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A systematic review on shifting trends of foodborne diseases in Pakistan

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Abstract

Foodborne diseases are increasing at an alarming rate, thereby eliciting constant threat to public health worldwide. Approximately, 200 foodborne cases are caused due to ingestion of contaminated food each year. In developing countries, unhygienic practices are main reasons for foodborne diseases. Precise estimate of population-based data on food borne illnesses are scarce in Pakistan. This review focuses to elucidate etiological cause of foodborne diseases dominant in Pakistan from 1990 to 2018. Various databases were searched, and 88 articles related to foodborne diseases were identified. Around 59 articles were included on quality assessment criteria. We determined dominant pathogens associated with foodborne diseases among all provinces of Pakistan. High numbers of foodborne diseases were reported in Sindh. Whereas, *Salmonella* was determined as primary cause of foodborne ailments. Most of the reported data on antibiotic resistance was unavailable. *Shagella spp* were first reported for antibiotic resistance in 1990, and *E. coli* was reported for multi-drug resistance in 1998. Nevertheless, *S. aureus* was reported for Methicillin-resistant in 2015-16. This study summarize various sources responsible for food-borne illness, of which unhygienic conditions, poor sanitation systems, lack of proper infrastructure and continuous influx of refugees plays key role in escalation of morbidity rate in the region. We emphasize need of active surveillance system in reducing foodborne outbreaks in future and enable policy makers to set appropriate goals in food safety area.

Keywords: Food control, drug resistance, food safety, Pakistan

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1. INTRODUCTION

Foodborne illnesses are infections of gastrointestinal (GI) tract which arises from improper handling, preparation, or food storage. Foodborne illnesses are major risk factors of morbidity and mortality around the world, affected by consumption of food polluted with pathogens, toxins and chemicals. According to WHO, foodborne diseases are mounting up at an alarming rate, causing significant impediment to socio-economic development of a country. Food based outbreak causes mortality of 2.2 million that contributes 4% of all deaths each year worldwide[1]. Around, 75% of diarrheal cases are associated with pathogenic

contamination of food. Around 1,500 million worldwide cases of diarrhoea occur annually, contributing 3 million deaths among children under five [2]. Pakistan—among primitive stages of nutrition transition faces crucial public health concerns as these outbreaks go unreported due to poor surveillance system. Whereas, globalization of food supply, street vendors, growing influx of refugees, open sewages, poor sanitation and hygiene facilitate wide dispersal of microbes into the environment amplifies the concern [3]. Approximately, 97% of foodborne illnesses emanate due to unhygienic handling, storage, and preparation of food that stimulate growth of pathogenic microorganisms [4-5]. Large proportion of community have living standards below poverty line, with undeveloped infrastructure, open sewages, damp places, unhygienic living, and polluted environment that intensifies foodborne issue. Furthermore, sewage-contaminated municipal water is commonly used for irrigation of crops even in metropolitan areas [6]. Lack of public policy, and equipment to maintain good hygiene are economic misfortunes associated with poor food security framework in Pakistan. Thus, all these practices promote foodborne disease [7]. Lack of awareness regarding these harmful pathogens has led to rise in mortality and morbidity in Pakistan [8].

Although, indispensable efforts are required to determine causes of foodborne outbreaks at regional level. Lack of evidence on etiological factors, morbidity and mortality data has demanded need to improve hygienic and quality practices. Several studies reveals diverse factors are responsible for high incidence rate of foodborne diseases. This research illustrates key factors involved in foodborne diseases occurring in Pakistan from 1990 to 2018. We compiled published data on foodborne illnesses and its reported pathogens from all provinces of Pakistan. To emphasize need of active surveillance system to enable policy makers to prevent future outbreaks.

2. MATERIALS AND METHODS

2.1 Search strategy and criteria

We analyzed data on foodborne pathogens and its associated illnesses in Pakistan. A total of 59 articles were assessed that comprised of cross-sectional, case reports, cases studies, cohort studies, reviews, descriptive surveys of foodborne diseases. Relevant data published from June, 1990 to September, 2018 were included in this study comprising of bacterial species, protozoans and viruses responsible for foodborne diseases in different cities of Pakistan. The data was searched from July to October, 2018. Foodborne illnesses instigated by foodborne microbes included: *Salmonella, Staphylococcus aureus, Clostridium botulinum, Shigella, Campylobacter jejuni, Clostridium perfringes, Escherichia coli, Vibrio, Listeria monocytogenes,, Bacillus subtilis, Bacillus cereus, Cryptosporidium parvum, Toxoplasma gondii, Giardia spp., Entamoeba histolytica, Norovirus, Astrovirus, Hepatitis virus, Aspergillus, Penicillium, Mucor. Common* outcomes related to pathogen based foodborne diseases were: food poisoning, cramps, diarrhoea, cold and chills, fever, headache, vomiting, nausea, dysentery, abdominal pain, dehydration, weakness, trouble breathing, headache, fatigue, bloating, gas or flatulence, and weight loss. Our study focused on the etiological factors of foodborne diseases and its associated incidence rate occurring each year. Published articles were hand searched and obtained from electronic databases such as: Google Scholar, Wiley Online library, JSTOR, Science Direct, NCBI, PubMed, World Health Organization (WHO) and JIDC. Additionally, we reviewed national surveillance data via national and international websites namely World Health Organization, Agha khan University, Center for Disease Control and Management to extract facts and figure regarding foodborne illnesses in Pakistan. The retrieved articles included major cities of Pakistan (Karachi, Islamabad, Rawalpindi, Quetta, Gilgit, Lahore, Mardan, Chitral, Peshawar, Skardu, Multan, Hyderabad, Buner and Tandojam).

2.2 Inclusion and exclusion criteria

Two investigators screened all relevant data based on title, abstract, or full-text articles according to inclusive criteria. Relevant information was extracted from each article and reviewed independently by the investigators to validate the inclusions and remove duplicate articles. We included studies comprising of causative agents particularly bacteria, protozoa and viruses responsible for foodborne diseases, its

resistance to drugs, sources of illness, symptoms, region and year for incidence rate was reported. We excluded data that were restricted to waterborne illnesses, mortality rates and, disability adjusted life years of foodborne illnesses due to unavailability of data. The precise structure of research strategy is shown in Fig 1.

