



## Review Article

# Food Safety Present Scenario: A Road Map of Pakistan

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**Abstract** | Food safety refers to the potentially hazardous agents or contaminants present in food that can cause food-borne illness. These extraneous agents are causing morbidity and mortality. Contamination of food by various agents includes physical, chemical, and microbiological. Food safety ensures that what we eat, chew, or drink is safe for human health. The whole food chain should be monitored right from production to consumption. The public health burden of developing countries is increasing beyond their resources. In developing countries like Pakistan, food safety issues result in serious health issues. Diarrhea is perhaps the most important problem that is responsible for more than half of the global burden of food borne diseases, causing 550 million people to fall ill and 230,000 deaths every year. Children are at particular risk of food borne diarrheal diseases, with 220 million falling ill and 96000 dying every year. There is a persistent rise in the health expenditure of Pakistan. Pakistan is spending 0.5 to 0.8% of its GDP. Total health expenditure during 2016-17 remains at 145.97 billion showing an increase of 9 percent over the last year. Pakistan has dire need of revamping the food safety policy and infrastructure. Food being an important intake is a major source of human exposure. Finally, risk of unsafe communication is required for management and prevention of consumer-based food borne illness, most prevailing illness. We ignore food safety challenges at our peril as potential consequences of a lapse are huge; keeping the food supply safe is a never-ending task.

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**Keywords** | Food safety, Food chain, Contaminants, Food borne illness, Food safety policy

## Introduction

Food safety is a multidisciplinary scientific approach that emphasizes on reduction and prevention of food-borne illness by ensuring safe intake. Food safety is a chain of management starting from production to consumption of food. Food safety measures range from simple household preparatory operation to the molecular approach being used to alleviate the arsenic in rice. Food safety measures not only are taken after the harvest of

eatable commodities. These should be implemented right from the production premises to the final consumption. Food contamination is caused by biotic and abiotic factors. The abiotic and biotic factors may be pathogenic and non-pathogenic. Among the abiotic contamination environmental contamination is causing raw food external contamination, transportation in non-sanitized containers, storage inappropriately, processing premises packing material (Nerín *et al.*, 2016). Soil, Irrigation source, animal dung is the major contributory at farm level

contamination. Chemical contamination may also occur at farm level non-voluntary chemical mixing with eatables. Pesticide bottles are washed with the irrigation water and produce is also washed by this contaminated water hence makes it unfit for human consumption (Marriott *et al.*, 2018).

Large food production volume to feed the increasing population has increased microbiological infestation. Food born and water-born contamination causing morbidity and mortality in infants. According to the WHO (World Health Organization) Waterborne diarrheal disease kills about 2.2 million people annually (Marušić, 2011). Food-borne illness is a threat to developing countries. Mode of transmission has a wide range from physical to microbiological contamination. Among the microbial pathogenicity *Clostridium botulinum*, *Vibrio cholera*, *Salmonella typhus*, *Campylobacter spp.*, *Toxoplasma gondii*, *Listeria monocytogenes*, and Nosocomial rotavirus which causes gastroenterocolitis in children (Javed, 2016; Nitsch-Osuch *et al.*, 2013). Food born contamination is shown in Table 1.

Food-borne contamination is a global threat not only for developing countries where the sanitary and hygienic conditions are not up to the mark thus facilitating its outbreaks. Comprehensive food safety measures are in need to be opted to restrict the economic burden. Food safety measures are imposing a 7 billion dollar economic burden on the USA. (Hussain and Dawson, 2013). The public health burden of Pakistan is increasing and imposing social as well as economic constraints. Total health care expenditure of Pakistan in 2000-01 was 24.28 billion rupees and in 2017-18 it has increased up to Rs.384.57 billion for the fiscal year 2017-18. The alarmingly increasing health care budget of Pakistan is imposing an extra economic burden. UN member states have to include 169 targets and 17 goals to frame their socioeconomic policies. Sustainable goals 3 and 6 are related to the health of people. This will be a milestone in decreasing the public health burden of Pakistan.

Social behavior and activities of the people impart a major impact on food safety and foodborne illness. Safe feeding of the 9 billion populations is a challenge in the present scenario. Epidemiological studies are also important to evaluate the association between unsafe feeding, morbidity, and mortality. Developed countries have decreased the public health burden

caused by unsafe intakes by practicing appropriate measures. Food safety is not merely related to health but also has a potential social and economic impact.

### Multidisciplinary contamination of food

Globalization and domestication are major contributory of food born contamination and illness. The mode of contamination varies from microorganism to the physical substances which are being mixed up in foodstuff intentionally or non-intentionally. Contamination may be external or internal. Where external contaminations are caused by physical factors such as soil, water, air, dust, irrigation water, insects, rodents, and by different farm operations (Marriott *et al.*, 2018). Food chain toxin cycle is shown in Figure 1.

