Habitat International 44 (2014) 403–411

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Exposure to WASH-borne hazards: A scoping study on peri-urban Ger areas in Ulaanbaatar, Mongolia

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ARTICLE INFO

Article history:
Available online

Keywords:
WASH
Hazards
Sustainable sanitation
Water kiosk
Peri-urban
Health

ABSTRACT

The present scoping study seeks to address the sources of water, sanitation, and hygiene (WASH) exposure of residents of peri-urban Ger areas of Ulaanbaatar, Mongolia. Field observations and semi-structured key informant interviews were carried out during 2012 and 2013 to assess the existing WASH situation in the peri-urban Ger areas of Ulaanbaatar, Mongolia. In addition, a knowledge, attitude, and practice (KAP) survey was conducted by *Action Contre la Faim* (ACF) Mongolia in 210 households to identify the sources of WASH-borne hazards in a statistically representative way. Moreover, the quality of drinking water was analyzed both at the household ($n = 210$) and water point (kiosk) ($n = 40$) levels to assess the risk of chemical and pathogenic contaminants. Both field observations and interviews revealed that the sanitary environment of the Ger residents is characterized by the lack of a drainage system, unimproved sanitation technology (e.g. unhygienic pit latrines and soak pits), unsafe water supply, and insufficient collection, transportation, and storage mechanisms. Poor infrastructure is associated with low standards of living. The transmission of WASH-borne disease (e.g. diarrhea, dysentery, hepatitis A) is the gravest consequence and source of hazards. The results from the water quality analysis demonstrate that Ger residents are more exposed to biological contamination of stored drinking water by *Escherichia coli* during the summer (May to August) than in the winter (November to February). During the winter, 36% of household storage containers were contaminated by *E. coli* at an average level of 12.5 *E. coli* per 100 ml, while, during the summer, 56% of household storage containers were contaminated at an average level of 50 *E. coli* per 100 ml. KAP surveys further reveal that the common practice of Ger residents to discharge greywater (with higher chemical oxygen demand) into pit latrines, soak-pits, yards, and streets likely causes environmental pollution and health hazards. Multifaceted WASH-borne exposure was addressed by the scoping study such that various WASH interventions could be planned for the study area and beyond. To tackle the above challenges and problems, a range of appropriate interventions and programs are recommended to reduce the exposure of WASH-borne hazards in the study area and other parts of the world – in both urban and peri-urban settings. The recommendations include: the development and implementation of a water safety plan (WSP), an effective monitoring system for collection, transportation and storage at both water kiosk and household levels, user training for correct use of water containers, effective coordination among stakeholders (including urban planners), development of a household greywater disposal system, and implementation of a functioning solid waste management system. Prior to taking these actions, a detailed study on the 'pollution load from peri-urban to urban' should be carried out to assess the WASH-borne vulnerability of both peri-urban and central urban population.

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http://dx.doi.org/10.1016/j.habitatint.2014.08.006
0197-3975/

Introduction

At present, water, sanitation, and hygiene (WASH) is a global concern and priority area in the international development sector (Dalton, Bendall, Ijaz, & Banks, 2008; Mara, 2003; UN, 2013). Although the Millennium Development Goals (MDGs) include improved drinking water supply, water quality and safety are still very precarious in many regions of the world. Globally, 748 million people still rely on unsafe drinking water sources such as rivers, streams, ponds, unprotected open wells, and poorly protected springs. In addition, even some populations who are using "improved" drinking water sources are not consuming safe water (UN, 2014). Improved sanitation facilities for one billion people need to be ensured by 2015, in order to meet the sanitation target set by the Millennium Development Goals (MDGs) (UN, 2013). In 2002, WASH-related deaths and disabilities occurred globally among children 14 years old and younger at rates of 25% and 22%, respectively (WHO, 2008b). Poor sanitation accounts for the death of a child every 20 s, including the 88% of deaths caused by diarrheal disease and insufficient access to sanitation. The United Nations estimates that good hygiene and a safe water supply could save 1.5 million children a year (UN WATER, 2013).