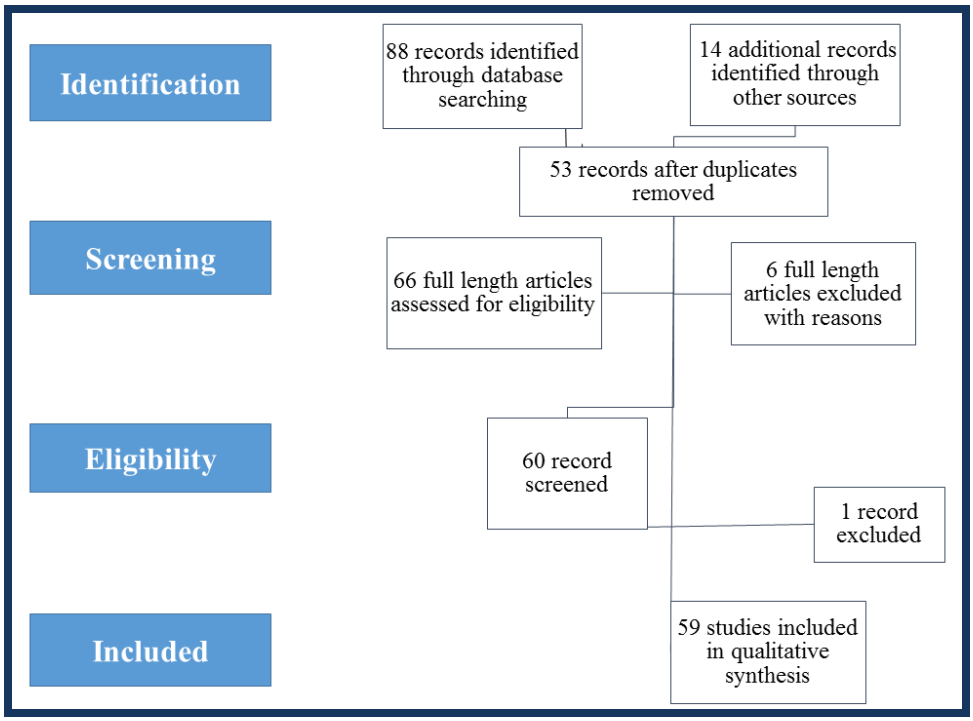

Fig. 1. Search strategy and inclusion criteria. A total of 66 relevant articles were identified on cause of foodborne illness in Pakistan reported from 1990 to 2018. After thorough screening only 59 articles were included in this study on the basis of study criteria

2.3 Risk of biases and data processing

Around 88 articles were reviewed, yet 59 articles qualified the inclusive criteria. The included studies were hospital-based with higher rate of foodborne pathogens, lab based with focus on unhygienic food responsible for foodborne illnesses, rest were surveys of general population identified with food poisoning. The source of foodborne for pathogenic species included: raw vegetables, raw and cooked rice, uncooked meat, fish, and smoked beef. Similarly, to minimize sample specific materials were engrossed.

3. RESULTS AND DISCUSSIONS

This research determines core reasons for foodborne diseases in Pakistan, and provides deeper understanding of true association between this disease and conditions that promote growth of these causal pathogens. This research is first ever to recuperate rising concerns and provide better approach to diminish foodborne disease from our society. Consumption of unhygienic foods is core reason of foodborne diseases reported from 1990 to 2018. Together, 12 bacterial infections were responsible for 46 food hazards, 5 viral infections responsible for 6 epidemics, and 3 protozoans responsible for 7 foodborne infections causing number of cases, deaths, and asymptomatic carriers in last 28 years. These pathogens were identified as core cause of foodborne illnesses in Pakistan such as: *Salmonella spp*., *Staphylococcal spp*., *Clostridium spp*., *Shigella spp*., *Cryptosporidium spp*., *Listeria monocytogens*, *Bacillus spp*., *Vibrio spp*., *Escherichia spp*., including protozoans such as: *Toxoplamosis gondii*., *Giardia spp*., *Entamoeba histolytica* and viruses like *Noroviruses*, *Astroviruses* and *Hepatitis virus* (See Table 1). Majority of foodborne cases in developing countries go unreported, due to lack of active surveillance system. Moreover, humid environmental conditions support microbes under optimum conditions. Contamination, poor sanitation, lack of

medication and resources are main contributing factors for annual morbidity rate of foodborne illnesses in Pakistan. *Salmonella spp., T. gondii Campylobacter spp.,* and *Norovirus* were accountable for highest morbidity rates, whereas*, L. monocytogenes*, *T. gondii* and *Norovirus* caused high proportion of mortality[9]. We found high incidence rate of foodborne illness caused by *Salmonella*, where many infections are asymptomatic. Latest serologic evidence from Europe also suggested that common cause of foodborne disease is *Salmonella spp*.[10]. Our data lacked mild illnesses associated with foodborne pathogens due to lack of registered cases. Botulism is a serious flaccid illness contracted by ingestion of contaminated food or polluted water. Previous research shows that mild cases of botulism are often associated with outbreaks, but affected persons seldom seeks medical care. Recently, botulism outbreaks have intensified with 1,000 cases occurring annually due to consumption of potent neurotoxins in unhygienic foods. *C. botulinum* is resistant to penicillin and metronidazole. Similarly, *L. monocytogenes* is recognized as cause gastroenteritis and fever, though hardly identified by routine stool test[11].

Pakistan being high burden country contributes an annual incidence rate of 413 per 100,000 populations [12](Raza *et al.,* 2014). A food that contains *Salmonella* includes crude or half-cooked eggs, unpasteurized milk, polluted water, and or uncooked meats. Poor sanitation and sterile conditions are predisposing factors responsible for 21 million cases and 21,000 fatalities annually. Of these, 80% of cases happen in Asia alone[13]. Resistance of *Salmonella spp*., to antimicrobial medications are now prevalent in both developed and developing nations[14]. The burden of staphylococcal infection, predominantly by methicillin resistant *S. aureus* strains (MRSA) has increased worldwide. Generally, *S. aureus* bacteremia (SAB) has incidence rate of 20 to 50 cases per 100,000 populations each year in Pakistan[15].

