

Review

Emerging Foodborne Diseases: What we know so far

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ABSTRACT - Foodborne diseases (FBD) pose significant public health problems and economic losses worldwide. In recent years, emerging foodborne diseases have resulted mainly from novel bacteria, viruses, protozoa, mycotoxins, prions in animal and plant sources. The consumption of unsafe food contaminated with harmful bacteria, viruses, parasites or chemical agents or naturally occurring toxins results in high morbidity and mortality. However, estimating the incidence and burden of FBD is a huge global challenge due to the difficulty in food source attribution to specific pathogenic or chemical hazards, underreported cases, diagnosing how infections are transmitted or when a person is infected are not well understood and thus makes the control of FBD very challenging. Therefore, implementing comprehensive food safety strategies and policies, enhancing surveillance, ensuring resilient health system, and intensifying education and training to ensure safe food and prevent foodborne diseases is everybody's responsibility.

Key words : Foodborne diseases, Food attribution, Food hazards, Morbidity and Mortality, Food safety

Foodborne diseases (FBD) pose a serious public health and huge economic burden on both developing and developed countries. Over the years, the incidence and emergence of FBD has been overwhelmingly high globally. FBD results in significantly high morbidity and mortality after the consumption of food contaminated with biological and or chemical hazards¹. Contamination may occur during all stages of food production and supply chain, from farm to fork. Therefore, it is imperative to reduce the risks involved in making food unsafe and to prevent infection and diseases². In addition to people suffering severely from FBD, the economic impact it poses cannot be overemphasized. A country's vibrant workforce, cost involved in prevention, treatment, product recall and investigations puts an enormous financial burden not only on governments but also on consumers and food industry. Several factors are believed to contribute significantly to the increase of FBD. These include globalization of food trade, complex food chains, increase in migration, poverty as in the case of developing countries, changes in climate, industrialization, changes in consumer lifestyles, microbial adaptation, conflicts leading to rise in refugees who lack safe drinking water and live in unhygienic conditions and inadequate public health

infrastructures^{3,4}.

Despite collaboration of World Health Organization (WHO) and government agencies to strengthen disease surveillance in several countries or regions, global estimates are still lacking and even if available are generally underestimated. The WHO 2015 global burden of FBD estimates that children under age 5 are the most affected representing about 30% of all death. According to this report in 2010, about 600 million which is almost 1 in 10 cases of illness worldwide are due to ingestion of contaminated food with an annual death of 420,000 people. Diarrheal disease agents accounted for 550 million illnesses causing 230,000 deaths. Thirty two diseases were found to be caused by 31 foodborne hazards⁵. However, these numbers have been reported to increase to over 200 diseases caused by the consumption of unsafe food contaminated with harmful bacteria, viruses, parasites or chemical agents². An estimate from the United States Centers for Disease Control and Prevention reveals that about 48 million people are affected with FBD annually, resulting in 128,000 hospitalizations and 3000 mortalities⁶. On the other hand, in Canada, FBD affects approximately 4 million people annually, causing 11,600 hospitalizations and 238 deaths⁷. However, the challenge of underestimating the incidence and burden of FBD is common in developing countries as only few cases of food infection or poisoning are reported to appropriate health authorities. In addition, in reported cases identifying the source of the hazard whether food, water, human,

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animals or environment is a big problem, which makes assessing disease burden difficult^{4,5}. However, it is only during outbreaks that such links are possible. Also, in some cases, difficulty of diagnosing how infections are transferred or when a person is infected are not well understood and thus makes the control of FBD very challenging⁸. Everyone is vulnerable to FBD. Immunity to FBD by virtue of geographical location is yet to be proven. This review highlights emerging FBD, their impacts on public health and economic development, challenges in estimating the disease burden globally and proposes preventive measures by everyone in the food supply chain to ensure safe food and prevent foodborne diseases.

