An overview of emerging foodborne and waterborne diseases

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نظرة عامة على الأمراض المستجدة ، المنقولة بالغذاء والماء

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خلاصة ظهرت في العقدين الأخيرين عدة أمراض منقولة بالغذاء والماء بسبب تغيرات طرأت في الكائنات المسببة أو العوائل التوية أو البيئة المحيطة . إن أعباء الأمراض المنقولة بالغذاء والماء ليست موزعة بالتساوى في جميع الأنحاء . فنظراً لانعدام المساواة في توزّع الموارد العالمية ، تنوء بعض البلدان بعبء أثقل مما تحتمل من الأمراض المُعدية . وما يعتبر كائناً مُمرضاً منبعثاً من مرقده في موقع جغرافي معين ، قد يكون متوطناً في موقع آخر .

ABSTRACT Several foodborne and waterborne diseases have emerged in the past two decades as a consequence of changes in etiological agents, hosts and the environment. The burden of foodborne and waterborne disease is not uniformly distributed globally: because of the inequitable distribution of the world's resources some countries carry a disproportionately heavy burden of infectious disease, and what is considered a re-emergent pathogen in one location may be endemic in another.

Aperçu général sur les maladies émergentes d'origine alimentaire et hydrique

RESUME Plusieurs maladies transmises par les aliments et par l'eau sont apparues au cours des vingt dernières années suite aux changements survenus chez les agents étiologiques, les hôtes et dans l'environnement. Le fardeau des maladies d'origine alimentaire et hydrique n'est pas réparti uniformément dans le monde: en raison de la distribution inéquitable des ressources mondiales, certains pays supportent une lourde charge disproportionnée de maladies infectieuses, et ce qui est considéré dans un endroit comme un agent pathogène réémergent peut être endémique ailleurs.

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It has been estimated that in children alone there may be between 3.5 to 18 million deaths per year worldwide from diarrhoeal disease [*1*]. Gastrointestinal disease is the second most common cause of morbidity throughout the world after acute respiratory tract illness [*2*]; the proportion that is directly foodborne or waterborne is unclear, but it is likely to be substantial.

A number of newly recognized pathogens have been identified as major agents in causing foodborne and waterborne disease, including *Campylobacter* spp., *Cryptosporidium parvum*, vero cytotoxin–producing *Escherichia coli* O157, Norwalk virus (small round-structured viruses) and hepatitis E virus.

Campylobacter species first came to light as human pathogens in the early 1970s when selective media for routinely identifying the organism were developed [*3*]. They are now the most commonly reported bacterial cause of infectious intestinal diseases in the United Kingdom and most other industrialized countries [*4*]. They usually occur as sporadic cases but in most countries, campylobacters are not routinely serotyped, and many outbreaks may go undetected. Milk, particularly unpasteurized milk, water and poultry are the most commonly reported vehicles of infection [*5*].

In many parts of the world, subsets of the population do not have access to clean potable water. In others, where public water supplies are available, system failures can place entire communities at risk; one such incident occurred in the spring of 1993. Contamination of a municipal water supply with *Cryptosporidium* in Milwaukee, Wisconsin, in the United States caused the largest outbreak of waterborne illness in the history of the country, with over 400 000 people affected and over 4000 admitted to hospital. Many other outbreaks associated with drinking water have been reported, yet *Cryptosporidium*, a coccidian protozoan parasite, was only identified as a human pathogen in 1976 [*6,7*]. It can cause diarrhoeal illness in immunocompetent as well as immunocompromised individuals [*8*].

Enteropathogenic *Escherichia coli* (EPEC) is an important cause of infantile diarrhoea in developing countries, and enterotoxigenic *E. coli* (ETEC) is the most common cause of traveller's diarrhoea; it is acquired principally by ingestion of contaminated food or water. Enteroinvasive *E. coli* (EIEC) produces an invasive dysentery type of diarrhoeal illness in humans with similar pathogenesis to shigella [*9*]. Symptomatic and symptom-free human carriers are presumed to be the principal reservoir for EPEC, EIEC and ETEC. The enterohaemorrhagic (EHEC) group of *E. coli* contains an emerging pathogen, vero cytotoxin–producing *E. coli* O157, which has its reservoir in cattle. It first came to prominence in 1982 with two outbreaks in the United States associated with the consumption of hamburgers from a fast-food chain [*10*]. Since then, outbreaks have been documented from a number of countries [*11–15*]. In early 1993 in the USA, the largest outbreak of *E. coli* O157 infection ever reported occurred in the western states of Washington, Idaho, Nevada and California. Seven hundred and thirty-two cases were identified, mostly children, of whom 195 were admitted to hospital, 55 developed haemolytic uraemic syndrome and four died, demonstrating the consequences of faults in large-scale food processing and preparation [*16*]. Transmission of *E. coli* O157 can be foodborne [*17*], particularly in undercooked ground beef [*18,19*] and unpasteurized milk [*20*], waterborne [*21–23*] through person-to-person spread [*23–27*]; from animals to people [*28,29*]; and possibly by other routes [*30,31*].