S. typhi and Hepatitis E virus are the prominent reported cases from Quetta, Baluchistan. Baluchistan has a dry and extreme weather and that may affect the proliferation of foodborne pathogens. Likewise, in summer the temperature in this area may rise up to 50^{o}C, which may permit food spoilage. It is the largest province in terms of land, yet deprived zone having no access to clean water, improper sewage, aseptic conditions, unhygienic food production, lack of proper infrastructure with continuous influx of refugees. *Salmonella* is common in children reported in different hospitals with 18.6% prevalence rate[16].

The economic status in KPK is equal to Baluchistan, the same structure gap exists, contributes to wide range of foodborne diseases. *Giardiasis* was observed among children from 4 to 14 years in Peshawar, where lack of hygiene, poor sewage system, congestion, and low financial status were witnessed as risk dynamics[17]. *Hepatitis E* virus from various cites of KPK was reported along with *Amebic* dysentery with prevalence *E. histolytica* higher (33.8%) among children and lower in adults (15.3%)[18]. In 2010, Pakistan experienced floods and consequently cholera outbreak with large number of cases associated with *Vibrio cholera 01* was reported from KPK, including Sindh and Punjab[19].

The results obtained from Gilgit Baltistan showed a large number of reported cases of *Salmonella typhi* during spring season (5%) trailed by summer (4.5%) and harvest time (2.17%), while no *S. typhi* invasion was recorded in winter[20]. High proportions of individuals face public hazards due to poor sanitation practices. Shigellosis is one of the common gastroentitis diseases occurring more often in summer[21]. *Toxoplasma gondii*, cases were reported in northern areas and of particular concern in women by causing abortion and pre-mature birth or inherent abnormalities in new born children 24.7% prevalence rate reported in Chitral showing. *Toxoplasma gondii caused m*aximum cases of toxoplasmosis in individuals are contracted by digestion of infected meat having tissue cysts. Toxoplasmosis prevalence of ranges from 11.33% to 29.45% in Pakistan. Infection peaks in hot, humid climates as oocysts survives better in these environment[71]. Where, *T. gondii* showed resistance towards azithromycin, spiramycin and sulfadiazine[23]. *Cryptosporidium parvum* is significant cause of diarrhea in infants and its incidence is considerably high in Gilgit and Skardu[24-25].

Foodborne pathogens reported from Sindh included: *Salmonella typhi, Staphylococci aureus, Campylobacter jejuni, Shigella spp. S. dysenteriae, S. flexneri, S. boydii and S. sonnei, Vibrio cholera 0, Vibrio cholera O139, Clostridium botulinum, Giardia duodenalis, Entamoeba histolytica, Norovirus, Astrovirus* and *Hepatitis E virus.* Carrier rate of typhoidal *S. enterica* serovars in food handlers working in

different food streets of Karachi is outrageous. Food handlers might be contributing to high prevalence of typhoid cases in Karachi, Pakistan[14]. Poor sanitation and sterile conditions are major inclining factors[26]. In a hazard analysis of food items *S. aureus* and MRSA were found in high proportion due to unhygienic conditions during handling, processing and packaging. Food handlers are significant source of staphylococcal dissemination. Despite the fact the hotspot for staphylococcal prologue to food stuffs was not followed out—questioning the nourishment security and policy makers on customer wellbeing[27]. In Pakistan *S. aureus* is found resistant to vancomycin and tetracyclines, doxycycline[27]. Moreover, Cholera cases are highly reported in Sindh due to improper sanitary practices. The incubation period of *V. cholera* is short term and cholera-related diarrhea occurs suddenly and causes watery fluid, nausea and vomiting which may persist for hours at a time and dehydration. *Vibrio cholera* is reported for resistant against tetracycline, ampicillin, kanamycin, streptomycin, and trimethoprim-sulfamethoxazole[1].

Pakistan has large proportion of cases instigated due to faecal contamination prompted with transmission of enteric pathogens through water, sustenance, human and creature. Consequently, gastroenteritis remains a noteworthy reason for loose bowels among pediatric population of our country. In Pakistan, self-medication and consumptions of drugs without a recommendation are commonly practiced. Thus, there is a larger likelihood of development of resistant isolates due to over use of antibiotics[28]. In developing countries, *Campylobacter* infection frequently occurs in children, where asymptomatic infection are more common[29]. Predominance of the *C. jejuni* are astounding in chickens (6 %), sheep (5 %) and cow (1 %)[30]. This pathogenic organism is developing resistant to antibiotics, especially fluoroquinolones and macrolides[31].

Shigella is major cause of acute dysentery in children. According to CDC 450,000 yearly episodes of shigellosis occur in United States[32]. Food associated with *Shigella* outbreak involves contaminated hand contact during preparation. Once inside host, bacteria causes lysis of cell membranes, and reinitiate intracellular replication to disseminate into the epithelium. *Shigella* species, were vulnerable to ampicillin, nalidixic acid, co-trimoxazole and chloramphenicol. However, recently they have established resistance against fluoroquinolones, cephalosporins and azithromycin. Moreover, insufficient knowledge regarding resistant strains to treat shigellosis is an ultimate challenge in Pakistan[28]. Movement of numerous strains with antibiotic resistance is alarming and demands active surveillance to facilitate control of shigellosis[33]. *L. monocytogenes* infection has global mortality rate of 20-30% [34]. *Listeria* is typically transmitted via contaminated food or water. Approximately, 20 to 30% of foodborne infections in immunocompromised individuals may result in fatality. *Listeria spp.,* are vulnerable to antibiotics except cephalosporin, nalidixic acid, oxacillin and clindamycin[30]. Moreover, high percentages of *E coli O157:H7 and Listeria monocytogenes* in milk are root cause of foodborne illnesses[35-36].

