important in the tracing the origin of illness in the food industry. Traditionally, this has involved collecting data from various sources, using case–control or co-hort studies and other traditional approaches to determine the likely cause of a foodborne illness.

Relatively recently, epidemiology has become easier with molecular sequencing and characterization (Deng et al., 2021). Such techniques have revolutionized not just the confidence in identifying a source of contamination and illness, relating samples from a patient to a food source, but helping in identifying specific clones that may represent a greater risk than others. An example is the tracing of antibiotic resistant variants of a particular pathogen (Hendrickson et al., 2019). Such information has value in treating illness as well as helping identify critical sources to focus on for elimination. Whole genome sequencing is a feasible cost-effective option for providing more depth of detail than ever before. This is potentially useful but also misleading if not aligned with the metadata associated with the pathogen contamination. Such detailed information can be confusing. Minor differences between isolates may or may not be significant in the investigation. Perfect matches are likely to be real clues as to the origin of contamination.

An excellent example of the use of epidemiology in providing an understanding of the primary source of *Campylobacter* illness in New Zealand involved multi-locus sequence typing of isolates from a variety of sources and matching those with the MLST results from human infection (Mullner et al., 2009, 2013; French et al., 2019). This clearly identified poultry as the primary, but not the only source of human illness. This information was used to support the development of control strategies in the poultry industry that reduced the incidence of *Campylobacter* food poisoning by 50%.

The food industry relies on simple traditional epidemiological techniques to trace pathogen intrusion into food manufacturing plants. This involves taking swab samples from different zones representing different levels of risk to the food products being manufactured. The swab samples are taken on a regular basis to predict any potential threat to pathogen contamination of food. Analysis is generally through traditional enrichment and plating techniques, however in a situation where pathogen contamination is detected, more advanced techniques may be used to increase the speed of results or to provide more specific information on the relationships between isolated from different sources. We now have ability to mine information that can provide faster and deeper information on pathogens affecting the food industry. Such information is essential to the operation of most food manufacturing plants, particularly those producing highly perishable products.

Importance in Food Safety—Source Attribution

Epidemiological studies in the food industry are primarily to identify the source of a foodborne illnesses or contaminants that are likely to cause foodborne illness. The term "source attribution" is often used for these epidemiological studies. They can be used to identify any agent of concern—bacteria, viruses, parasites, or toxins—that may cause disease via the consumption of contaminated food. These studies may focus on a particular food, the manufacturing process, or the raw material. The presence of a specific cause of food poisoning is important but consideration needs to be given to the target population which will vary depending on the susceptibility of the population. Variations in the characteristics of the agent capable of causing disease are also important. These can be such things as the pathogenicity of the agent (capability of causing disease) or virulence (degree of pathogenicity) will influence the likelihood of the agent causing disease and the severity of that disease. Such factors as the intrinsic properties of the food may impact on the likelihood of causing disease. These can include the pH and water activity of the food that may inhibit the growth of any contaminating microorganism. Extrinsic factors such as the temperature in which the food is stored can also impact on the likelihood of causing disease. Epidemiology can also include aspects involved in the handling of food and include such things as personal hygiene. All these factors need to be considered when trying to understand the epidemiology of food poisoning.

Some Factors Influencing Epidemiological Studies

- Mode of transmission

  This relates to how the food poisoning agent enters the food and the consumer. Transmission can occur from an infected food handler, from contaminants during food manufacture or from the raw materials used to prepare the food. The ultimate source of a food poisoning agent is human, animal or environmental.
- Incubation period

  This is the time taken for the consumption of food containing a contaminant to cause disease. This is critical in epidemiological studies to establish a timeline that relates to the possible source. The incubation period can range from hours for such contaminants as staphylococcal enterotoxin to days for such infections as *Salmonella*, or weeks for hepatitis A virus. This period can be complicated by the susceptibility of the individual, and amount of the infective agent consumed.

- Disease carrier
  Humans and animals can become asymptomatic carriers of disease. This means that an infected food handler can spread food poisoning and an infected animal may be used as a food source without any knowledge of the danger. This is where survey work to identify these possible sources of infection is an important epidemiological tool.
- Disease patterns
  Epidemiologists use terms such as endemic, epidemic and pandemic to describe the extend of a disease outbreak. Endemic refers to an on-going disease threat associated with a particular food source, community or area. Epidemic refers to a short timeframe in which a disease appears and is normally associated with a particular food source or problem. Pandemic refers to a world wide problem, rarely associated with the food industry but typically associated with a flu or other disease outbreak across the world.
- Disease outbreak
  This is defined differently in different countries but is most commonly where two or more people become ill from a particular contaminated source. The numbers of infected people can grow and result in an epidemic. An epidemic is normally seen as a rapid rise in the number of infected individuals, followed by a gradual decline.
- Incidence
  Incidence is defined as the number of persons who develop disease over a specific period of time.
- Prevalence
  Prevalence refers to the number of cases of infection or illness at a particular point in time.
- Relative risk
  Data collected in relation to a food safety incident is used to assess risk and determine if there is an association between exposure to a particular potential source of infection and disease. Relative risk examines the likelihood of those consuming a particular food at a function becoming sick compared with the general population at that function.
- Odds ratio

The relative measure of association between cases of illness and the control population is defined as the odds ratio. This compares the odds of being exposed among the persons with disease with the odds of being exposed among the people without disease. Essentially this gives a figure stating how many times more likely those with the disease ate a particular food compared with the control population.

Types of Epidemiological Studies

Epidemiological studies are generally retrospective studies attempting to identify the cause of a foodborne illness through observations relating to such things as location, consumption of a particular food and behaviors. However, these studies are complicated by many confounding factors. These studies are descriptive using current data and comparing with historical data. Traditionally, there is no hypothesis associated with these descriptive studies.

Analytical studies do have an hypothesis about the association of disease with possible risk factors. They compare with and without exposure to the food source suspect of causing the illness. There are two types of analytical studies used in epidemiological investigations in the food industry—cohort studies and case control studies.

Cohort studies evaluate the occurrence of disease in a specific population. These studies can be retrospective or prospective and are often used to investigate an outbreak in a specific group such as a wedding function.

Case control studies focus on the people with the disease and compare them with a control group free from the disease and look at potential risk factors. Such studies involve a small group of people and produce results quickly. The main concerns with case control studies are bias in the selection of members of either group and recall bias where there is variation in the recall of events associated with the illness.

Recent Developments

The most important development in epidemiology is the use of molecular testing that can accurately and rapidly determine a specific biological variant and differentiate the cause from other potential causes. This enables tracing the origin of an infection to a particular source. There are various tools available for this including multi locus sequence typing and whole genome sequencing. The best example of the use of whole genome sequencing has been the use in tracing Covid-19. Although not related to food borne illness, this does demonstrate the power of whole genome sequencing tracing the cause of infection. One of the early successes in the use of molecular techniques in providing useful information for the food industry was in tracing the source of *Campylobacter* infections in New Zealand to the poultry industry. New Zealand had one of the highest incidences of *Campylobacter* food poisoning in the world. The use of molecular typing confirmed poultry as the primary source, providing data to support action in controlling this pathogen on poultry farms, in chicken processing plants and in educating consumers on the handling of chicken. The result was a 50% drop in the annual number of cases of *Campylobacter* food poisoning.

Conclusions

Epidemiology is key to providing information to enable targeted control of foodborne illness. Historical studies using basic typing techniques and surveys have been succeeded by rapid molecular based techniques that provide greater accuracy and confidence in source attribution. Epidemiology can be used at any stage in the food chain, from on-farm studies to manufacturing and processing plant through to consumer handling.

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