Overview of Emerging Foodborne Disease

Foodborne diseases (FBD) result from the ingestion of food contaminated with biological agents such as viruses, bacteria, and parasites or their toxins and chemical agents like heavy metals (cyanide, mercury, arsenic, etc)¹. Generally, bacteria and viruses account for a majority of diarrheal diseases causing huge hospitalizations and deaths⁵. Their microbial pathogens cause FBD through intoxication, infection and toxin-mediated infection. Some produce toxins in food before ingestion (intoxication), others are activated when ingested, grow in the host and colonize (infection) or both, that is, cause illness by producing toxins while growing in the host (toxin-mediated infection)^{9,10}. It is worth noting that, moisture, acidity, time, nutrient components of ingested food, temperature and the presence or absence of oxygen can influence the growth of these bacteria and viruses^{10,11}. Disease symptoms include but are not limited to nausea, vomiting, diarrhoea, typhoid fever, cholera and other life-threatening diseases such as brain disorders, kidney and liver syndrome, cancers¹². Children, the elderly, and the immunocompromised persons are usually known to be at high risk of FBD. Foodborne diseases occur when a pathogen ingested via a food vehicle, survives, reproduces, or produces a toxin in the consumer resulting in illness¹³. However, the severity of FBD not only depends on the type and load of microbial pathogen but also the underlying metabolic state of a person.

In recent years, emerging foodborne diseases have resulted mainly from novel bacteria, viruses, protozoa, mycotoxins, prions in animal and plant sources. Contamination of sea foods, fruits and vegetables with enteric viruses such as rotavirus, human noroviruses and hepatitis A and E viruses are considered the most relevant pathogens causing nonbacterial gastroenteritis and fatalities globally^{14,15}. Other types of pathogenic viruses causing global threats to human health are influenza A virus H5N1,

also known as bird flu¹³ and Nipah virus^{16,17}. However, a more recent global and public health emergency is the outbreak of a novel coronavirus COVID-19 in Wuhan, China, first reported in late December 2019¹⁸. The virus is believed to originate from animals, nonetheless, the exact source of this hazard and how it affects people is unknown. Since the outbreak, a total of 1870 deaths and 73,332 confirmed cases were recorded globally as at February 18, 2020. Out of the total infected people, 72,528 cases were reported in China and 804 disease incidence outside China, in 25 countries including USA, Hong Kong, South Korea, Japan, UK, Canada, Germany, Australia, Philippines, Thailand, Taiwan, India, Malaysia, France, Singapore, Vietnam, United Arab Emirates, Russia, Italy, Finland and Spain among others¹⁹.

However, WHO and health experts in China, other regional and global countries have put in place preventive measures to curb the spread of the disease since it causes respiratory illnesses and can be transmitted from human to human¹⁹. These standard hand and respiratory hygiene, and safe food practices include (1) wearing medical mask (2) frequent handwashing with alcohol based sanitizers or soap and water (3) avoiding close contact with persons with fever and cough (4) seeking early medical care for persons with fever, cough and difficulty breathing (5) avoiding unprotected contacts with live animals and (6) avoiding the consumption of raw or undercooked animal products²⁰. Furthermore, WHO has developed strategic public health controls to limit the spread of infections and expedite the development of diagnostics, therapeutics and vaccines. These measures include rapid identification, diagnosis and management of incidences, identification and follow up of the contacts, prevention and control of infection in healthcare facilities, implementation of health measures for travelers, awareness creation and risk communication¹⁶.