Giardia lamblia is a protozoan parasite of small digestive tract that causes major number of morbidity globally. Infection is initiated by ingestion of contaminated water with few cysts adequate to cause disease[37]. Antimicrobial resistance is observed against furazolidone[17]. *Entamoeba histolytica* infects 50 million individuals with mortality rate of 55,000 individuals' annually worldwide[38]. An investigation conducted in Konkor, Gadap, District Karachi, determined 48.86% *Entamoeba histolytica* are responsible for diseases. Factually socio-economic factors were found unrelated, while age and immunity were found correlated to initiation of disease[37]. Transmission occurs via ingestion of contaminated food and water polluted with *E. histolytica cysts*[37].

Norovirus and *Astrovirus* standout amongst as well-known cause of intense gastroenteritis among children in developing countries. *Astroviruses* are known causative agents of gastroenteritis since 1975, with fluctuates predominance rate in Asia between 10– 30%[39]. *Norovirus* causes intense gastroenteritis among children in undeveloped countries. *Noroviruses* causes morbidity of 267,000,000 cases annually around the world. However, prevalence rate are under reported in Pakistan [40]. No information on the predominance and hereditary fluctuation of *norovirus* are accessible for Pakistan, where early youth mortality because of intense gastroenteritis is common. This report affirms presence of different *norovirus* genotypes in hospitalized kids with intense gastroenteritis in Pakistan[40].

This review identified causal agents of foodborne diseases, which was particularly high in Karachi due with high influx of patients. Consequently, due to advanced treatments or overcrowding that disseminates the diseases more commonly. Second being the largest province with population is Punjab where high rates of foodborne pathogens were isolated. Followed by KPK, Gilgit and Balochistan, where low income, low populace, refugee influx, lack of proper sewage systems thrived the diseases and most of which remain unreported. The largest factor in contributing the food borne ailments were lack of hygiene and resistance to antibiotics. Furthermore, self-medication without a prescription and over use of antibiotics are important factors responsible for development of resistant strains.

Table 1. Foodborne diseases in Pakistan from 1990 to 2018.

Causative agent	***Specimen***	***Sample size***	***Incidence/prevalence rate***	***Year***	***Location***	***Antibiotic resistance***	***Study design***	***Reference***
Shigella spp.	Faecal sample	152	not available	1990	Lahore	Ampicillin, nalidixic acid, cotrimoxazole	Case study	28
Astrovirus, Norovirus, Sapovirus	Faecal sample	517	11.2%, 9.9%, 3.2%	1990-1994	Karachi	Not available	Cohort study	41
Vibrio cholerae	Faecal sample	886	97%	1990-96	Karachi	Not available	Case study	42
Staphylococcus aureus, coliforms, Staphylococcal enterotoxin type A	Milk-based Confectioneries	200g	Not available	1991	Islamabad	Not available	Hazard analysis	43
Staphylococcus aureus, Clostridium perfringens, Bacillus cereus, Staphylococcus aureus, Salmonella	Food items	13 food items	Not available	1992	Islamabad	Not available	Hazard analysis	44
Campylobacter jejuni	Faecal sample	52,777	24.8%	1992-2002	Karachi	ampicillin; tetracycline and ofloxacin	Cohort Study	45
Salmonella typhi	*Food, water*	100 cases	36%	1994	Karachi	Not available	Case control study	46

Hepatitis E virus	Polluted water	600	Not available	1995	Peshawar, Mardan, Abbottabad, Islamabad, Sargodha, Multan, Hyderabad, Quetta and Karachi.	Not available	Cross sectional study	47
Shigella dysenteriae, Shigella flexneri, Shigella boydii, Shigella Sonnei	Faecal specimen	1573	0%, 54.4%, 10%,39%	1996-2007	Karachi	Ampicillin, trimethoprim+ Sulfamethoxazole, nalidixic acid, ofloxacin	Cohort Study	48
Salmonella typhi	Faecal specimens	585	3.6%	1997-1999	Gilgit	Cefotaxime, ceftriaxone, ciprofloxacin and enoxacin.	Cohort study	20.
Shigella spp.	Faecal specimens	585	13.2%	1997-1999	Gilgit	Chloramphenicol, nalidixic acid, ampicillin, ceftriaxone, cefotaxime, ciprofloxacin, and enoxacin	Cohort study	21
E coli O157:H7	Urine	1000	73.1%	1998	Lahore	Multi drug resistance	Cross sectional Study	49
Vibrio cholera O1	Blood, faecal sample	8	Not available	1998-2008	Pakistan	None	Case study	50.
Vibrio cholera O139	Faecal Sample	550	Not available	2000-2001	Karachi	None	Case study	51

Salmonella typhi, Salmonella paratyphi A	Blood sample	3671	79.3%, 59.9%	2001-2006	Karachi	co-trimoxazole, chloramphenicol and ampicillin	Cohort study	52
E coli O157:H7	Raw milk	160	88%	2002	Tandojam	Not available	Hazard analysis	35
Entamoeba histolytica, Giardia lamblia	faecal sample	263	48.86%, 50%	2002	Karachi	Not available	Cross sectional study	37
Campylobacter jejuni	Faecal sample	100	39%	2002	Rawalpindi	Not available	Cohort study	29
Shigella spp.	Faecal sample	4688	4.1%	2002-2003	slums of Karachi	Ofloxacin, ceftriaxone, Cotrimoxazole, nalidixic acid, ampicillin	Cross-sectional study	32
Campylobacter jejuni,	Food items and brewages	1636	48%	2002-04	Faisalabad, Lahore and Islamabad	Not available	Hazard analysis	53
Listeria monocytogenes	Meat	40	10-37.5%	2003	Faisalabad	Not available	Hazard analysis	54
Giardia lamblia	Faecal sample	239	30.96%	2004-2006	Peshawar	Not available	Cohort study	17
Norovirus	Faecal sample	255	16.1%	2006-2008	Karachi, Lahore, Rawalpindi	Not available	Case report	40.
Listeria monocytogenes	Bovine milk	200	12%	2007	Hyderabad	Cotrimoxazole, erythromycin, penicillin (Oxoid)	Hazard analysis	36
Not available	Sign and symptoms	110	94.7%	2007	Military training center	Not available	Outbreak	55

