

Review Article

Risk science and communication issues and challenges for food: an Australian perspective

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From any perspective, whether it be Australia or other countries, the issue of risk and food is one that includes all sectors of the community. The expansion of information technology and globalisation is making society as a whole more knowledgeable and expectant of safer foods with minimal risk. There is risk in everything and the basis of risk science is one that involves a number of established steps such as risk assessment, management and communication. The evolution of food technology, production and dietary habits, together with changes in trade, will no doubt raise new safety issues and governments need to be abreast of risk science to assess such changes.

Key words: food quality and safety, risk assessment.

Introduction

Worldwide, the growth of scientific knowledge and greater community awareness has raised concerns that certain chemical, physical, biological and social factors may pose a risk to human health. This situation has placed pressure on governments, regulatory and industry bodies to develop appropriate tools to assess public health issues including those relating to food and adopt strategies that effectively manage these issues. Effective communication is also essential to this process so that the real risks to health are identified and understood and the available resources utilised for maximum benefit.

Principles of risk assessment

Risk assessment is a scientific process that estimates the nature and magnitude of a risk. The quantitative health risk assessment for environmental chemicals involves four steps, namely (i) hazard identification, (ii) exposure assessment, (iii) dose–response assessment and (iv) risk characterisation.

Hazard identification involves identifying an agent that may cause harm to humans. Identifying a potentially hazardous agent requires gathering evidence from animal studies, *in vitro* studies and human epidemiological studies to determine the likelihood that a specific agent will cause harm.

Exposure assessment evaluates (either qualitatively or quantitatively) how much of the harmful agent people are being or may be exposed to, the form of exposure (inhalation, ingestion or dermal contact) and the duration of exposure (a single dose, intermittent or continuous).

Dose–response assessment evaluates the quantitative evidence (from both human exposure and animal experiments) to estimate the nature and magnitude of harm that different levels of exposure to the agent will cause in humans.

Risk characterisation estimates the probable risk posed by this agent now or in the future. Information from exposure assessments and dose–response assessments are used to estimate the type and magnitude of risk faced by the exposed population. Risk characterisation should also describe areas of uncertainty in the exposure and dose–response assessments that may affect the outcome.

The major area of uncertainty is dose–response assessment. The consequences of acute high-level exposure are usually known but the consequences of chronic low dose exposure must be extrapolated (usually from animal experiments). These extrapolations are based on a number of assumptions. For example, in cancer risk assessment, it is assumed that an agent found to be carcinogenic in animals will also be carcinogenic to humans despite the fact that the animals used in such experiments are small in number and are often highly sensitive to the agent. Furthermore, it is difficult to estimate with certainty how well experimental conditions translate into environmental conditions where other factors may influence the outcome.¹

Quantitative microbial risk assessment has additional complexities to those that relate to chemical risk assessment. The number of microorganisms in a food or a water supply can grow substantially over time (storage) and these growth patterns may vary widely depending on the environment/medium that the organism inhabits. Temperature, pH, mois-

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ture levels and the presence or absence of other microorganisms, are several factors that can markedly influence microbial survival and growth. These are usually difficult to estimate or quantify.² Furthermore, the pathogenic characteristics of many microorganisms are complicated by the biological variability of the organism, which affects both the probability of infection and the consequences of infection, for example, whether or not the infection remains asymptomatic, causes mild to severe illness or results in death. The magnitude of uncertainty that currently surrounds microbial risk estimates requires the implementation of good food safety management practices like the Hazard Analysis Critical Control Point (HACCP) concept.²

Epidemiological estimates of risk

Gastroenteritis is common in the community and most cases resolve without treatment. A study of infectious intestinal disease in 70 general practices throughout England revealed that for each person visiting their general practitioner for an infectious intestinal disease there were approximately five other cases in the community. It was estimated also that for every gastrointestinal pathogen reported to the national surveillance scheme there were 136 community cases of gastroenteritis.³ To further complicate estimates for microbial risk, the treatment and reporting ratios vary for different microorganisms.

It is generally assumed that microorganisms are responsible for a large proportion of food-borne illnesses. Gastroenteritis attributed to food-borne illness has been estimated to be between 30 and 60% of cases.⁴ However, little consideration is given to the prospect that food allergy/intolerance or non-dietary factors (medications, stress, medical conditions) may also be an important and an underestimated cause of gastroenteritis.