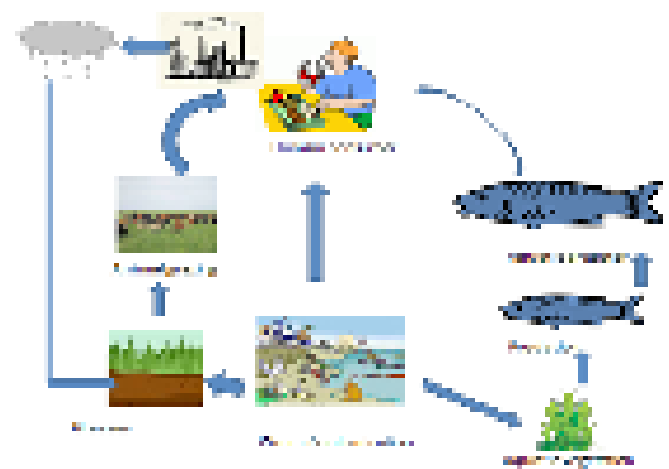


Figure 1: Food chain Contamination cycle.

Biological contamination is either pathogenic or non-pathogenic. Pathogenicity of microorganisms contaminating food varies from morbidity to mortality. Diversified food safety measures are needed to prevent food borne illness because these organisms are well adapted with the environmental conditions, multiple host range and rapid reproduction mechanism (Adamus-Bialek and Wawszczak, 2015). *Listeria monocytogenes*, *Escherichia coli*, *Salmonella spp.*, *Clostridium botulinum* are the major bacterial contaminants. Potential measure to control their pathogenic impact need adoption of proper sanitary and hygienic conditions not only in processing premises but also in the production and consumption vicinities (Gorman *et al.*, 2002; Redmond *et al.*, 2004; Wright *et al.*, 2004).

Diarrhea and other systemic infections are caused primarily by the *Salmonella* affect immune deficient, infants and elder persons. *Salmonella enteridis* affected about 800,000 to four million peoples annually in

USA only. Eggs are the most prominent food (Coker *et al.*, 2002) infecting people. Campylobacter is intestinal infecting bacteria. Pathogenicity may result in morbidity to mortality. *Campylobacter jejuni* and *C. coli* are food borne infectious agents causes Guillain-Barr syndrome. Raw milk and untreated water is major

carrier of these bacteria. Some physical extraneous substance which don't induce pathogenicity but are not safe to be ingested with food stuff. Food containing these extraneous material iron pieces etc. can cause injury by mechanical abrasion in gastrointestinal track. Microbial toxin effect is shown in Table 2.

**Table 1:** *Water contaminants and their health hazards.*

Toxicant	Disorder/Disease	References
Bisphenol A and some alkyl-phenols	endocrine disrupting effects on humans by altering the development of mammary glands	Anku <i>et al.</i> (2017)
Malathion	disruption of the functioning of the cholinergic system	Tchounwou <i>et al.</i> (2015)
Alachlor, atrazine, benomyl, 2,4-D, diazinon, gossypol, 1,1-dichloroethane Organochlorine pesticides	Abnormal sperm (morphology, motility, and sperm count) Chloracne Leukemia, reproductive, immunological, and neurological cancers	(Fawell and Nieuwenhuijsen, 2003; Hughes, 2002; Papanikolaou <i>et al.</i> , 2005)
Lead	Cataracts	(Fawell and Nieuwenhuijsen, 2003; Patra <i>et al.</i> , 2011; Patrick, 2006; Sokol <i>et al.</i> , 1985)
Mercury	Cerebral palsy	(Bernhoft, 2012; Berry and Ralston, 2008; Fawell and Nieuwenhuijsen, 2003)
Arsenic	Cancer of the skin, lung, bladder and probably liver, hyperkeratosis and peripheral vascular disease	(Fawell and Nieuwenhuijsen, 2003) and (Humans Organization and Cancer, 2004; Ramesh <i>et al.</i> , 2014)
Fluoride	Dental fluorosis, an unsightly brown mottling of teeth, higher intakes result in skeletal fluorosis, a condition arising from increasing bone density and which can eventually lead to fractures and crippling skeletal deformity	(Fawell and Nieuwenhuijsen, 2003; Hughes, 2002; Humans <i>et al.</i> , 2004; Ramesh <i>et al.</i> , 2014; Zahir <i>et al.</i> , 2005)
Selenium and uranium	loss of hair, weakened nails and skin lesions, and more seriously, changes in peripheral nerves and decreased prothrombin time	(Berry and Ralston, 2008; Buschmann <i>et al.</i> , 2008; Fawell and Nieuwenhuijsen, 2003)
Nitrate	Stomach, esophagus, bladder, brain, colon, rectum, pancreas, ovarian, and kidney cancers, adverse pregnancy outcomes, diabetes and thyroid disorders	(Berry and Ralston, 2008; Hickey and Martin, 2009; Lee and Beauchemin, 2014; Santamaria, 2006)