Shiga toxin–producing Escherichia coli (STEC)	Faecal sample	23	21.7%	2007	Faisalabad	Ampicillin	Case study	56
Cryptosporidium parvum	Faecal sample	200	9%	2007-08	Peshawar	Not available	Cohort study	57
Cryptosporidium parvum	Polluted water.	300	9.4%	2007-2008	Gilgit	Not available	Descriptive study	24
Salmonella typhi and Salmonella paratyphi, Salmonella spp	*Not available*	2532	53.7%, 42.7%, 3.7%	2007-2011	Lahore	Ciprofloxacin, Ampicillin and Co-trimoxazole	Retrospective cohort study	12
Shigella flexneri, Shigella sonnei, Shigella boydii, Shigella dysenteriae.	Faecal sample	8155	62%, 18%, 11%, 9%	2008	urban slums of Karachi	Cotrimoxazole, ampicillin	Surveillance study	33
Astrovirus	Faecal sample	535	7%	2009-2010	Rawalpindi	Not available	Case report	58
Klebsiella, Enterobacter, Staphylococcus aureus and Bacillus subtilis	Raw meat samples and surface swabs from meat processing equipment	340	84%	2010	Karachi	Ampicillin, amoxicillin, novobiocin and cefaclor	Hazard analysis/ Experimental	29
Vibrio cholera 01	Faecal sample	319	(not available)	2010	Sindh, Punjab and Khyber Pakhtunkhwa	Not available	Cross sectional	19
Salmonella enteritidis, Salmonella typhi, Salmonella pullorum, Salmonella typhimurium	Broiler chicken meat	100 samples	38%	2010	Hyderabad	Ampicillin	Surveillance/ Survey	59
Entamoeba histolytica	Faecal sample	234 patients	57.6%	2011	Slums of karachi	Not available	Cross sectional study	38

Hepatitis A	Fruits/ vegetables	29	10%	2011	Mardan	Not available	Hazard analysis	60
Salmonella typhi	Blood sample	2964 Patients	18.6%	2011-2012	Quetta	Not available	Cohort study	16
Escherichia coli (Pathotypes, enterotoxigenic EC)	Flooded water sample	200	33%. 50%	2011-12	KPK province	Not available	Cross sectional study	22
Campylobacter jejuni (C. jejuni)	Diarrheal cases of poultry, cattle and humans	436	35%, 25%, 11.3%	2011-12	Islamabad	Cephalothin, sulfamethoxazole+trimethoprim, Ampicillin, Beta-lactamase	Cohort study	13
E. coli, S. aureus, Salmonella	Food items	91	25.5%, 16.6%, 11.1%	2012	Islamabad	Not available	Cross sectional study	61
Salmonella. Typhi, Salmonella paratyphi	Blood	2	(not available)	2013	Karachi	nalidixic acid, ampicillin, chloramphenicol and cotrimoxazole	Case report	26
Entamoeba histolytica	Faecal sample	316	23.1%	2013	Buner	Not available	Cross sectional study	18
Klebsiella spp. Enterobacter spp. Enterococcus spp. Staphylococcus aureus	Salad	50	16%, 11%, 13%, 7.5%	2014	Lahore	Not available	Hazard analysis	62
Clostridium perfringes	Meat	300	6 %	2014	Lahore	Not available	Hazard analysis	30
Cryptosporidium parvum	Faecal sample	53	20.8%	2014-2015	Skardu	Not available	Case study	25

Campylobacter jejuni,	Meat	600	20.8%	2014-2015	Lahore	Not available	Cross-sectional study	31.
Salmonella enteritidis	broiler chickens	150	23.3%	2014-15	Kohat	Ampicillin, tetracycline, augmentin, chloramphenicol	Hazard analysis	63
Bacillus subtilis	Cooked and Raw Rice	168	52, (raw rice) 25(cooked rice)	2015	Lahore	Not available	Hazard analysis	64
Bacillus cereus	Cooked and Raw Rice	168	38%(raw rice), 46%(cooked rice)	2015	Lahore	Not available	Hazard analysis	64
Bacillus alvei, Bacillus subtilis, Bacillus polymyxa, Pseudomonas aeruginosa, Staphylococcus aureus, Klebsiella pneumonia, Escherichia coli and Enterobecter	Unpasteurized packed fruit juices	60	Not available	2015	Lahore	Not available	Hazard analysis	65
Shiga toxin-producing E. coli pathotypes	Salad	260	34 %	2015	KPK	Tetracycline, Ampicillin	Hazard analysis	66
Salmonella Enterica serovars	*Street food*	220	9.1%	2015	Karachi	sulfamethoxazole+trimethoprim, Ampicillin	Cross-sectional study	14
Bacillus spp., Staphylococcus aureus, Escherichia coli, Aspergillus spp., Saccharomyces cerevisiae, Penicillium sp. and Rhizopus	Fruit juices	90	Not available	2015	Lahore	Not available	Hazard analysis	67

Enterobacteriaceae, Coliforms, Escherichia coli	Surfaces, equipments	3499	47.3%, 30.8%, 21.9%	2015-16	Hub	Not available	Hazard study	68
Staphylococcus aureus	Eggs	300	59%,	2015-16	Haripur	Methicillin-resistant	Hazard analysis	69
Toxoplasma gondii	Blood sample	300	24.7%	2016	Chitral	Not available	Cross sectional study	71
Toxoplasma gondii	Blood sample	600	17.83	2017	Mardan	Not available	Case control study	23
Staphylococci spp, Staphyloccus aureus, MRSA	Processed food items	1012	71.4%, 36.2%, 8.3%	2017	Karachi	Not available	Cross sectional study	27
Salmonella spp., Listeria Monocytogenes, Campylobacter jejuni and E.coli (O157:H7)	Chicken, beef meat, Milk, Vegetable, salad sample	800	19%, 1.25%, 28.99%, 8%	2018	Quetta	N/A	Cross sectional Study	70