During the 1970s a number of viruses associated with acute gastroenteritis were discovered, and transmission by the food-borne or waterborne route has been documented for astroviruses and caliciviruses (human calicivirus and Norwalk-like viruses) [*32,33*]. Norwalk-like viruses have become important causes of both sporadic and epidemic gastroenteritis [*34,35*]. In November 1993 an outbreak of Norwalk virus gastroenteritis occurred in six states of the United States and was associated with the consumption of oysters from one oyster bed [*36*]. Humans are the only known reservoir for Norwalk viruses, emphasizing the risk of harvesting shellfish in water contaminated by human sewage [*37*]. Since their identification as a human pathogen in 1973, rotaviruses have been found to be the most important cause of gastroenteritis in infants and young children worldwide [*38*]. A proportion of cases of infection may be food-borne or waterborne [*39*].

Although hepatitis epidemics occurred in India in the 1950s that were non-A non-B and attacked mainly young adults, resulting in high mortality among pregnant women, the likely etiological agent, hepatitis E virus, was only recognized in 1990 [*40*]. The natural history of infection is similar to that of hepatitis A virus. Epidemics caused by hepatitis E virus have been recognized in Asia, Africa, Peru and Mexico, mostly linked to faecal contamination of water [*41*].

Cyanobacteria, especially members of the genera *Microcystis*, *Anabaena*, *Aphanizomenon* and *Oscillatoria*, are common and potentially harmful inhabitants of freshwater [*42*]. Various human illnesses after contact with water containing cyanobacteria have been reported, usually through recreational activities or after consumption of water from contaminated reservoirs [*42,43*].

A group of protozoal parasites that are emerging pathogens in immunocompromised individuals are the microsporidia [*44*]. The exact modes of transmission have yet to be established, and the food-borne and waterborne routes have not been ruled out.

Humans can become infected with toxoplasmosis by several routes, including ingestion of oocysts from soil or water contaminated with cat faeces; ingestion of viable tissue cysts in raw or undercooked meat or tachyzoites in milk from infected intermediate hosts; and transplacental transmission from a mother who is acutely infected. Maternal transmission can result in intrauterine deaths and a proportion of cases having clinically apparent disease at birth have been reported [*45*]. In people with impaired immunity, infection has been documented in association with cancer, transplantation of organs, connective tissue disorders and HIV infection [*46,47*].

Brucellosis is endemic in some countries whereas in others it has almost been eradicated. However no country can afford complacency, as exemplified by an outbreak in Malta where 135 cases of brucellosis were identified between January and July 1995 compared to 22 cases in the previous three years [*48*]. Illness was associated with the consumption of soft cheese made from unpasteurized milk from sheep and goats. This demonstrates that diseases considered almost eradicated can re-emerge and present clinical problems for more recent cohorts of clinicians unfamiliar with its presentation.

Salmonellas continue to be one of the main causes of foodborne illness worldwide. The organism is ubiquitous among domestic and wild warm-blooded animals, including birds. These bacteria can adapt to different species and take advantage of changing environmental factors. Although there are more than 2200 serovars of salmonella,

Salmonella enteritidis and *S. typhimurium* account for three-quarters of reported cases in the United Kingdom, where there has been a dramatic increase in salmonellosis since 1984. This increase has been almost entirely due to *S. enteritidis*, particularly PT4. The intensive rearing of poultry using strains of poultry selected for food conversion efficiency and egg production, rather than disease resistance, provided fertile ground for *S. enteritidis*. *S. enteritidis* PT4 causes an invasive infection in poultry that leads to septicaemia and subsequent chronic infection of various organs; when the ovary is infected, transmission of the organisms to the contents of the egg can occur [*49*]. Contamination of eggs and poultry meat and an increasing consumption of poultry meat has led to the predominance of *S. enteritidis* PT4 as a cause of human salmonellosis. Many European countries have experienced a high incidence of *S. enteritidis* PT4 infections, and the organism has been isolated from human cases and food items in more than 10 European countries and from countries as far apart as Argentina and Japan [*50*]. In parts of the USA there have also been large increases in *S. enteritidis* infections associated with shell eggs [*51*].