**Table 2:** *Microbial contamination health hazards.*

Toxicant	Disorder/Disease	References
<i>B. pertussis</i>	disease progression via endocytosed into a cell	Rudkin <i>et al.</i> , 2017
<i>Staphylococcus aureus</i> and modify the host's cells without <i>Streptococcus pyogenes</i> .		Hernández-Cortez <i>et al.</i> , 2017
<i>Salmonella</i> Species	Internalizing, Nausea, Vomiting, Abdominal, cramps, Diarrhea, Fever, Chills, Headache and Blood in the stool	(David <i>et al.</i> , 2013; Finley <i>et al.</i> , 2006; Forshell and Wierup, 2006; Marzano <i>et al.</i> , 2003; Pui <i>et al.</i> , 2011)
<i>Eschersia Coli</i>	Abdominal cramping, sudden, severe watery diarrhea that may change to bloody stools, gas, loss of appetite or nausea, vomiting, fatigue and fever.	(Bélanger <i>et al.</i> , 2011; Harrington <i>et al.</i> , 2006; Johnson and Russo, 2002; Kaper <i>et al.</i> , 2004)
<i>Campylobacter</i>	Belly cramps, Bloating and Fever	(Coker <i>et al.</i> , 2002; Dasti <i>et al.</i> , 2010; Gilbert and Slavik, 2004; Nachamkin <i>et al.</i> , 2008)
<i>Clostridium botulinum</i>	Difficulty swallowing or speaking, Dry mouth, Facial weakness on both sides of the face, Blurred or double vision, drooping, abdominal cramps and Paralysis.	(Arnon <i>et al.</i> , 2001; He <i>et al.</i> , 2002; Savidge <i>et al.</i> , 2003)
<i>Vibrio cholera</i>	Watery diarrhea, Rapid heart rate, Loss of skin elasticity, Dry mucous membranes (dry mouth) and Low blood pressure.	(Fasano, 2002; Sánchez and Holmgren, 2011)

*Global/ Pakistan health and nutrition burden*

According to the economic survey there is consistent increase in the health budget each year. Data revealed in economic survey 2017 demands solid food safety policy which will be effective to decrease the public health burden of the country and will uplift the living standard of the people. Public health burden of Pakistan is shown in graph 1. Public health burden and GDP % is shown in graph 2.

A study was carried out to investigate the microbial load of fresh vegetables in Multan city. Vegetables are grown near the cities by irrigating with sewage water. Sewage water is a potential contaminator of these fruits and vegetables and contributing to the outbreak of food-borne illness. These vegetables contained a higher microbial percentage of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *E. coli*, *Enterobacter* spp. and *Salmonella* spp. to be 48%, 60%, 48%, 64%, and 8% (Razzaq *et al.*, 2014). Another study indicated that eatables such as burger, chaana chart, and fruit chart, and samosa have alarmingly high total coliform, *S. aureus*, and *salmonella* spp. count. This microbial infestation has been propagated by the street vendor preparing these eatables in non-hygienic and unsanitary conditions. Street vendors are a major contributory to increasing food-borne illness (Afreen *et al.*, 2016).

Water is the basic necessity and required to sustain life. The importance of water has been revealed in Holy Quran. Life has been created with water. Contaminated water is out breaking gastrointestinal as well as chronic liver disease. The situation is more miserable in the urban population rather than the rural population. Water is being contaminated by various environmental and biological factors. Water horizon below the soil is being polluted by synthetic fertilizers, pesticides, and herbicides. Intake of contaminated water is causing foodborne illness. Among the food bore illness diarrheal problem is the overwhelming and major contributor of infants' mortality. *E. coli*, *Citrobacter*, *Enterobacter*, and *Kiebsiella* species are the major contaminator of water among bacteria. In Pakistan, only 20 % population has access to safe drinking water. Waterborne disease contributing to 80% of all diseases and 33 % of all death (Hashmi *et al.*, 2005).