4. CONCLUSIONS

We have reviewed prevailing foodborne pathogens and its associated diseases from 1990 to 2018 among all provinces of Pakistan on the basis of reported cases, incidence rate, source of disease and antibiotic resistance. We conclude that overall environmental conditions in Pakistan are humid providing optimum conditions to microbes for their survival. Contamination, poor sanitation, fewer resources and lack of medication are the key factors to elicit foodborne infections in the regions. *Salmonella spp., Campylobacter spp.,* and *T. gondii* induces most hospitalizations, while *Norovirus* stimulates high mortality rates. Moreover, misuse of antibiotics pose greater challenge in developing new strategies to counter antimicrobial resistance. Therefore, scientific community are actively involved in investigating novel bioactive compounds against resistant microbes. This research utilizes prevalent rates of foodborne diseases to provide directions to policymakers' in predicting annual burden in future. We recommend active surveillance system to report food safety issues and burden of foodborne illnesses to provide better approach emphasizing to eradicate foodborne disease from our society.

CONFLICT OF INTEREST

All the authors claim that there is no conflict of interest regarding the publication of this paper.

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REFERENCES

1. World Health Organization. World Water Day 2001, *Disease fact sheet: Diarrhoea.Geneva*: WHO 2000.

2. Laurian U. Nancy H. Food Safety Issues In The Developing World. Washington, DC: World Bank 2000:469
3. CIA World Factbook. https://www.cia.gov/library/publications/the-world-factbook. (2014).
4. Baş M, Ersun AŞ, Kıvanç G. The evaluation of food hygiene knowledge, attitudes, and practices of food handlers' in food businesses in Turkey. Food control 2006;17(4):317-22.
5. Wilson M, Murray AE, Black MA, McDowell DA. The implementation of hazard analysis and critical control points in hospital catering. Managing Service Quality: An International Journal 1997;7(3):150-6.
6. Ullah H, Khan I, Ullah I. Impact of sewage contaminated water on soil, vegetables, and underground water of peri-urban Peshawar, Pakistan. Environmental monitoring and assessment 2012;184(10):6411-21.
7. Yahya F, Zafar R, Shafiq S. Trend of fast food consumption and its effect on Pakistani society. Food Science and Quality Management 2013;11:1-8.
8. Ahmad KA, Khan LH, Roshan B, Bhutta ZA. A 12 year clinical experience with paediatric salmonellosis from an endemic population in Karachi. In Proceedings of The International Society for Infectious Diseases Meeting, Argentina 2000.
9. Tauxe RV. Emerging foodborne pathogens. International journal of food microbiology 2002;78(1-2):31-41.
10. Parry CM, Threlfall EJ. Antimicrobial resistance in typhoidal and nontyphoidal salmonellae. Current opinion in infectious diseases 2008;21(5):531-8.
11. Abdulla CO, Ayubi A, Zulfiquer F, Santhanam G, Ahmed MA, Deeb J. Infant botulism following honey ingestion. BMJ Case Reports 2012: bcr1120115153.
12. Raza A, Sultan F, Mahboob A, Nizammudin S, Nazeer SH. Salmonella bacteraemia among healthcare workers and their dependents. Journal of Pakistan Medical Association 2014;64(7):748-50.
13. Siddiqui FM, Akram M, Noureen N, Noreen Z, Bokhari H. Antibiotic susceptibility profiling and virulence potential of Campylobacter jejuni isolates from different sources in Pakistan. Asian Pacific journal of tropical medicine 2015;8(3):197-202.
14. Siddiqui TR, Bibi S, Mustufa MA, Ayaz SM, Khan A. High prevalence of typhoidal Salmonella enterica serovars excreting food handlers in Karachi-Pakistan: a probable factor for regional typhoid endemicity. Journal of Health, Population and Nutrition 2015;33(1):27.
15. Lambrechts AA, Human IS, Doughari JH, Lues JF. Bacterial contamination of the hands of food handlers as indicator of hand washing efficacy in some convenient food industries in South Africa. Pakistan journal of medical sciences 2014;30(4):755.
16. Khan MN, Shafee M, Hussain K, Samad A, Awan MA, Manan A, Wadood A. Typhoid fever in paediatric patients in Quetta, Balochistan, Pakistan. Pakistan journal of medical sciences 2013;29(4):929.
17. Younas M, Shah S, Talaat A. Frequency of Giardia lamblia infection in children with recurrent abdominal pain. Journal Of Pakistan Medical Association 2008;58(4):171-74
18. Zeb A, Qureshi AW, Khan L, Mansoor A, Ullah S, Irfan M. Prevalence of Entamoeba histolytica in district Buner Khyber Pakhtunkhwa, Pakistan. Journal of Entomology and Zoology studies 2018;185:185-188
19. Shah MA, Mutreja A, Thomson N, Baker S, Parkhill J, Dougan G, Bokhari H, Wren BW. Genomic epidemiology of Vibrio cholerae O1 associated with floods, Pakistan, 2010. Emerging infectious diseases 2014;20(1):13-2
20. Ahmad KA, Khan LH, Roshan B, Bhutta ZA. A 12 year clinical experience with paediatric salmonellosis from an endemic population in Karachi. In Proceedings of The International Society for Infectious Diseases Meeting, Argentina 2000.
21. Ahmed K, Shakoori FR, Shakoori AR. Aetiology of shigellosis in northern Pakistan. Journal of Health, Population and Nutrition 2003;1:32-9.
22. Shah MS, Eppinger M, Ahmed S, Shah AA, Hameed A, Hasan F. Flooding adds pathogenic Escherichia coli strains to the water sources in southern Khyber Pakhtunkhwa, Pakistan. Indian journal of medical microbiology 2016;34(4):483-88
23. Khattak MN, Iltaf M, Rehman AU, Malik S, Zahid M. Prevalence, socio-demographic determinants and risk factors of toxoplasmosis: case-control study in a rural community of Mardan district, Northern Pakistan. JAPS: journal of Animal and Plant Sciences 2017;27:617-26.