Challenges for risk assessment

Food safety is dynamic in nature, with most current food safety issues almost certainly being driven by unprecedented advances in technology and transport, as well as increases in migration and changes in consumer food preferences.

Technology

Many aspects of food production, processing and consumption are changing with new technology and consumer preferences. Traditional preservation methods limited food storage life whereas recent technology has enabled certain foods to be stored for longer periods of time than was initially possible. This new technology, however, has also led to the emergence of food-borne pathogens like *Listeria monocytogenes*.⁵ Some food coatings (like waxed fruit) may not allow adequate decontamination or microbial control, giving rise to new food safety issues.

Manipulation of nutrient composition has been constrained by the available technology; however, as this field has expanded there has been a greater manipulation of the nutrient composition of different food products. The demand for foods that are 'fresh' rather than 'processed' or for foods that have less salt, fat, sugar and other additives has, in part, been due to many of the health messages conveyed to consumers.^{6,7} Manipulating the nutrient composition of foods to make them more 'healthy' may increase the presence of

microbial pathogens and health risk. Salt, fat, sugar and other additives have been used traditionally to enhance the palatability and appearance of food, as well as increase the shelf life and safety of certain foods. Salt, for example, can inhibit the growth of some microbial pathogens.

Local/global issues

It is now possible to transport fresh produce (and pathogens) on a large scale over long distances. Bulk processing and the wide distribution of food to a larger, geographically dispersed population can, if a food becomes contaminated, potentially magnify the spread of pathogens to new locations.

The food supply has become more globalised and with it food safety issues relating to various food standards (and lack of equivalence).

Demographic issues

In most countries, populations are ageing. Immune function declines with age and ageing adults are more susceptible to infection.^{8,9} Many of the gastrointestinal infections commonly experienced by older adults are associated with food poisoning.¹⁰ The ability to detect spoiled foods may be compromised in elderly adults, as their ability to taste and smell deteriorates with age.¹¹ Immunocompromised people are also more susceptible to infection and therefore are at greater risk of food poisoning if exposed to microbial pathogens. Immunocompromised groups include patients with HIV, diabetes, those who have undergone chemotherapy or an organ transplant and also those on renal dialysis.

Cultural diversification has led to the adoption of many new food patterns. The demand for greater food variety (whether consumer or industry driven) has largely been responsible for the vast diversity and availability of food products found in Australia and other affluent societies. Supermarkets in Australia are estimated to hold between 8000 and 15 000 different food items, a staggering 8–15 fold increase in such items over the last 50 years.¹²

There has been a greater demand for convenience foods and foods eaten outside the home. This has meant consumers are less directly involved in food preparation. As a consequence the transfer and acquisition of traditional food safety knowledge and skill is more limited and an understanding of each step in the food chain has become less clear for individuals who rely on the food preparation services of others. These changes increase the likelihood of error in consumer choice.

Extensive use of antibiotics as growth promoters in veterinary medicine, such as virginiamycin, may have contributed to the emergence of antibiotic resistant microorganisms.¹³ Humans can become infected with these drug-resistant organisms through direct contact with an infected animal or by eating infected meat that is raw or undercooked.⁶

New testing methods

In the past, technology used to determine microbial safety was restricted to methods involving bacterial pathogens. Newer technology now enables the detection of viruses and parasites. As new testing methods are developed, more food-borne pathogens will be recognised that might previously have gone undetected. Traditional detection methods

required the growth of bacterial cultures. Detection is now improved with the use of antibody probes, DNA/RNA segments, biochemical activity and Viable Non-Culturable (VNC) resuscitation. However, the detection of certain microorganisms may be of little consequence unless these organisms are really 'alive' and able to cause infection.

Sydney water contamination

A dramatic illustration of the difficulties that may arise from the use of new and unproven test procedures occurred in Australia's largest city, Sydney, in 1998. A testing program for protozoa in water supplies was introduced in May 1998, using a relatively new testing method. A few months later, in July, high levels of *Cryptosporidium* and *Giardia* were detected, leading to the imposition of a boil water alert for the population of over 3 million people. The crisis continued when high levels of protozoa were detected again during August and September. This caused major disruptions to business, particularly in the food and hospitality sectors and also to the general public.¹⁴

An intensive health surveillance program was implemented by the New South Wales Health Department, however, there was no evidence of increased illness in the community due to *Cryptosporidium* and *Giardia* infection. Surveys of compliance with the boil water alerts suggested that up to 36% of the population disregarded the alerts, suggesting that detectable illness would have occurred if the microorganisms were viable and infectious. The ability of the routine health surveillance system to detect *Cryptosporidium* outbreaks had been previously demonstrated in relation to swimming pool related outbreaks. The subsequent government inquiry was not able to identify any specific cause for the incidents and it has been speculated that the test results may have been false positives due to algal cells resembling protozoa.¹⁵ Alternatively, the organisms may have been inviable or may have been species or strains which were unable to infect humans.