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*Pakistan: Present scenario of food safety*

Globalization and urbanization have increased the food demand for the population. Ensuring the population health extensively needs food safety measures. Street vendors involved in the eatable business and household have to be focused to create mass awareness of the food chain, food born contamination, ways to prevent/reduce instant food contamination, sanitation, and hygienic conditions. Globally food safety has got attention in Uruguay round 1995 during the international trade conference. Food regulations and standards are being observed throughout the production, processing, and consumption chain to ensure food safety. Punjab province has taken the initiative taking into consideration of food safety importance formulated Punjab food Authority Act, 2011 which has been followed by KPK in 2014. Two provinces of Pakistan have an organization for the standardization and regulation of food standards. Punjab Pure Food Rules cover about 104 food items with nine broader categories. Food safety is not only a national need now. International trade prerequisite the food safety measure for the export of the food items either raw or processed. ISO (The International Organization for Standardization) is an international standard-setting body. It is headquartered in Geneva, Switzerland, with 162 member countries. USA, EU, and the majority of Gulf countries allow the import and export of eatables if have the food safety certification. The government of Pakistan has adopted 22070 ISO Standards and developed 8857 Pakistan Standards. Food Standards are aligned with Codex Alimentarius Commission



and traceable with WHO.

### *Food safety technologies and policy*

Production chain of fruit and vegetables should be critically evaluated by considering the sources of infection. No innovative antimicrobial chemical available that could be applied effectively and efficiently to remove pathogenic microbes (Plantation to production). Contamination at production can multiply the microbial load, hence could increase its pathogenicity. Washing of fruit and vegetables at production site in running water can effectively reduce its pathogenic load and make it safer for human consumption. Disinfection could also reduce the microbial up to the extent to make farm produce more safe and healthy. Government and food safety regulatory organization should provide resources and technical guidance to the producer to make their produce safe.

### *Food safety requirements for processing premises*

Processing premises should opt appropriate location and design, equipment design, pest control, waste management, sanitary measures. Personnel hygiene, appropriate handling, packaging and storage and training of staff to ensure end product safety.

### *Food safety requirements related to processing*

Food safety can ensure by proper food processing operations including use of food additives, food preservatives, flavoring, antioxidants, antimicrobial agents to ensure the quality and safety of processed food.

### *Food safety certification in Pakistan*

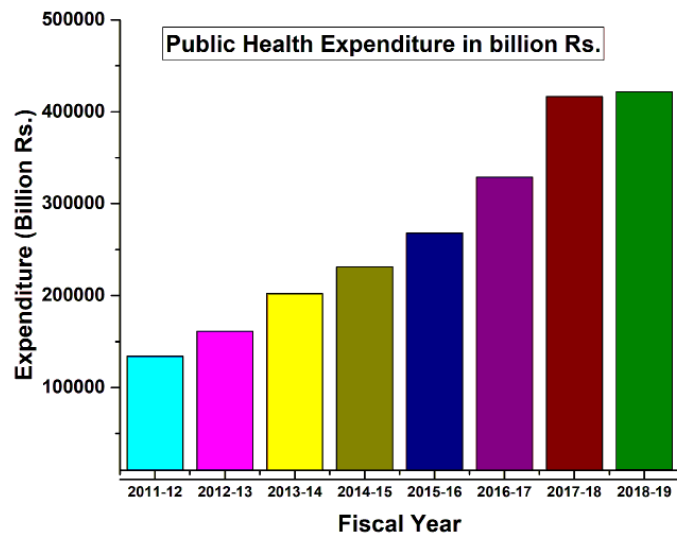
Following are the organization involved in the food safety certification. The following certification agencies should address the food safety issue at gross root level. Being developing country our food business is predominately run by the street vendors. Comprehensive action plan is needed to address the food vendors regarding their knowledge about safe food, its handling and health hazards for using un safe food. SGS Pakistan (Pvt.) Limited, Systems and Servicer Certification Supporting an organization's aims and objectives, an ISO 9001, ISO 22000 QMS documents the processes, procedures, and responsibilities for achieving quality policies and objectives. Based on eight quality management principles, the ISO 9001:2015 standard defines the way an organization operates to meet the requirements

of its customers and stakeholders including customer focusing, leadership, and involvement of people, process approach, organizational context, continual improvement, fact-based decision making and risk-based thinking.