24. Farooq, M., Butt T., Sultan, M. Cryptosporidium parvum. Public health concern among children of northern areas of Pakistan. Pakistan Journal of Pathology 2016.
25. Khushdil A, Murtaza F, Chattha MN. Cryptosporidiosis among children of district Skardu, Pakistan. Journal of Ayub Medical College Abbottabad 2016;28(3):575-7.
26. Sultan BA, Fasih N, Qaiser S, Khan E, Zafar A, Irfan S. Mixed Salmonella infection: a case series from Pakistan. Journal of Pakistan Medical Association 2013;63(4):524.
27. Mirani ZA, Aqeel A, Naz S. Prevalence of Staphylococci in commercially processed food products in Karachi-Pakistan. Journal of Microbiology and Infectious Diseases 2017;7(02):83-7.
28. Khalil K, Khan SR, Mazhar K, Kaijser B, Lindblom GB. Occurrence and susceptibility to antibiotics of Shigella species in stools of hospitalized children with bloody diarrhea in Pakistan. The American journal of tropical medicine and hygiene 1998;58(6):800-3.
29. Ali AM, Qureshi AH, Rafi S, Roshan E, Khan I, Malik AM, Shahid SA. Frequency of Campylobacter jejuni in diarrhoea/dysentery in children in Rawalpindi and Islamabad. Journal-Pakistan Medical Association 2003;53(11):517-20.
30. Khan M, Nazir J, Anjum AA, Nawaz M, Shabbir MZ. Toxinotyping and antimicrobial susceptibility of enterotoxigenic Clostridium perfringens isolates from mutton, beef and chicken meat. Journal of food science and technology 2015;52(8):5323-8.
31. Nisar M, Mushtaq MH, Shehzad W, Hussain A, Nasar M, Nagaraja KV, Goyal SM. Occurrence of Campylobacter in retail meat in Lahore, Pakistan. Acta tropica 2018;185:42-5.
32. Zafar A, Sabir N, Bhutta Z. Frequency of isolation of Shigella serogroups/serotypes and their antimicrobial susceptibility pattern in children from slum areas in Karachi. Journal of Pakistan Medical Association 2005;55(5):184.
33. Zafar A, Hasan R, Nizami SQ, von Seidlein L, Soofi S, Ahsan T, Chandio S, Habib A, Bhutto N, Siddiqui FJ, Rizvi A. Frequency of isolation of various subtypes and antimicrobial resistance of Shigella from urban slums of Karachi, Pakistan. International Journal of Infectious Diseases 2009;13(6):668-72.
34. Meyer-Broseta S, Diot A, Bastian S, Rivière J, Cerf O. Estimation of low bacterial concentration: Listeria monocytogenes in raw milk. International Journal of Food Microbiology 2003;80(1):1-5.
35. Soomro AH, Arain MA, Khaskheli M, Bhutto B. Isolation of Escherichia coli from raw milk and milk products in relation to public health sold under market conditions at Tandojam. Pakistan Journal of Nutrition 2002;1(3):151-2.
36. Chandio TH, Soomro AH, Bhutto MB, Dewani P, Shah G. Occurrence ofListeria monocytogenes in bovine milk in Hyderabad, Pakistan. Annals of microbiology 2007;57(3):341-4.
37. Siddiqui MI, Bilqees FM, Iliyas M, Perveen S. Prevalence of parasitic infections in a rural area of Karachi, Pakistan. The Journal of the Pakistan Medical Association 2002;52(52):315-20.
38. Ibrahim F, Talat R, Ain QU. A Record of Intestinal protozoan infection from different hospitals of Karachi Pakistan. RADS Journal of Biological Research & Applied Sciences 2012;3(2):12-7.
39. Colomba C, De Grazia S, Giammanco GM, Saporito L, Scarlata F, Titone L, Arista S. Viral gastroenteritis in children hospitalised in Sicily, Italy. European Journal of Clinical Microbiology and Infectious Diseases 2006; 25(9):570-5.
40. Alam A, Qureshi SA, Vinjé J, Zaidi A. Genetic characterization of norovirus strains in hospitalized children from Pakistan. Journal of medical virology 2016;88(2):216-23.
41. Phan TG, Okame M, Nguyen TA, Maneekarn N, Nishio O, Okitsu S, Ushijima H. Human astrovirus, norovirus (GI, GII), and sapovirus infections in Pakistani children with diarrhea. Journal of medical virology 2004;73(2):256-61.
42. Sheikh A, Khan A, Malik T, Fisher-Hoch SP. Cholera in a developing megacity; Karachi, Pakistan. Epidemiology & Infection 1997;119(3):287-92.
43. Teufel P, Bryan Fl, Qadar F, Riaz S, Roohi S, Malik ZU. Risks of salmonellosis and staphylococcal food poisoning from Pakistani milk-based confectioneries. Journal of food protection 1992;55(8):588-94.
44. Bryan Fl, Teufel P, Roohi S, Qadar F, Riaz S, Malik ZU. Hazards and critical control points of food preparation and storage in homes in a village and a town in Pakistan. Journal of food protection 1992;55(9):714-21.
45. Ibrahim NG, Zafar A, Hasan R. Evaluation of frequency of isolation and trends in antibiotic resistance among Campylobacter isolates over 11 year period. Evaluation 2004;54(6): 291-294.