The crises led to a loss of public confidence in the safety of the water supply and had significant impacts throughout the Australian water industry. The incidents and ensuing investigation also entailed heavy financial costs including an estimated \$2–5 million for the costs of the Sydney Water Inquiry, compensation payouts to business and domestic consumers of about \$26 million and recurrent costs of operational changes in water treatment amounting to about \$16 million per year. These incidents highlighted the difficulty in interpreting the results of new testing methods which have not been adequately validated and where the public health implications of a positive result are uncertain.

Novel/modified foods

Another potential area of concern in risk assessment is the increasing consumption of novel and modified foods. Many 'functional' foods are now being promoted as having beneficial effects on health, including some containing biologically active phytochemicals. Changes in food supplementation or food consumption patterns may lead to sudden increases in the exposure levels to large sectors of the population to such chemicals, with potentially uncertain health consequences.

For example, in Australia there has recently been a rapid increase in the number of soy- and linseed-containing prod-

ucts in the marketplace. Both soy and linseed contain phytoestrogens, biologically active compounds that were initially discovered because of their ability to cause infertility in sheep. Asian communities traditionally consume high levels of phytoestrogens in their diet, mainly from soy products. Such communities also demonstrate reduced cancer risks, reduced incidence of cardiovascular disease and reduced incidence of female menopausal symptoms and there is some evidence from clinical trials that these beneficial effects may be attributable to phytoestrogens.¹⁶

The presumed safe levels of phytoestrogen consumption have been estimated on the basis of the soy product content of traditional Asian diets at around 60 g of soy products per day. The typical soy contents for average daily intakes of soy-supplemented products on the Australian market are illustrated in Table 1.

Thus, it is evident that the increasing use of soy supplements and additives in the Australian market may in some individuals lead to phytoestrogen consumption levels well in excess of 60 g per day.

The long-term exposure of Asian populations to high levels of phytoestrogens may have been accompanied by genetic adaptation of the population to the metabolism of these compounds, however, such adaptations may be lacking in Caucasian populations. The question then arises as to whether consumption of soy-based products in excess of the levels normally present in the Asian diet may entail health risks to other populations and how these risks might be assessed.

Evolution of knowledge

Another area of challenge is the continual evolution of knowledge and the need to revise risk assessments accordingly. An example of this is the changing evidence on the role of nitrate in drinking water and food. High levels of nitrate in drinking water have been associated with the condition methaemoglobinaemia in infants and it has been speculated that ingestion of nitrate may lead to nitrosoamine formation in the stomach with potential cancer risks. The accepted view of methaemoglobinaemia, initially proposed in 1945, has been that the condition is directly caused by ingestion of nitrate. However, recent evidence suggests that endogenous nitrite production within the body in response to intestinal inflammation is the primary cause.¹⁷

Recent evidence also does not support the conventional viewpoint that ingestion of nitrate may lead to nitrosamine formation and increased cancer risks. Epidemiological studies consistently show that vegetarian diets, which are rich in nitrates, are associated with reduced risks for many types of cancer. New research also demonstrates that nitrosamine

Table 1. Average daily intakes of soy-supplemented products on the Australian market

Soy-supplemented products	Soy content (g)
Soy and linseed bread	30–40
Soy and linseed cereal	10–15
Soy and linseed crackers	5–10
Soy yoghurt	10–20
Soy cheese	1–2

formation is unlikely to occur under physiological conditions. It has even been suggested that nitrate may have a protective role in preventing gastrointestinal infections and may be partly responsible for the reduction in cardiovascular disease rates associated with high vegetable intake.¹⁸ Thus, the view of nitrate as a harmful contaminant of food and water supplies may soon undergo a reversal if these preliminary findings are supported by further research.

Conclusion

In summary, a safe food supply depends on the effective application of risk science and communication. New safety issues will continue to emerge as food production, trade, technology and food habits evolve over time. It is evident that the benefits of innovations with food science and technology will be more available if its governance embraces health risk science.

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