Recently, the complexity of the food chain from farm to fork globally introduces several routes of hazard transmission thereby making risk management very challenging and relevant⁸. Fig. 1 shows the main transmission pathways of food borne hazards. Animal sourced food, food and feed plants, pets and wildlife and the environment (water, soil, pollutants, etc) are the major reservoir for both biological and chemical contamination causing human foodborne diseases. Animal feed is critical to the food chain as their contamination with pathogenic organisms such as *Salmonella*, *Campylobacter*, *Listeria*, Shiga toxin and enterotoxin-producing *E. coli*, *Yersinia*, *Toxoplasma*, and *Vibrio* contributes to infection of animal sourced food which are later transmitted to humans causing FBD^{4,21}. Furthermore, foods and water are contaminated with agrochemicals such as pesticide residues, and

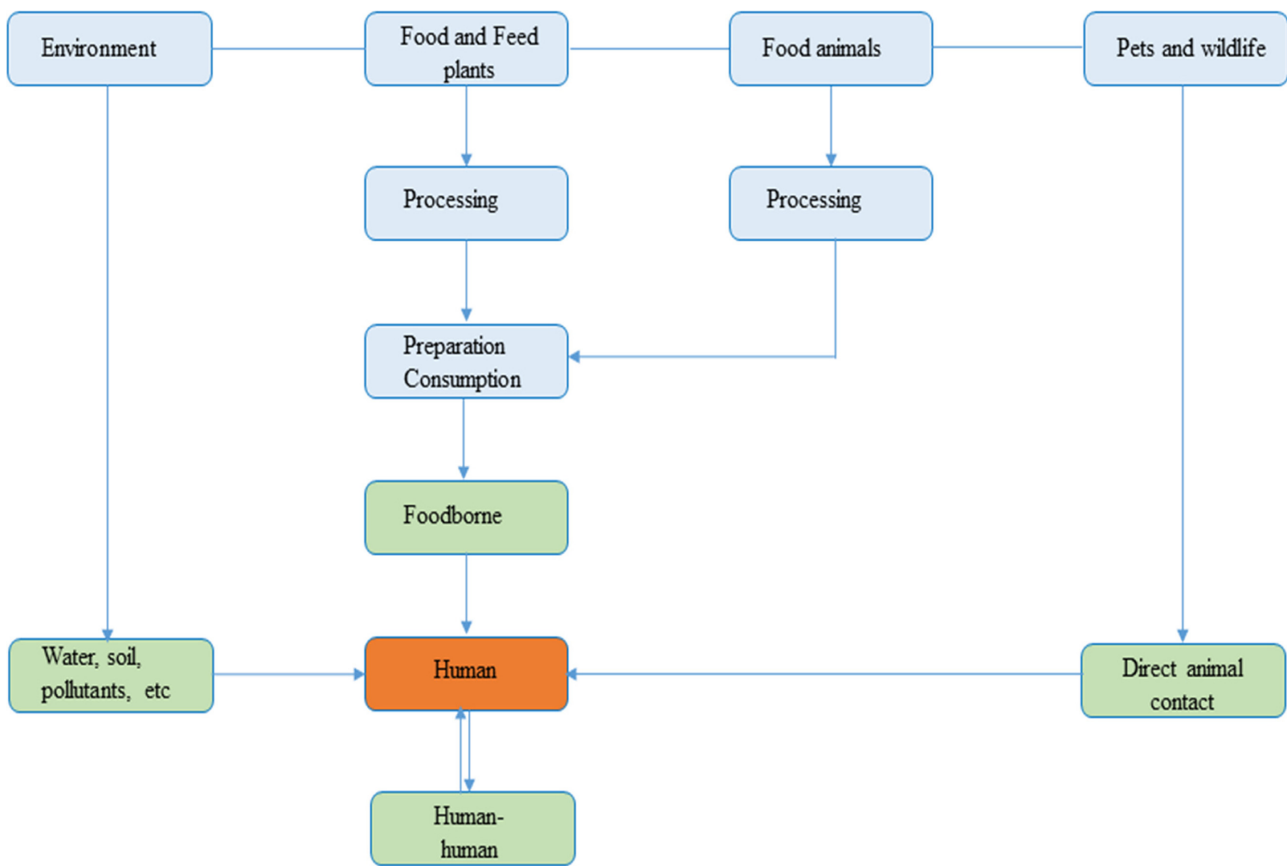


Fig. 1. Major transmission routes of human foodborne diseases. Adapted from Hald et al.⁸⁾.