The safety and accessibility of drinking water are major concerns worldwide. Production and consumption of water contaminated with infectious agents, toxic chemicals, and radiological hazards increase both public health and environmental health hazards, particularly in low income countries (Craun, Hubbs, Frost, Calderon, & Via, 1998; Nelson & Murray, 2008; WHO, 2013). It has been evidenced that global incidence of WASH-borne illness, particularly cholera, has increased by 130% from 2000 to 2010 (UN, 2013). Oftentimes, WASH-borne illness results directly from the exclusion of the urban poor in national WASH policy, planning, and intervention processes. One of the root causes of this exclusion has been the long-standing inability of utility and city managers and their advisors to plan and implement water and sanitation systems, which respond to the realities faced by the urban poor (Evans, 2007). Both surface and groundwater sources can be polluted by lack of sanitation facilities, indiscriminate disposal of waste, and the lack of good governance surrounding the provision of sanitation services (Palamuleni, 2002). In many parts of the world, disparities in access to WASH solutions often stem from socioeconomic or geographic differences, such as 'urban vs. rural', 'urban vs. peri-urban', 'rich vs. poor', 'homeless vs. non-homeless' and 'majority vs. minority' (Rheingans, Cumming, Anderson, & Showalter, 2012; UN, 2014). In both urban and peri-urban settlements, including slums, provision of sanitation services from the government is absent or altogether ignored, particularly in low- and middle-income countries (Scott, Cotton, & Khan, 2013; UN, 2014; Winters, Karim, & Martawardaya, 2014). Mongolian peri-urban areas are no exception to this kind of attitude adopted by the government.

The present study was conducted in the peri-urban Ger areas (i.e. informal settlements) of Ulaanbaatar, Mongolia during the period of September 2012 to July 2013 under an ongoing research project jointly executed by *Action Contre la Faim* (ACF) Mongolia and University of Science and Technology Beijing and funded by ACF International in France. The paper predominantly focuses on discussing the main sources of exposure to WASH-borne hazards. The possible solutions/interventions presented herein aim to reduce the exposure to WASH-borne hazards in the study areas and can ideally be replicated in other parts of the world, especially in urban and peri-urban areas, to tackle the global challenges (Moe & Rheingans, 2006) in water, sanitation and health sectors.

WASH-borne hazards and exposure

Over the past few decades, 'hazards' have been addressed, defined and characterized in a wide array of fields, including climate, health, environment and disaster studies (see for instance, Dewailly, Poirier, & Meyer, 1986; Evans, Ribeiro, & Salmon, 2003; Kjellstrom et al., 2007; Riebsame, Diaz, Moses, & Price, 1986; Terblanche, 1991). CCOHS (2009) defines a hazard as 'any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work'. In the context of disasters, Wisner, Gaillard, and Kelman (2012) refer to 'specific natural processes and events that are potentially harmful to people and their assets and disruptive of their activities (Wisner et al., 2012). Similarly, UNISDR (2009) considers that a hazards is ' a dangerous phenomenon, substance, human activity or condition that may cause the loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption or environmental damage'. In the particular context of WASH, hazards include 'harmful substances (physical/chemical/biological) that originate from the absence/lack/failure of water, sanitation and hygiene interventions/programs/policies and cause loss of life, disability, other health impacts, socio-economic loss, or environmental bane' (e.g. Hutton & Haller, 2004; Kulshrestha & Mittal, 2003; Montgomery & Elimelech, 2007; Pruss-Ustun, Kay, Fewtrell, & Bartram, 2004; Terblanche, 1991; WHO, 2008b).

On the other hand, 'exposure' includes "people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses" (UNISDR, 2009). Numerous pathways of exposures to both biological and chemical contaminants have been identified in freshwater and food, which may increase waterborne infections as well as fetal and infant death in many parts of the world – most notably low-income countries (Abhirosh, Sherin, Thomas, Hatha, & Abhilash, 2010; Milton et al., 2005; Montgomery & Elimelech, 2007; Pruss, Kay, Fewtrell, & Bartram, 2002; Rahman, Asaduzzaman, & Naidu, 2011; Suk, Murray, & Avakian, 2003). The exposure pathways include, for instance, air and water systems, soil, sewage, and food, among other indirect forms of contact. These studies are important; and greater efforts are needed to reduce exposure to both WASH and health hazards (Lioy et al., 2005; Steinemann, 2004). To this end, the exposure science should be considered widely to reduce or prevent exposures to WASH-borne hazards for all groups, without any disparities, and by adopting a bottom-up approach.