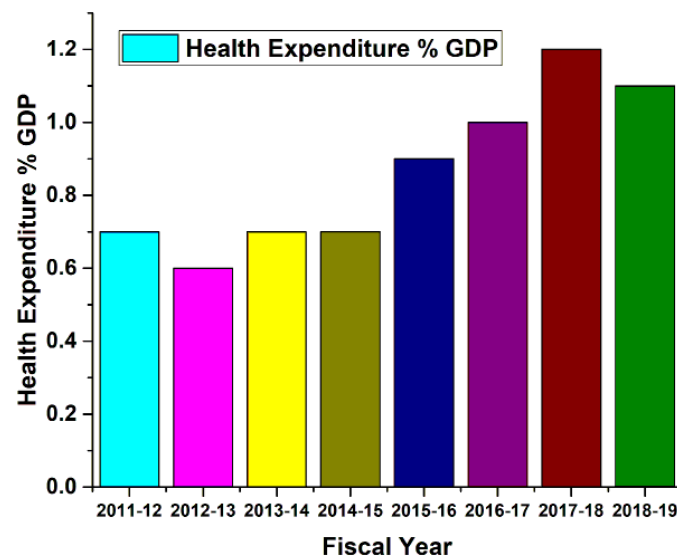
Bureau Veritas Certification (BV Certification) enable organization compete in the global food and beverage industry, players must demonstrate that their products, processes and services meet the highest levels of safety, quality and responsibility, while keeping up with evolving trends and market demands. Whether you are a food manufacturer, processor, importer, supplier or retailer, stringent industry and regulatory standards, and complex, globalized supply chains are making this an increasingly challenging task.

Certification Services Pakistan (CeSP) is a Conformity Assessment Body established to provide certification, training and inspection services as per requirements of National and International Standards like Quality Management System (QMS), Environment Management System (EMS), Occupational Health and Safety Management System (OHSAS), Food Safety Management System (FSMS) and Information Security Management System (ISMS), Halaal Food Management System (PS 3733), personnel certification, product certification, inspection services and/or any other field of certification emerging from time to time. CeSP team includes qualified and competent management system auditors, trainers and support staff committed to provide professional and value added services to its customers. Provincial food authorities entrusts the following functions and responsibilities to regulates and monitors the food business in order to ensure compliance by farmers, manufacturers, distributors, importers and other stake holders in orders to provide safe food, formulate standards, procedures, processes and guidelines in relation to any aspect of food including food business, food labeling, food additive, and specify appropriate enforcement systems, enforcement of food safety and quality standards, specify procedures and guidelines for setting up and up-gradation of food laboratories, specify licensing, prohibition orders, recall procedures, improvement notices and prosecution in the court of law, provides scientific advice and technical support to the Government in matters relating to food safety, establishment of food laboratories, organize training programme in food safety and standards, promote general awareness regarding food safety

and standards, certify food products/items for export, forward and backward traceability of food items and surveillance including collection, integration, analysis, interpretation and dissemination of data related to food and nutrient intakes.



**Figure 2:** Public health Expenditure(Billion Rupees) in Pakistan (2011-2019).



**Figure 3:** Public Health expenditure (Billion Rupees) of % GDP in Pakistan (2011-19).

## Conclusions and Recommendations

A major barrier in the implementation of efficacious food safety standards includes improper time and financial resources for the proper function of food regulatory organizations. Massive training and food handling equipment could be an effective tool to have its efficacy but have a high initial cost. Food handler's especially street vendors are illiterate so their literacy level is a huge barrier against their education regarding safe food. Communication strategies should be framed

in the local language and culture should be highly focused. The whole food chain should be focused and the person involved in the food business should be aware of the nature, composition, and perishability of foodstuff being handled by them. Food safety regulatory organizations should focus on massive awareness campaigns instead of imposing heavy fines for revenue generation. Lack of knowledge, lack of set standards, attitude, lack of time, lack of motivation, lack of experience, lack of facilities, and inadequate equipment are prominent barriers in implementing food safety regulations. National Food safety council is needed to be established under the umbrella of the Federal Government. NFSC will be the regulatory authority for the provincial bodies. Instead of imposing fines, the food authorities should organize mass awareness campaigns to give an understanding of safe food and foodborne illness especially in the remote areas of Pakistan. The street vendor and household who are involved in food preparation should be educating regarding sanitation and hygienic conditions. This will be a milestone in the reduction of the public health burden of the country and term will ensure the prosperity of the people also. National Food safety council is needed to be established under the umbrella of Federal Government. NFSC will be the regulatory authority for the provincial bodies. Instead of imposing fines the food authorities should organize mass awareness campaign to give the understanding of safe food and food borne illness especially in the remote areas of Pakistan. Street vendor and household who are involved in food preparation should be educating regarding sanitation and hygienic conditions. This will be milestone in reduction of public health burden of the country and in term will ensure the prosperity of the people also.

## Novelty Statement

Manuscript covers food safety scenario, food borne illness, present interventions and future perspective of food safety in Pakistan. This is novelty of this manuscript. Contamination chain is shown in pictorial demonstration to have better understanding of contamination.