A worrying development is the emergence of antibiotic resistant salmonellas. *S. typhi* is endemic in many countries, and treatment with an appropriate antibiotic is essential and should commence as soon as the clinical diagnosis is made, which may be well before the results of antimicrobial sensitivity tests, if available, are known. In 1948 chloramphenicol was introduced and proved particularly successful in treating typhoid. However in the 1970s, plasmid-mediated chloramphenicol resistance in *S. typhi* spread rapidly in certain parts of the world, with an increasing proportion of strains showing resistance in the past decade [*52–54*]. In the past five years trimethoprim and ampicillin resistance has been detected, perhaps as a result of the spontaneous transposition of trimethoprim and ampicillin resistance genes from plasmids to the chromosome. Outbreaks of this multiresistant strain have been reported in India, Pakistan and Bahrain [*55–57*].

In addition to *S. typhi*, multiple drug resistance has recently been detected in other salmonellas [*58*]. In 1990 there was an upsurge in multiple drug resistance in *S. typhimurium*, notably chromosomally integrated resistance to ampicillin, chloramphenicol, streptomycin, sulfonomides and tetracyclines in *S. typhimurium* DT104 in England and Wales [*59,60*]. Another significant development has been the emergence of resistance to fluoroquinolone drugs in the poultry associated serotypes *S. hadar* and *S. virchow* [*61*]. It has been suggested that the development of these strains is a consequence of the use of antibiotics as growth promoters and for treatment in animals [*62*]. Whatever the mechanism, it has resulted in a progressive reduction in options for the management of invasive salmonellosis in humans.

In Belgium, Canada, the Netherlands, Australia, New Zealand and parts of Germany *Yersinia enterocolitica* rivals salmonella as a cause of acute gastroenteritis [*63–65*]. Although identified as a human pathogen in 1939 it was not recognized as a foodborne pathogen until the mid 1970s. It can grow at temperatures as low as 0 °C, and the increased use of refrigeration in the food chain may play a part in the increase in prevalence of this organism in food [*66*]. Different serotypes of *Y. enterocolitica* are associated with human infections in different regions of the world. In Europe, Canada and Japan, sporadic infections caused by serovar O:3 and to a lesser extent O:9 are predominant whereas in the United States sporadic cases, which are uncommon, are associated with multiple serovars, and outbreaks, which are more common, mainly involve serovar O:8.

Another organism that can multiply in food at refrigeration temperatures is *Listeria monocytogenes*. Over the past decade several studies have documented its importance as a foodborne pathogen [*67*]. Although listeriosis is uncommon in the general population, the incidence among pregnant women, persons with malignancy and those who are immunosuppressed is much higher, and in these subgroups it can cause severe disease [*68–70*].

In December 1992 a large epidemic of cholera began in Bangladesh and subsequently spread to neighbouring countries [*71,72*]. The organism has been characterized as *Vibrio cholerae* O139 Bengal. This strain is derived genetically from the current El Tor pandemic strain but has changed its antigenic structure such that there is little existing immunity and all ages, even in cholera endemic areas, are attacked. The apparent tendency of *V. cholerae* to evolve toward greater virulence is cause for concern [*73*]. That cholera is transmitted by water has been known since John Snow removed the handle of the Broad Street pump in London in 1832; it is disappointing to report that it remains a world problem today.

That pathogens can adapt to changes in host susceptibility and environmental factors is also demonstrated by shigella. Its epidemiology varies in different parts of the world with different subgroups of shigella affecting different subsets of the population. Within countries there have been changes in the seasonal prevalence, age groups affected and dominant strains of shigella.