When public health and WASH are intertwined, comprehensive WASH-borne hazard analyses can be conducted. As early as the nineteenth century, John Snow (1855) defined water as a "vehicle of disease transmission". It is indeed said that drinking water is a major source of microbial pathogens in low-income countries, while poor WASH accounts for millions of deaths every year (Ashbolt, 2004). Lack of access to potable water, poor quality of water, absence of sanitation facilities, lack of hygiene practices, and environmental factors are all considered as possible causes of waterborne diseases due to microbiological and chemical hazards (Aiello, Coulborn, Perez, & Larson, 2008; Ako, Nkeng, & Takem, 2009; Pruss-Ustun et al., 2004; Terblanche, 1991). As a result, addressing WASH-borne hazards is urgently needed to protect affected populations from various kinds of chemical and pathogenic contaminants. Fig. 1 summarizes factors which significantly increase WASH-borne hazards. Lack of access to proper WASH facilities and lack of resources (e.g. income) likely reduce capacities to tackle WASH-borne hazards, while increasing exposure to WASH-borne hazards and threats. Alwang, Sigel, and Jorgensen (2001) addressed the poor and near-poor as vulnerable groups due to their inferior access to resources and limited abilities to respond to hazards.

WASH situation in Mongolia

Mongolia, a landlocked nation bordered by China and the Russian Federation, has an estimated population of 3.2 million (CIA, 2013). The country boasts the coldest capital city in the world with an annual mean temperature of −3.7 °C and a harsh climate with low precipitation (approximately 200 mm/year) (Altansukh, 2008; Hauck, 2008).

Ulaanbaatar, the capital of Mongolia, has a population of over one million people and is experiencing an influx of migrants from rural areas resulting in many environmental, health, and socio-economic problems. Forest fires, floods, waterborne disease, unsafe water supply, inadequate sanitation, insufficient heating, absence of suitable roads, high concentration of uranium in groundwater, wetlands and river pollution due to industrial and agricultural pollution, untreated wastewater from the city's sewage treatment plants, and heavy metal pollution in the soil (arsenic and lead) are amongst the greatest challenges faced in the capital (Altansukh, 2008; Asian Development Bank, 2010; Batjargal, Otgonjargal, Baek, & Yang, 2010; Itoh et al., 2011; Nriagu et al., 2012; Sigel, Altantuul, & Basandrorj, 2012; Uddin, Li, Mang, Huba, & Lapegue, 2014).

Mongolia, one of the world's fastest growing economies (BBC, 2014; The Diplomat, 2013; The Economist, 2013), is, unfortunately, not "on track" to meet the sanitation targets set by the Millennium Development Goals (MDGs) (UNESCAP, 2011; UNICEF & WHO, 2012). A majority of the population – particularly in the Ger areas of Mongolia (peri-urban unplanned informal settlements that surround the city) – employ unimproved and unhygienic sanitation technologies to solve sanitary problems, most notably unimproved pit latrines (Sigel et al., 2012; Uddin, Li, Mang, Huba, et al., 2014). In urban Mongolia, the coverage of piped and improved water supply is supposedly 100% (illustrating that Ger areas are not considered "urban" and highlighting the longstanding strategic issue of using the Joint Monitoring Program (JMP) as a baseline for peri-urban development projects). Sanitation coverage in urban Mongolia is 64%, which is considered improved, while the remaining 36% accounts for unimproved sanitation (UNICEF & WHO, 2012).

This study was conducted in the peri-urban Ger areas of Ulaanbaatar, Mongolia (Fig. 2). Much of the population in the capital and its surroundings inhabits Ger areas. Ger areas comprise over half of the total population of Ulaanbaatar and are increasing rapidly (i.e. "urban sprawl") (Sigel et al., 2012). Unlike their urban neighbors that occupy apartments and homes built on formal sites, Ger area residents live in felt tents or yurts ("Gers"). Recent research indicates that there is some modernization occurring in the Ger areas, mostly in terms of housing and food habits.