## Author's Contribution

**Muhammad Suhail Ibrahim:** Fetched main idea of draft and write up.

**Asif Ahmad:** Reviewed and supervised the article.

**Anwaar Ahmed:** Supervised the draft.  
**Amer Mumtaz:** Arranged Tables.  
**Muhammad Javaid Asad:** Drafted the diagram.  
**Saqib Jabbar:** Checked the article for language.  
**Ahmad Mujtaba:** Checked the reference.  
**Muhammad Nadeem:** Finalized manuscript

### Conflict of interest

The authors have declared no conflict of interest.

## References

- Adamus-Bialek, W. and M. Wawszczak. 2015. Microbiological contamination of food. *Ecol. Chem. Eng. A*, 22(4): 509-5016.
- Afreen, A., S. Afreen and M.F. Mustafa. 2016. Traditional street vended foods: A potential reservoir for Foodborne pathogens Foodborne pathogens in traditional street foods. *Transylvanian Review*, (5).
- Anku, W.W., M.A. Mamo and P.P. Govender. 2017. Phenolic compounds in water: sources, reactivity, toxicity and treatment methods. *Phenolic compounds-natural sources, importance and applications*, pp. 420-443. <https://doi.org/10.5772/66927>
- Arnon, S.S., R. Schechter, T.V. Inglesby, D.A. Henderson, J.G. Bartlett, M.S. Ascher and S. Lillibridge. 2001. Botulinum toxin as a biological weapon: medical and public health management. *JAMA*, 285(8): 1059-1070. <https://doi.org/10.1001/jama.285.8.1059>
- Bélanger, L., A. Garenaux, J. Harel, M. Boulianne, E. Nadeau and C.M. Dozois. 2011. *Escherichia coli* from animal reservoirs as a potential source of human extraintestinal pathogenic *E. coli*. *FEMS Immunol. Med. Microbiol.*, 62(1): 1-10. <https://doi.org/10.1111/j.1574-695X.2011.00797.x>
- Bernhoft, R.A., 2012. Mercury toxicity and treatment: A review of the literature. *J. Environ. Public Health*, 2012. <https://doi.org/10.1155/2012/460508>
- Berry, M.J. and N.V. Ralston. 2008. Mercury toxicity and the mitigating role of selenium. *EcoHealth*, 5(4): 456-459. <https://doi.org/10.1007/s10393-008-0204-y>
- Buschmann, J., M. Berg, C. Stengel, L. Winkel, M.L. Sampson, P.T.K. Trang and P.H. Viet. 2008. Contamination of drinking water resources in the Mekong delta floodplains: Arsenic and other trace metals pose serious health risks to population. *Environ. Int.*, 34(6): 756-764. <https://doi.org/10.1016/j.envint.2007.12.025>
- Coker, A.O., R.D. Isokpehi, B.N. Thomas, K.O. Amisu and C.L. Obi. 2002. Human campylobacteriosis in developing countries1. *Emerg. Infect. Dis.*, 8(3): 237. <https://doi.org/10.3201/eid0803.010233>
- Dasti, J.I., A.M. Tareen, R. Lugert, A.E. Zautner and U. Groß. 2010. *Campylobacter jejuni*: A brief overview on pathogenicity-associated factors and disease-mediating mechanisms. *Int. J. Med. Microbiol.*, 300(4): 205-211. <https://doi.org/10.1016/j.ijmm.2009.07.002>
- David, J.M., P. Sanders, N. Bemrah, S.A. Granier, M. Denis, F.X. Weill and L. Watier. 2013. Attribution of the French human Salmonellosis cases to the main food-sources according to the type of surveillance data. *Prev. Vet. Med.*, 110(1): 12-27. <https://doi.org/10.1016/j.prevetmed.2013.02.002>
- Fasano, A., 2002. Toxins and the gut: Role in human disease. *Gut*, 50(suppl 3): iii9-iii14. [https://doi.org/10.1136/gut.50.suppl\\_3.iii9](https://doi.org/10.1136/gut.50.suppl_3.iii9)
- Fawell, J. and M.J. Nieuwenhuijsen. 2003. Contaminants in drinking water environmental pollution and health. *Br. Med. Bull.*, 68(1): 199-208. <https://doi.org/10.1093/bmb/ldg027>
- Finley, R., R. Reid-Smith, J.S. Weese and F.J. Angulo. 2006. Human health implications of *Salmonella*-contaminated natural pet treats and raw pet food. *Clin. Infect. Dis.*, 42(5): 686-691. <https://doi.org/10.1086/500211>
- Forshell, L.P. and M. Wierup. 2006. *Salmonella* contamination: A significant challenge to the global marketing of animal food products. *Rev. Sci. Tech. Off. Int. Epiz*, 25(2): 541-554. <https://doi.org/10.20506/rst.25.2.1683>
- Gilbert, C. and M. Slavik. 2004. Determination of toxicity of *Campylobacter jejuni* isolated from humans and from poultry carcasses acquired at various stages of production. *J. Appl. Microbiol.*, 97(2): 347-353. <https://doi.org/10.1111/j.1365-2672.2004.02302.x>
- Gorman, R., S. Bloomfield and C.C. Adley. 2002. A study of cross-contamination of food-borne pathogens in the domestic kitchen in the Republic of Ireland. *Int. J. Food Microbiol.*, 76(1-2): 143-150. [https://doi.org/10.1016/S0168-1605\(02\)00028-4](https://doi.org/10.1016/S0168-1605(02)00028-4)
- Harrington, S.M., E.G. Dudley and J.P. Nataro.



