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Prevalence Waterborne Infections after Earthquakes Considered as Serious Threat to Increasing Victims in Disaster-Affected Areas

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THE disasters are competent for beginning the prevalence of waterborne infections. The earthquakes are the most important disaster worldwide. Studies have reported waterborne pathogens can causing about thirty-eight types of infections after each earthquake. Also, waterborne pathogens can cause a higher fatality than an earthquake. Therefore, a strategy for prevention from infections that may occur for people is important after each earthquake. Waterborne infections were sometimes causing two folds fatalities than the earthquake. Disasters are the most important complications in developing countries for the World Health Organization (WHO). Notably, occurrences of infectious diseases after natural disasters commonly occur, especially in seismic regions. Iran is located in the Alpine-Himalayan seismic belt and considered a seismic country. The planning of an infectious disease strategy is necessary for decreasing health problems. Therefore, our aims of the present study were to introduce important bacterial waterborne infectious agents that prevalence after the previous earthquakes and explained several important relevant prevention strategies.

Keywords: Earthquake, Waterborne infections, Bacteria.

Introduction

The disasters of earthquakes sometimes cause contamination of drinking water supplies and spread waterborne infections among the area's population. Following the earthquake and tsunami of Indonesia (December 26, 2004, and March 28, 2005, in Aceh and North Sumatra provinces), acute watery diarrhea introduced as the second leading cause of death [1]. Therefore, waterborne infections are known as an important health concern in disaster-affected areas [2, 3]. Notably, alternative strategies must be planned to post-natural disasters responding [4], which has been done by several countries to decreasing losses [5].

Review of literature

Waterborne infections

Robert Koch in 1883 (Berlin, Germany) first time has reported high heterotrophic colony counts of bacteria in tap water [6]. Studies have reported that approximately thirty-eight types of infectious diseases can occur following an earthquake by waterborne pathogens [4, 7]. The common waterborne pathogens are several groups of enteric and aquatic bacteria, enteric viruses and enteric protozoa [8]. Because of easy dispersion, physiological diversity and high tolerate in extreme conditions, waterborne pathogens cause severe infections and death, especially in young children, elderly and immune-suppressed individuals [9]. Here, we introduced several important bacterial waterborne pathogens, especially bacteria that were reported in past earthquakes.

Vibrio cholera

The toxigenic V. cholera serogroups O1 and O 139 caused acute and watery diarrheal also fatality and rapid spread infectious disease as cholera [10]. The V. cholera serogroup O1, serotype Ogawa, biotype El Tor had been killed thousands of people following the Haiti earthquake in January 2010 [10-13]. However,

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after the Great Earthquake in the east of Japan (2011), V. cholera serogroups O1 and O139 were detected. Also, more diagnosis bacteria belonged to Bacteroidetes or Proteobacteria genera were known (14).

Salmonella spp.

They are zoonotic enteric pathogens with a worldwide prevalence that causes an intestinal illness or severe systemic diseases e.g. typhoid and paratyphoid fever [15]. Its co-infection with V. cholera has been reported following Port-au-Prince, Haiti earthquake, [16]. After the Bam earthquake (Iran, 2004), 738 cases were detected with watery and dysentery diarrhea, because of loss laboratory data only 0.4% reported as typhoid [17]. The typhoid fever incidence was 11.9% and 20.5% following the tsunami in Banda Aceh and earthquake in Yogyakarta, Indonesia, respectively [3].

Shigella spp

The Shigella spp. is another important enteric pathogen that isolated from patients with acute diarrhea after Port-au-Prince, Haiti earthquake (2010). Moreover, its co-infection with V. cholera also reported among several patients [16]. Moreover, outbreaks of 15 cases of shigellosis were reported after the earthquake in Taiwan, September 21, 1999 [18].

Escherichia coli

The pathogenic strains of *E. coli* causes intestinal or extra-intestinal infections such as gastroenteritis, urinary tract infections, neonatal meningitis, hemolytic-uremic syndrome, mastitis, peritonitis, septicemia, and pneumonia [19, 20]. It has been reported that near 80-92% of drinking waters were contaminated by *E. coli*, Vibrio spp., and other bacteria after April 2007 Solomon Island earthquake [21]. The enterotoxigenic *E. coli* (ETEC) was isolated from Port-au-Prince, Haiti earthquake patients with acute diarrhea, which had also co-infection with *V. cholera* [16]. In addition, Gupta et al. (2007) reported high *E. coli* contamination of drinking waters following tsunami and earthquake in Indonesia [1].