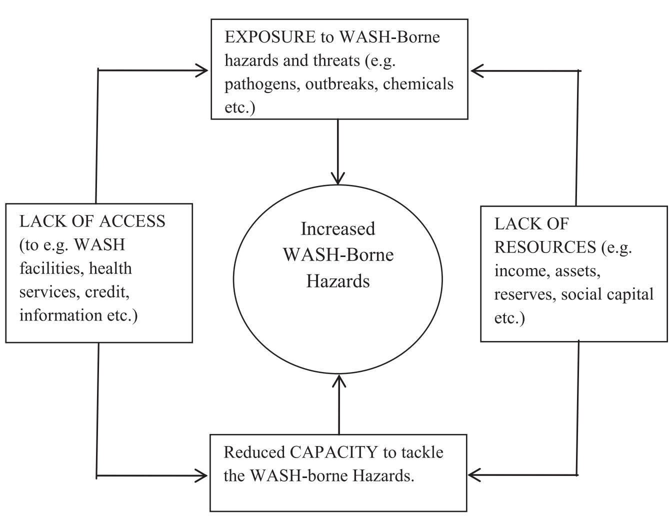

Fig. 1. Factors leading to increased WASH-borne hazards. Adopted from Wisner, 1996.

Materials and methods

Drinking water quality was analyzed to assess the chemical and pathogenic contamination to envisage the possible vulnerability of the health hazards of the Ger residents. A total of 250 water samples were collected by ACF Mongolia through random sampling, including from 210 households and 40 water kiosks from the Ger areas during the winter period of December 2012 and January 2013. Additionally, a similar quantity of samples was analyzed in the summer period of May and June 2013 to compare the seasonal state of water quality both at the household level and at water kiosks. All of the water samples were analyzed by the National Accredited Professional Inspection Central Laboratory of Ulaanbaatar in Mongolia. Three parameters were analyzed: biological *Escherichia coli*, chemical hardness, and pH, in order to identify drinking water contaminants and their sources. Furthermore, greywater generated from households was tested to ascertain chemical characteristics, which might have additional impacts on human health and environmental conditions in Ger areas (Uddin, Li, Mang, Ulbrich, et al., 2014).

In addition, research based on field observations was carried out by transect walks, which involved community members and key informants through the area from one side to other, observing, asking questions, and listening (Kar, 2005). Five transect walks were carried out in five different geographic areas with key community actors and ACF Mongolia WASH team members to characterize WASH and environmental conditions. The observations revealed implications of solid waste dumping, greywater discharge, toilet conditions, availability of water near toilets for handwashing, water collection systems, water storage systems at the household level, heating systems, and both indoor and outdoor air emissions.

In addition, five community-based representatives, five NGO officials, two doctors, three healthcare officers, and three university faculty members were chosen as key informants for interviews to ascertain the major sources of WASH-borne hazards in the Ger areas. Community-based leaders proved very knowledgeable about WASH-related issues, including health implications.

Fig. 2. Ger areas of Ulaanbaatar (Field Survey, Uddin, July 2013).

Fig. 3. Water kiosk, container, and trolley used for water collection and transportation in the Ger areas (Field Survey, Uddin, July 2012 and November 2013).

Representatives from ACF Mongolia, World Vision Mongolia, UNICEF Mongolia, ECO TV, and district health offices were considered key informants for a comprehensive diagnostic of the WASH situation in the area of interest and, moreover, to conceive of possible solutions to solve principal WASH-borne challenges. In addition, three faculty members from the Mongolian University of Science and Technology, Mongolian State University of Agriculture, and the National University of Mongolia were interviewed to inform proper solutions for reducing WASH-borne hazards in the study area.

A WASH-focused knowledge, attitude, and practice (KAP) survey, which serves as an educational diagnostic of the community, was also conducted by ACF Mongolia at 210 households in Ger areas at the end of 2012. Multiple choice questions where more than one answer could be chosen were asked to the respondents. The sites selected for the KAP survey are the Ger districts of Ulaanbaatar where the current ACF WASH program is being implemented. Intervention areas were selected based on several factors, such as population density, poverty level, and water and sanitation accessibility. The cluster sampling method was applied, due the large population size and scattered households in the intervention area. According to ACF & WHO sampling standards and methodology (Henderson & Sundaresan, 1982) – where a statistical accuracy of 10% precision is preferred – the total sample required was 210 households. Households were randomly selected for interviews in each residential cluster. The questions developed covered a range of topics related to domestic water, sanitation and hygiene practices, family health status, and waterborne disease transmission.

Moreover, an observational study and structured survey were carried out by ACF Mongolia with students and teachers from eights schools (three primary schools, three middle schools, and two high schools) to assess WASH conditions in schools. One hospital in the Ger area was likewise subjected to an observational study and semi-structured key informant interviews to gain further insight into hygiene issues and practices.