2006. Pathogenesis of enter aggregative *Escherichia coli* infection. FEMS Microbiol. Lett., 254(1): 12-18. <https://doi.org/10.1111/j.1574-6968.2005.00005.x>
- Hashmi, H.N., A.R. Ghuman and N.E. Malik. 2005. Root cause of waterborne diseases in Pakistan. Proc. First Int. Conf. Environ. Sustain. Dev., 5: 1-3.
- He, D., S. Sougioultzis, S. Hagen, J. Liu, S. Keates, A.C. Keates and J.T. LaMont. 2002. Clostridium difficile toxin A triggers human colonocyte IL-8 release via mitochondrial oxygen radical generation. Gastroenterology, 122(4): 1048-1057. <https://doi.org/10.1053/gast.2002.32386>
- Hernández-Cortez, C., I. Palma-Martínez, L.U. Gonzalez-Avila, A. Guerrero-Mandujano, R.C. Solís and G. Castro-Escarpulli. 2017. Food poisoning caused by bacteria (food toxins). Poisoning: From specific toxic agents to novel rapid and simplified techniques for analysis, pp. 33. <https://doi.org/10.5772/intechopen.69953>
- Hickey, C.W. and M.L. Martin. 2009. A review of nitrate toxicity to freshwater aquatic species. Environment Canterbury.
- Hughes, M.F., 2002. Arsenic toxicity and potential mechanisms of action. Toxicol. Lett., 133(1): 1-16. [https://doi.org/10.1016/S0378-4274\(02\)00084-X](https://doi.org/10.1016/S0378-4274(02)00084-X)
- Hussain, M.A. and C.O. Dawson. 2013. Economic impact of food safety outbreaks on food businesses. Foods, 2(4): 585-589. <https://doi.org/10.3390/foods2040585>
- IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, World Health Organization, and International Agency for Research on Cancer. 2004. Some drinking-water disinfectants and contaminants, including arsenic (Vol. 84). IARC.
- Javed, A., 2016. Food borne health issues and their relevance to Pakistani society. Am. Sci. Res. J. Eng. Technol. Sci., 26(4): 235-251.
- Johnson, J.R. and T.A. Russo. 2002. Extraintestinal pathogenic *Escherichia coli*: The other bad *E. coli*. J. Lab. Clin. Med., 139(3): 155-162. <https://doi.org/10.1067/mlc.2002.121550>
- Kaper, J.B., J.P. Nataro and H.L. Mobley. 2004. Pathogenic *Escherichia coli*. Nat. Rev. Microbiol., 2(2): 123-140. <https://doi.org/10.1038/nrmicro818>
- Lee, C. and K.A. Beauchemin. 2014. A review of feeding supplementary nitrate to ruminant animals: nitrate toxicity, methane emissions, and production performance. Can. J. Anim. Sci., 94(4): 557-570. <https://doi.org/10.4141/cjas-2014-069>
- Marriott, N.G., M.W. Schilling and R.B. Gravani. 2018. Food contamination sources. In: Principles of Food Sanitation, Springer, Cham. pp. 83-91. [https://doi.org/10.1007/978-3-319-67166-6\\_5](https://doi.org/10.1007/978-3-319-67166-6_5)
- Marušić, A., 2011. Food safety and security: What were favourite topics for research in the last decade? J. Glob. Health, 1(1): 72.
- Marzano, A.V., M. Mercogliano, A. Borghi, M. Facchetti and R. Caputo. 2003. Cutaneous infection caused by Salmonella typhi. J. Eur. Acad. Dermatol. Venereol., 17(5): 575-577. <https://doi.org/10.1046/j.1468-3083.2003.00797.x>
- Nachamkin, I., Szymanski, C. M., & Blaser, M. J. 2008. *Campylobacter* (No. Ed. 3). ASM Press.
- Nerin, C., M. Aznar and D. Carrizo. 2016. Food contamination during food process. Trends Food Sci. Technol., 48: 63-68. <https://doi.org/10.1016/j.tifs.2015.12.004>
- Nitsch-Osuch, A., E. Kuchar, A. Kosmala, K. Zycinska and K. Wardyn. 2013. Nosocomial rotavirus gastroenterocolitis in children hospitalized primarily due to respiratory infections. In: Respiratory Regulation Clinical Advances, Springer, Dordrecht. pp. 267-274. [https://doi.org/10.1007/978-94-007-4546-9\\_34](https://doi.org/10.1007/978-94-007-4546-9_34)
- Papanikolaou, N.C., E.G. Hatzidaki, S. Belivanis, G.N. Tzanakakis and A.M. Tsatsakis. 2005. Lead toxicity update. A brief review. Med. Sci. Monit., 11(10): RA329-RA336.
- Patra, R.C., A.K. Rautray and D. Swarup. 2011. Oxidative stress in lead and cadmium toxicity and its amelioration. Vet. Med. Int., 2011. <https://doi.org/10.4061/2011/457327>
- Patrick, L., 2006. Lead toxicity, a review of the literature. Part I: Exposure, evaluation, and treatment. Altern. Med. Rev., 11(1): 2-22.
- Pui, C.F., W.C. Wong, L.C. Chai, R. Tunung, P. Jeyaletchumi, N. Hidayah and R. Son. 2011. Salmonella: A foodborne pathogen. Int. Food Res. J., 18(2): 465-473.
- Ramesh, M., R.M. Aruna, N. Malathi and R. Krishnan. 2014. A review of fluoride and its diverse effects. SRMJ. Res. Dental Sci., 5(1): 42. <https://doi.org/10.4103/0976-433X.129072>