Helicobacter pylori

It was found that approximately 83.1% of the uninjured patients with a gastric ulcer that developed after the Hanshin-Awaji at 1995 in Japan were infected by *H. pylori*, however, the incidence of all types of peptic ulcers and hemorrhagic ulcers were 1.5 and 2.2-fold increased, respectively [22, 23]. Rasheed et al. (2009) reported that drinking water quality in earthquake-affected areas was more substandard than other areas in Pakistan. They were not detected positive results for *H. pylori* but detected other bacterial pathogens such as *V. cholera*, *Salmonella spp*. *Shigella dysenteriae*, *E. coli*, *Acinetobacter baumanii*, *Staphylococcus aureus, Pseudomonas aeruginosa*, *Vibrioparahaemolyticus*, *Klebsiellas spp*., *Aeromonas hydrophila*, *Citrobacter freundii*, Proteus sp., *Edwardsiella tarda*, *Enterobacter spp., Stenotrophomonas spp., Staphylococcus spp. and Streptococcus spp*. [7]. Following the October 2011 earthquake in the eastern Anatolian city of Van in Turkey, *H. pylori* infection was observed in 56.5% of earthquake survivors with dyspepsia [24].

Staphylococcus aureus

Staphylococcus aureus is an important opportunistic pathogen that causes water-borne infections [25]. Kang et al. (2009) showed that the most frequently isolated gram-positive bacteria were *S. aureus*, enterococci, and coagulase-negative staphylococci, respectively among survivors of May 12, 2008, Wenchuan County, Sichuan Province, China earthquake [26]. In the study by Tao et al. (2009) that applied to the survivors of the Wenchuan earthquake *S. aureus* isolates belonged to pathogenic bacteria that detected [27]. 7-*Pseudomonas aeruginosa* and *A.baumanii*: *Pseudomonas aeruginosa* and *A.baumanii* are two important opportunistic human pathogens [28, 29]. After the 17 August 1999 earthquake in the Marmara (Northwest Turkey), among 220 patients were hospitalized, 15 *A. Baumanii* (31.2%), 9 *S. aureus* (18.7%), 7 *P. aeruginosa* (14.6%), 6 *E. coli* (12.5%), 6 *K. Pneumoniae* (12.5%), 2 *Stenotrophomonas maltophilia* (4.2%) and three various *Pseudomonas spp*. (6.3%) were detected [30]. Following the 12 May 2008 Chongqing, China, earthquake the results showed that the infectious bacteria mainly included *E.coli*, *S. aureus*, *Staphylococcus haemolyticus*, *A. Baumanii*, *Aerobacter cloacae*, *P. aeruginosa* and *Bacillus Aerogenes capsulatus* [31]. Kang et al. (2009) demonstrated that *A. Baumannii*, *E. coli*, *P. aeruginosa*, *E. cloacae*, K. *pneumonia*,

and *Aeromonas hydrophila* were the most Gram-negative bacilli isolated from patients affected by 12 May 2008, Wenchuan County, Sichuan, China earthquake [26]. Tao et al. (2009) also conducted a study on some victims of Wenchuan County. The most frequent pathogens isolated were *E. coli*, *A. Baumannii, E.cloacae,* and *P. aeruginosa* [27].

Other important waterborne pathogens: Legionella spp., Enterococci spp., Aeromonas spp., Bacillus spp., Burkholderia Pseudomallei, Klebsiella spp., Campylobacter spp., and *Yersinia spp*. are other important potential pathogenic agents for drinking water sources [32].

The prevention and control measurements

After the flood, the earthquakes have the most natural disasters, which lead to the spread of potentially infectious pathogens [33]. The earthquake disasters have been reported to many concerns in both undeveloped or developed countries [34, 35]. The previous experiences have been shown that the people of disaster-affected areas extremely affected by infectious agents [36]. Therefore, prevention of infections occurs among victims must be considered as an important topic after earthquakes [35]. It is worth noting that waterborne infections were sometimes responsible for two folds fatalities in compare to the disaster itself [37, 38], which causes important concerns for the WHO [39].

The initial proceeding

After earthquakes, building collapse and traumatic injuries are the main reasons for losses [40], while the outbreak of infectious diseases is known as the second reason for increasing victims. We have to initially habitant people in shelters and control population migration [41]. Thereafter, we must apply other measurements to prevention waterborne infections outbreaks in the disaster-affected areas.

Site planning

We must try those disaster-affected people not transfer to elsewhere. It is worth noting that crowding can lead to unsanitary conditions, increases multiple contacts, and an outbreak of pathogens [42, 43]. Each person must have 3 m2 space, and one latrine for every twenty persons is necessary [44], nobody drinks from non-drinking waters and the minimum water reserve for each person must be 20 liters per day [33]. The water supplies should be protected from contamination by distinct from the latrine (about 100 m) and chlorination [38].