Water supply related hazards

Water supply in the Ger areas

Results from the KAP survey indicate that water kiosks (Fig. 3) account for the main source of water supply for both drinking and non-drinking purposes in the peri-urban Ger areas for the majority of respondents. Some water kiosks are connected to the central water supply network, while others are fed by water tank trucks managed by the Ulaanbaatar Water Supply and Sewage Authority (USUG). Other sources of water, such as unprotected private boreholes and springs, are also used by some of the respondents: 15.4% of respondents reported using private boreholes, while 2.5% of interviewees reported using spring water. The use of plastic containers is almost exclusively used for the transportation (94.3%) and storage (92.4%) of water.

Presently in Mongolia, coordination between stakeholders from the government and civil society is weak, especially with regards to solving environmental sanitation challenges in peri-urban settings. The present approach is centralized and functions at a very slow pace. The government aims to provide a centralized system for 40% of the population by 2015. There currently is no policy to encourage a decentralized system. In the Ger areas, water kiosks are the only way to access water for drinking, cooking, and cleaning purposes. The water kiosks can either be fed from a central water connection or by water tanks. Water in the Ger areas is mainly provided by approximately 550 public water kiosks, where the average water consumption is 10 L/person/day (World Bank, 2010).

Unsafe water supply and storage

The results from the water quality analysis show higher contamination in the summer than in the winter. However, the contamination in both seasons does not meet the Mongolian drinking water quality standard (MNS ISO 4697-1998: drinking water should not contain *E. coli* bacteria levels that exceed WHO 2008 guidelines for drinking water) (WHO, 2008a). The water quality analysis (Table 1) conducted in the winter illustrates that 36% of drinking water samples taken at the household level was contaminated by *E. coli* with low-to-high levels of health risks. The average number of *E. coli* in the contaminated drinking water samples was 12.5 ml per 100 ml, with a range of 1–52 ml. There were two water kiosks out of 40 total sampled that were found to be contaminated by *E. coli* during the winter. To show the contamination of households around the contaminated water kiosk, 6 samples were collected and tested, showing that the drinking water of all households was contaminated at levels as high as 31 *E. coli* per 100 ml.

On the other hand, summer analysis of the drinking water of similar households shows that over half of the samples were contaminated by *E. coli* with an average of 50 *E. coli*/100 ml of drinking water. There were five water kiosks found to be contaminated among the 40 samples, two of which were highly contaminated by *E. coli*: 120 and 189 *E. coli*/100 ml water. The sources of the above contamination at the household level may be due to the collection and transportation processes from the water kiosks using low quality containers. Water contamination during the summer is

Table 1
Contaminated drinking water by *E. coli* at the household level.

Season of sampling	Period of sampling	Contaminated households ($n = 210$) 10% precision	% Of households contaminated	Average number of *E. coli*	Range of *E. coli*
Winter	Dec 2012–Jan 2013	76	36	12.5	1–52
Summer	May–June 2013	117	55.71	50	1–404

Fig. 4. Unimproved and unhygienic pit latrines in the Ger Areas (Field Survey, Uddin, April 2012).

much higher than the winter, including at water kiosks. Water kiosk contamination might not only depend on the types of water supply (either piped or tank water supply), but also the maintenance of the pipes and tanks.

KAP survey results shows that 57% of the respondents among the surveyed households do not boil water before drinking, which may very well increase their risk of water-borne disease. Moreover, the majority of respondents use containers that are secondhand, unhygienic, and old for water collection and storage. 79.5% of respondents use secondhand containers to transport water, while 84.3% of respondent use secondhand containers to store water. These unsafe water supply, transportation, and storage practices increase the hazards of the Ger residents to waterborne disease.

Low water consumption and greywater production

Although the UN (2013) suggests that individuals have access to 20–50 L of water daily for drinking, cooking, and cleaning purposes, the average consumption of Ger residents is very low at 10 L/person/day (World Bank, 2010). KAP survey results show that the average consumption is 8 L/person/day, which drops to 4 L/person/day during the winter. There are several factors accounting for low consumption of water in the Ger areas, including distance of water kiosks from households, short period of daily distribution, consumption differences between the winter and summer months, low frequency of bathing outside the compound (public bath), irregular cloth washing, and reuse of water without treatment.