The transmissible spongiform encephalopathies have been known about for many years, yet much remains to be discovered about this family of neurodegenerative diseases. These are unique diseases in that they are infections but some also have a genetic component. They are described in many animal species, including *Homo sapiens*. The precise nature of the infective agent remains unknown. The magnitude of the present epidemic of bovine spongiform encephalopathy is without precedent in the recorded history of this group of neurodegenerative diseases. There is increasing national and international concern over the possibility of transmission of spongiform encephalopathy from cattle to human beings.

Demographic change in parts of the world means that there is a dramatic increase in certain population groups that are especially susceptible to foodborne and waterborne diseases. Many developing cities are growing so rapidly than their water supply and sewage treatment infrastructures are unable to keep pace, and high morbidity and mortality from infectious diseases result, particularly in childhood. Environmental changes resulting from floods, droughts, famines, wars and civil unrest can disrupt routine food and water supplies and present opportunities for infectious diseases to spread [*74*]. An increasing proportion of the population of many countries is elderly, and a growing number of persons are immunosuppressed as a result of many factors, including HIV infection and various therapies. These populations are at increased risk of foodborne and waterborne diseases that may not present a major problem for the general population; such diseases can have devastating consequences for these vulnerable subgroups and consume large amounts of costly health care resources. For individuals with HIV infection many environmental organisms have become opportunistic pathogens, and the possibility of foodborne and waterborne transmission exists for *Pneumocystis carinii* and *Mycobacterium avium intracellulare*. In certain countries there are increasing numbers of people in residential care and more use of nurseries for children where both parents are working, both presenting the opportunity for secondary spread of pathogens initially introduced by the foodborne and waterborne routes.

Increasing international travel has contributed to the introduction and dissemination of new pathogens. After an absence of a century, cholera caused an epidemic in Peru in January 1991 and spread rapidly through Latin America [75]. *V. cholerae* El Tor has now become established in the Americas with persistent large epidemics in 1992 and 1993. With the El Tor strain the ratio of cases to carriers is much less than in cholera due to the classic biotype [76]. In addition the duration of carriage and the survival of the organism in the environment may have facilitated the spread of the El Tor biotype.

Eating habits, especially in industrialized countries, are changing rapidly. There is an increasing tendency for people to eat more meals outside the home, to buy food in bulk (and less often) and to eat more fast foods, which require less preparation. Increasing mass production and global distribution of ready-to-eat foods present the opportunity for the dissemination of emerging or re-emerging infections and put large populations at risk. There has been a steady increase in international travel and commerce over the past two decades to magnify the risk. Competition in the food industry may force manufacturers to put cost reduction before food safety; therefore it is important that retailers make food safety a top priority so that companies compete on that basis. It is unrealistic to assume that all microbiological hazards can be eliminated; therefore efforts must be directed to reduce their occurrence as far as possible. The "zero tolerance" policy cannot be used as a basis for a realistic strategy. The focus must be on limiting the growth, survival and spread of pathogens in foodstuffs, and, considering the susceptibility of the particular consumers, agreements should be reached on what levels of these pathogens are acceptable in which foods.

Recommendations

Timely recognition of emerging infections requires early warning systems to detect these diseases so that investigations and preventive measures can be rapidly initiated before they become major public health problems. Global public health networks for effective disease surveillance are necessary if emerging and resurgent infectious diseases are to be recognized. Recent developments in electronic communication have enhanced national and public health surveillance systems and facilitated progress. The Internet has presented an opportunity for rapid global information exchange at low cost. One international system with applications for foodborne and waterborne disease is Salm-Net, a European surveillance system for salmonella infections, which has also been used successfully for other pathogens [77]. With its links within the European Union and its extended links to parallel electronic and manual reporting systems in other surveillance centres outside Europe it has demonstrated its usefulness in the rapid identification of outbreaks and enabled the early introduction of control measures. In 1994 Salm-Net was successfully used to identify and enable rapid control of an international outbreak of shigella dysentery in three European countries associated with the consumption of iceberg lettuce exported from a fourth [78]. In 1995 a Salm-Net collaborative investigation of a cluster of cases of *S. agona* in England, associated with the consumption of a peanut flavoured snack, led to the recognition and control of outbreaks in Canada and the United States and a massive outbreak involving over 2000 cases in Israel. The identification of this contaminated product with a widespread distribution demonstrates the benefits of international surveillance and collaborative investigation.

The diseases associated with both food and water can be overcome provided that our monitoring systems give us an early warning, that our basic science gives us sufficient understanding of the pathogen or the toxin and that our control and educational systems can react quickly enough.

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