- Razzaq, R., K. Farzana, S. Mahmood and G. Murtaza. 2014. Microbiological analysis of street vended vegetables in Multan city Pakistan: A public health concern. *Pak. J. Zool.*, 46(4): 1133-1138.
- Redmond, E.C., C.J. Griffith, J. Slader and T.J. Humphrey. 2004. Microbiological and observational analysis of cross contamination risks during domestic food preparation. *Br. Food J.*, 106(8): 581-597 <https://doi.org/10.1108/00070700410553585>
- Rudkin, J.K., R.M. McLoughlin, A. Preston and R.C. Massey. 2017. Bacterial toxins: Offensive, defensive, or something else altogether? *PLoS Pathogens*, 13(9): e1006452. <https://doi.org/10.1371/journal.ppat.1006452>
- Sánchez, J. and J. Holmgren. 2011. Cholera toxin a foe and a friend. *Indian J. Med. Res.*, 133(2): 153.
- Santamaria, P., 2006. Nitrate in vegetables: Toxicity, content, intake and EC regulation. *J. Sci. Food Agric.*, 86(1): 10-17. <https://doi.org/10.1002/jsfa.2351>
- Savidge, T.C., W.H. Pan, P. Newman, M. O'Brien, P.M. Anton and C. Pothoulakis. 2003. Clostridium difficile toxin B is an inflammatory enterotoxin in human intestine. *Gastroenterology*, 125(2): 413-420. [https://doi.org/10.1016/S0016-5085\(03\)00902-8](https://doi.org/10.1016/S0016-5085(03)00902-8)
- Sokol, R.Z., C.E. Madding and R.S. Swerdloff. 1985. Lead toxicity and the hypothalamic-pituitary-testicular axis. *Biol. Reprod.*, 33(3): 722-728. <https://doi.org/10.1095/biolreprod33.3.722>
- Tchounwou, P.B., A.K. Patlolla, C.G. Yedjou and P.D. Moore. 2015. Environmental exposure and health effects associated with Malathion toxicity. *Toxic. Hazard Agrochem.*, 51: 2145-2149. <https://doi.org/10.5772/60911>
- Wright, J., S. Gundry and R. Conroy. 2004. Household drinking water in developing countries: A systematic review of microbiological contamination between source and point of use. *Trop. Med. Int. Health*, 9(1): 106-117. <https://doi.org/10.1046/j.1365-3156.2003.01160.x>
- Zahir, F., S.J. Rizwi, S.K. Haq and R.H. Khan. 2005. Low dose mercury toxicity and human health. *Environ. Toxicol. Pharmacol.*, 20(2): 351-360. <https://doi.org/10.1016/j.etap.2005.03.007>