The results from the KAP survey illustrate that 51.4% of households have soak-pits in their compound to discharge greywater, while 40% of households pour greywater into their pit latrines. The rest of the households discharge greywater onto the roads, in yards, or in other places. Ger residents frequently discharge their greywater into pit latrines, soak-pits, yards, and on open streets, which causes immediate environmental pollution and health hazards due to high concentration of chemical agents in the greywater. In the warmer months, the same practices lead to even greater environmental degradation, as well as favorable conditions for vectors to breed (Uddin, Li, Mang, Ulbrich, et al., 2014; WHO, 2006).

Sanitation hazards

Unimproved sanitation technologies

A range of sanitation technologies that are not recognized as improved sanitation technologies, such as unimproved pit latrines (Fig. 4), soak pits for greywater discharge, and unplanned sites for solid waste disposal have been identified in the Ger areas. Over 80,000 pit latrines were estimated to solve the majority of sanitation problems, yet most of the technologies are unimproved and unhygienic due to the low maintenance, technological drawbacks, and poor quality. As a result, users are often exposed to contact with pathogens that result from the contamination of groundwater sources (Girard, 2009; Palamuleni, 2002).

The KAP survey illustrates that 96.7% of respondents use domestic and shared pit latrines, which are categorized as “unimproved sanitation facilities”. The rest of the respondents use public toilets, a neighbor's latrine, “ecosan” toilets, and/or open defecation. Common problems encountered with the current toilets are pit filling (43.1%), odor (41.1%), cold conditions (26.3%), flies (21.5%), and safety of use (17.2%) (15.3% of respondents said there were no problems).

No drainage system

During the rainy season, the lack of a proper drainage system results in frequent flooding. The problem is exacerbated by the fact that Ger residents often dispose of garbage in flat areas, which are often subject to the flooding. Exposure to waste-borne contaminants further exposes residents to pathogens. Moreover, the high concentration of household wastewater draining to yards, roads, and areas surrounding housing compounds also create health and environmental hazards for residents (Uddin, Li, Mang, Ulbrich, et al., 2014). A failure on the part of the government to invest in the infrastructural development of Ger areas makes these challenges even harder to combat.

Traditional heating system and environmental pollution

The Mongolian winter is very harsh with temperatures dropping to −40° C (Manaseki, 1993). Ger residents do not possess central heating and instead use traditional systems of coal and wood burning. Low quality coal burned for heating in the winter accounts for 77% of total air pollution, which has additional adverse health impacts (World Bank, 2009). The Ger residents dump ash from combustion outside (e.g. yards, streets), which may be a source of arsenic and other heavy metal contamination in the soil in Ulaanbaatar and its surrounding peri-urban settlements (Batjargal et al., 2010)

Unplanned solid waste management

Ulaanbaatar is facing multiple problems, due to an unplanned solid waste management system that is particularly pervasive in Ger areas. Average solid waste generation is 0.956 kg/capita/day, which is over four times that of the main city with predominantly tenement housing (Batsuuri, 2010). The city has been facing serious problems associated with solid waste output due to the increasing number of migrants moving to urban areas and their increasingly consumptive lifestyles (MNEC, 2011). Illegal dumpsites are a common feature in Ulaanbaatar, particularly in the Ger areas, due to the infrequent household collection, lack of central collection points, poor education of the Ger inhabitants, and very few landfills in urban and peri-urban settings (Altantuya, Zhang, & Li, 2012; The Asia Foundation, 2014). There are some open fields which have been considered as unplanned disposal sites; and these fields are highly hazardous for hundreds of scavengers (people who scavenge recyclable wastes) living near the areas (Altantuya et al., 2012).