Handling corpus

The body dead handling and burial is very important to the prevention of infectious disease outbreaks. Surprisingly, in some countries (such as India and Bangladesh) somebody deadfall into the rivers, which causes a reservoir for waterborne pathogens [45]. Sometimes, the body dead cremation is only a suitable way in some heavy disasters with high victims. It is showed that body dead (human or animals) can infect by cholera, shigellosis, hemorrhagic fever and other infectious diseases. Moreover, the personal protection should be done by gloves, body bags, disinfection of equipment and vehicles or body dead disinfection before the burial [33, 46].

Personal hygiene

Personal hygiene is very important in the prevention and control of waterborne infections [41, 47]. Hand washing should be done especially "before" the food eating, contact to patients or "after" the going to latrine and bathroom, contact to patients, handling garbage, animal or waste [42, 47].

Rapid identification of pathogenic agents

The conventional diagnostic procedures for routine bacterial identification are laborious and time-consuming, especially when samples tested to the presence of multiple different agents. It is worth noting that several modifications have been also descriptive for faster and easier bacterial identification by conventional diagnostic methods [48]. Notably, although PCR and real-time PCR developed as molecular methods, they are also limited in scope and scale for both the number of samples processed and possible pathogens that can be detected. The multiplex PCR/ligation detection reaction (LDR) has been explained as a situating method to provide accurate surveillance of food and waterborne pathogens [49]. The microarray method could overcome the disadvantages described above for diagnostics. Moreover, it is simultaneously able to identify multiple microorganisms in a single sample, and its results are accurate and reliable [32]. Also, numerous biosensors including bioluminescence, impedimetric and piezoelectric (e.g. flow

cytometry, solid-phase cytometry, and electronic nose), and immunological methods based on antigen-antibody reaction (ELISA) have been recently developed [48].

Vaccination

It is clear that people vaccinations the significance prevention of immunization preventable diseases. For instance, cholera vaccination has been recognized as a useful strategy for cholera prevention or control in cholera-endemic areas, especially after earthquakes [10]. Oral cholera vaccine (OCV) was successfully used after the Haiti earthquake in 2010 an estimated 75% risk community received OCV [50]. After the Taiwan earthquake (September 21, 1999), vaccination services applied within one week post-earthquake in the affected areas. Although the incidence of acute respiratory infections and acute gastroenteritis were significantly higher than those in neighboring unaffected areas, no outbreak of vaccine-preventable diseases was reported post-earthquake [18].

Telemedicine

Telemedicine known as the use of telecommunications or other electronic information processing technologies (such as audio, video) to data transmission for diagnosis and treatment of medical conditions, provide health services or help healthcare personnel at distant places (Fig. 1) [51]. Therefore, victims can receive health care in similar quality or sometimes more efficient from the person in the hospital. Also, telemedicine services cause costs decreasing, health outcomes improve as well as facilitates or increase access to different primary and specialty health care. Unfortunately, despite successful experience during the past decade, telemedicine services have been not used in disaster areas [52]. The telemedical services have been used in the disaster area (Miyako Island) of the Great East Japan earthquake on March 11, 2011. In addition to its applications, but finding showed that it still needs further reform in the operability, portability and mobile communication environment [53]. Currently, telemedicine has applications in telenursing, Telepharmac, telerehabilitation, telephone care, Teletrauma care, Tele counseling and E-learning, telepathology, teleradiology, teledermatology, teleradiology, teledentistry, and teleophthalmology [54].

Conclusion

The infectious diseases outbreak after natural disasters commonly occurs, especially in seismic regions. Iran is located in the Alpine-Himalayan seismic belt and considered a seismic country. Therefore, we suggest that planning an infectious disease care program is necessary for decreasing hygiene problems. Importantly, this program must be fast, practical and applicable.

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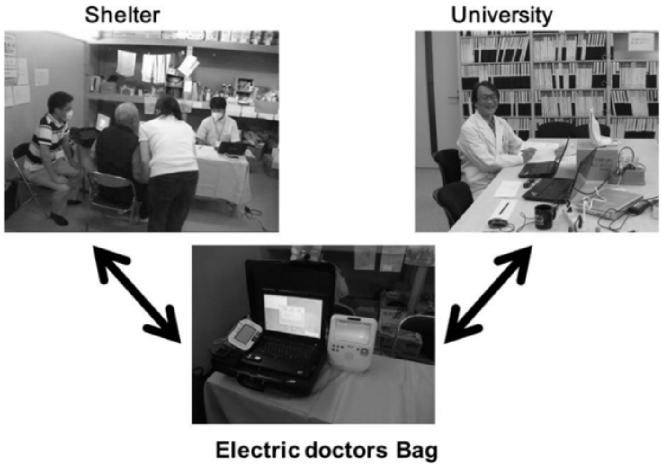

Fig. 1. Clinical application of the telemedicine (shelter: Kesennuma city; university: Tohoku university) [55].

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