vetterinary drugs and in some cases toxic chemicals from pollution and food packages such as dioxins, heavy metals and chlorinated biphenyls. Dioxins cause serious immune system damage, reproductive and developmental health problems, hormonal interruption, and cancer. Heavy metals such as lead, mercury, arsenic, and cadmium contamination have been linked to severe neurologic and kidney damage. Some toxins such as mycotoxins, cyanogenic glycosides to mention a few occur naturally in cereal grains and other crops. This may cause damage to immune system, affect normal development or even some cancers if accumulated in the human body at higher dosages^{4,22)}. Moreover, foodborne illness also occur when foods are not properly stored, fully cooked, or cross-contamination between raw and cooked “ready-to-eat” foods²³⁾.

Management of Food Safety Challenges

Modern food safety systems involves both reduction of hazards in the food supply chain and hygiene and safe storage practices in places of food preparation. Therefore, targeted interventions programs in food supply chain and

preparation areas are necessary to maintain a strong food safety management system, improve malnutrition and meet global nutrition goals²⁴⁻²⁷⁾. For effective management of FBD, it is imperative to understand and quantify the link between foods and FBD hazards²⁸⁾. A recent study by Hoffmann et al.²⁶⁾ assessed the correlation between foodborne disease and specific foods as pathways for pathogenic hazards in 14 subregions worldwide. Despite considerable variation and similarities in food source attribution for some hazards, their findings provide useful insights into policy efforts to strengthen food safety risk assessment from farm to fork.

Conclusion

The increase of FBD incidences due to globalization of food trade, complex food chains, changes in climate and consumer dietary patterns among others have contributed greatly to severe public health problems and economic losses worldwide. The consumption of unsafe food contaminated with harmful bacteria, viruses, parasites or chemical agents or naturally occurring toxins results

significantly in high morbidity and mortality. Children, the elderly and immunocompromised persons are the most affected. Moreover, everyone is vulnerable to FBD. Immunity to FBD by virtue of geographical location has not been proven yet. However, estimating the disease burden of FBD has been a great challenge due to underreporting of disease cases, difficulty attributing specific foods to pathogenic hazards and assessing the numerous chemical and toxin contaminating the food supply chain especially in developing countries. Therefore, the reduction of hazards in the food supply chain and hygiene and safe storage practices in food preparation areas are necessary measures to protect human health and minimize economic losses. Ensuring safe food is everyone's responsibility. Hence, it is imperative for governments, regulatory authorities, and industry players including food producers, suppliers, handlers and consumers to work more closely to implement comprehensive food safety strategies and policies, enhance surveillance, ensure resilient health system, and intensify education and training to ensure safe food and prevent foodborne diseases.

국문 요약

식중독(식품 매개 질병)은 전 세계적으로 심각한 공중 보건 문제와 경제적 손실을 초래한다. 최근 몇 년 간 새로이 발생한 식중독은 주로 동식물에서 유래하는 새로운 박테리아, 바이러스, 원생 동물, 곰팡이독, 그리고 프리온에서 발생했다. 유해 박테리아, 바이러스, 기생충 또는 화학 물질이나 자연 발생 독소 등으로 오염된 불안정한 음식의 섭취는 질병의 발병률과 사망률을 높인다. 그러나 특정 병원성 또는 화학적 위험요인, 불충분한 보고 사례, 감염 전염 방식 및 시기 진단 등에 대한 식품 소재 귀인(歸因)의 어려움 때문에 식중독의 발병률과 부담을 추정하는 것은 전 세계적으로 큰 도전이며 식중독을 통제하는 것은 매우 어렵다. 그러므로 종합적인 식품 안전 전략 및 정책의 시행, 관리 감독 강화, 탄력적인 건강 시스템 보장, 안전한 식품 보장 및 식품 매개 질병 예방을 위한 교육 및 훈련 강화에 대해 모두가 책임져야 한다.

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