46. Luby SP, Faizan MK, Fisher-Hoch SP, Syed A, Mintz ED, Bhutta ZA, McCormick JB. Risk factors for typhoid fever in an endemic setting, Karachi, Pakistan. Epidemiology & Infection 1998;120(2):129-38.
47. Malik IA, Tariq WU. Hepatitis E in Pakistan. Eastern Mediterranean health journal. 1996;2(1):121-8.
48. Khan E, Jabeen K, Ejaz M, Siddiqui J, Shezad MF, Zafar A. Trends in antimicrobial resistance in Shigella species in Karachi, Pakistan. The Journal of Infection in Developing Countries 2009;3(10):798-802.
49. Tanvir R, Hafeez R, Hasnain S. Prevalence of multiple drug resistant Escherichia coli in patients of urinary tract infection registering at a diagnostic laboratory in Lahore Pakistan. Pakistan Journal of Zoology 2012;44(3):707-12.
50. Jabeen K, Siddiqui J, Zafar A, Shakoor S, Ali N, Zaidi AK. Vibrio cholerae O1 bacteremia in Pakistan: analysis of eight cases. Transactions of the Royal Society of Tropical Medicine and Hygiene 2010;104(8):563-65
51. Jabeen K, Hasan R. Re-emergence of Vibrio cholerae O139 in Pakistan: report from a tertiary care hospital. JPMA 2003;53(335).
52. Hasan R, Zafar A, Abbas Z, Mahraj V, Malik F, Zaidi A. Antibiotic resistance among Salmonella enterica serovars Typhi and Paratyphi A in Pakistan (2001-2006). The Journal of Infection in Developing Countries 2008;2(04):289-94.
53. Hussain I, Mahmood MS, Akhtar M, Khan A. Prevalence of Campylobacter species in meat, milk and other food commodities in Pakistan. Food microbiology 2007;24(3):219-22.
54. Mahmood MS, Ahmed AN, Hussain I. Prevalence of Listeria monocytogenes in poultry meat, poultry meat products and other related inanimates at Faisalabad. Pakistan Journal of Nutrition 2003;2:346-9.
55. Siddiqui MS, Nadeem SF. Epidemiological investigation of an outbreak of food poisoning traced to yogurt among personnel of a Military training center. Pakistan Armed Forces Medical Journal 2007;57(3):194-200.
56. Mohsin M, Haque A, Ali A, Sarwar Y, Bashir S, Tariq A, Afzal A, Iftikhar T, Saeed MA. Effects of Ampicillin, Gentamicin, and Cefotaxime on the Release of Shiga Toxins from Shiga Toxin–Producing Escherichia coli Isolated During a Diarrhea Episode in Faisalabad, Pakistan. Foodborne pathogens and disease 2010;7(1):85-90.
57. Mumtaz S, Ahmed J, Ali L. Frequency of cryptosporidium infection in children under five years of age having diarrhea in the North West of Pakistan. African Journal of Biotechnology 2010;9(8):1230-1235
58. Alam MM, Khurshid A, Rana MS, Shaukat S, Sharif S, Angez M, Naeem M, Zaidi SS. Serotype diversity of astroviruses in Rawalpindi, Pakistan during 2009–2010. PloS one 2013;8(4):e61667.
59. Soomro AH, Khaskheli M, Bhutto MB, Shah G, Memon A, Dewani P. Prevalence and antimicrobial resistance of Salmonella serovars isolated from poultry meat in Hyderabad, Pakistan. Turkish Journal of Veterinary and Animal Sciences 2011;34(5):455-60.
60. Khan W, Irshad M, Rehman G, Hussain A. HAV in fresh vegetables: a hidden health risk in district Mardan, Pakistan. SpringerPlus 2014;3(1):675.
61. Yasin N, Khan J, Shah N, Khan RA, us Saba N. Bacteriological study of food in the Pakistan's peri-urban areas of Rawalpindi and Islamabad. African Journal of Biotechnology 2012;11(39):445-9451.
62. Hannan A, Rehman R, Saleem S, Khan MU, Qamar MU, Azhar H. Microbiological analysis of ready-to-eat salads available at different outlets in Lahore, Pakistan. International Food Research Journal 2014;21(5).
63. Asif M, Rahman H, Qasim M, Khan TA, Ullah W, Jie Y. Molecular detection and antimicrobial resistance profile of zoonotic Salmonella enteritidis isolated from broiler chickens in Kohat, Pakistan. Journal of the Chinese Medical Association 2017;80(5):303-6.
64. Qureshi R, Zakki SA, Hussain A. Prevalence of Bacillus Species and Fungal Species Isolated from Cooked and Raw Rice. RADS Journal of Pharmacy and Pharmaceutical Sciences 2015;3(1):55-61.
65. Iqbal MN, Anjum AA, Ali MA, Hussain F, Ali S, Muhammad A, Irfan M, Ahmad A, Irfan M, Shabbir A. Assessment of microbial load of un-pasteurized fruit juices and in vitro antibacterial potential of Honey against bacterial isolates. The open microbiology journal 2015;9:26-32
66. Shah MS, Eppinger M, Ahmed S, Shah AA, Hameed A, Hasan F. Multidrug-resistant diarrheagenic E. coli pathotypes are associated with ready-to-eat salad and vegetables in Pakistan. Journal of the Korean Society for Applied Biological Chemistry 2015;58(2):267-73.

67. Iqbal MN, Ali S, Anjum AA, Muhammad K, Ali MA, Wang S, Khan WA, Khan I, Muhammad A, Mahmood A, Irfan M. Microbiological Risk Assessment of Packed Fruit Juices and Antibacterial Activity of Preservatives Against Bacterial Isolates. Pakistan Journal of Zoology 2016;48(6):1695-1703
68. Ali R, Hayat A, Fatima M, Noman M. Detection and enumeration of Enteric bacteria associated with food handlers and surfaces of food manufacturing industry located in Hub city, Pakistan. World Scientific News 2016;49(2):192-203.
69. Syed MA, Shah SH, Sherafzal Y, Shafi-ur-Rehman S, Khan MA, Barrett JB, Woodley TA, Jamil B, Abbasi SA, Jackson CR. Detection and molecular characterization of methicillin-resistant Staphylococcus aureus from table eggs in Haripur, Pakistan. Foodborne pathogens and disease 2018;15(2):86-93.
70. Samad A, Abbas F, Ahmad Z, Pokryrshko O, Asmat TM. Prevalence of Foodborne Pathogens in Food Items in Quetta, Pakistan. Pakistan Journal of Zoology 2018;50(4): 1597-1600.
71. Shah H, Saeed M, Farhat Naz AJ, Ullah R, Khan SF, Haseeb A, Ahmad I, Younas M. Seroprevalence and Risk Factors of Toxoplasmosis among Women in District Chitral, Khyber Pakhtunkhwa, Pakistan. World Journal of Zoology 2016;11(3):135-40.