In addition, coal ash deposition is a significant concern in the Ger areas where people use coal for heating their Ger houses. During the winter, around 50% of waste generated from ash which are deposited in the environment. These exposures pose severe environmental hazards, exposing residents to many toxic metals released from these ashes. There are several thermal power plants, which also use coal for heating households in the city. The coal ash contains various heavy metals including arsenic (As), which is a significant anthropogenic source of contamination in the environment (Pandey, Singh, Singh, Sing, & Yunus, 2011). In Ulaanbaatar, an average of 260–280 thousand tons of dry waste are produced a year. 40–50% of this waste goes to a dumpsite, while the rest is accumulated in the environment, such as in river basins, Ger areas, and illegal dumpsites. The major composition of the solid waste includes paper (13%), glass (6.5%), plastics (11%), other organic waste (30%), other inorganic waste (36.5%), household hazardous wastes (0.02%), and others (3.0%) (e.g. car parts, metal, healthcare wastes). However, there is no classification system or standard for urban waste. Most households, enterprises and industries including governmental organizations, dispose of waste without any classification (Altantuya et al., 2012; Serrona, Yu, & Che, 2010; Shinee, Gombojav, Nishimura, Hamajima, & Ito, 2008; WHO, 2005). The Master Plan for Solid Waste Management has been implemented by the Municipality of Ulaanbaatar since 2007 with technical support from Japan International Corporation Agency (JICA). In addition, solid waste processing and recycling factories are included in the Urban Development Master Plan 2030 (Ministry of Construction and Urban Development, 2013). However, the plan does not include the communities who are informally collecting and recycling waste, who should be protected from dangerous and poisonous wastes. There is still much need for an action plan and policies pertaining to: recycling solid waste for resource recovery, improved environmental and health protection, and the wellbeing of communities who informally collect waste. The key informant interviews show that the solid waste collection system is fairly irregular in the Ger areas, which causes waste to accumulate in the yard or roads and can affect the human and environmental health systems. Key informant interviews with doctors revealed that the hazardous WASH situation, particularly due to biological and chemical contaminants in surrounding peri-urban Ger and mountainous areas, may have potential to harm the population living in the central urban areas due to rainfall, flooding and runoff during the summer months.

Hygiene and wash-borne hazards

Unhygienic practices at home

KAP survey results show that 52.4% of respondents wash their hands after engaging in unsanitary activities, 36.4% after changing diapers, 27.7% before cooking, 23.3% before eating, and 20.9% after defecating. Among the respondents who wash their hands, 33.8% do not use soap, whereas 56.7% use soap during hand washing. Engaging in unhygienic practices significantly increases vulnerability to human health hazards. When respondents' were asked if water could transmit diseases, 52.4% replied yes, 15.7% replied no, and 31.9% replied that they did not know.

Unhygienic practices in schools

There were several challenges that were revealed from the study conducted in schools in the peri-urban settlements of Ulaanbaatar, including the lack of appropriate WASH facilities, unavailability of soap, and inadequate hygiene promotion among students. The survey results among the school students show that 59% of students do not wash their hands, 34% wash their hands with water only, and 5% wash with water and soap, bringing their own soap from their homes.

Unhygienic practices in hospitals

Hospitals are particularly sensitive areas where proper hygiene practice, safe water, and proper sanitation facilities should be considered to further reduce risk of infection. The results of the hospital study in the Ger areas revealed that no soap is provided for washing hands inside the hospital, including in bathrooms. A key informant interview with a doctor revealed that most of the patients affected by diarrhea and dysentery are children under five years of age, the majority of which visit the hospital frequently (once or twice in a month) for treatment. Public health data, particularly in Ger areas, is not available. National health statistics gathered at the district and national levels do not separate Ger areas, making comparisons between Ger areas and other urban areas difficult (GoM, 2011).

Ways forward to reduce WASH-borne hazards

There are various interventions and initiatives around the world that are considered effective ways to reduce WASH-related risks. Effective preventative measures are considered to be at the heart of proper risk management, with a focus on providing safe drinking water (Hrudey, Hrudey, & Polland, 2006). A systematic review has been done by Fewtrell et al. (2005); and all of the intervention studies were found to significantly reduce the risk of diarrheal illness with a similar degree of impact. Less *E. coli* contamination of stored water and a lower incidence of diarrhea were found in the households benefitting from 'point-of-use' water treatment versus households serving as controls (Quick et al., 1999). Some studies show that providing both toilets and safe water supply systems can reduce the incidence of cholera by as much as 76% (Azurin & Alvero, 1974). Aiello et al. (2008) shown that hand-hygiene practices alone can reduce the incidence of gastrointestinal disease by 31%, thereby illustrating the effectiveness of hand washing in preventing gastrointestinal illness. Likewise, Cairncross et al. (2010) show that hand washing with soap can reduce the risk of diarrhea up to 48%. Adequate practices of environmental sanitation can reduce incidences of pathogen-positive diarrhea among children by 40% (Baltazar et al., 1988). In addition, raising public awareness and conducting systematic monitoring are often recommended as ways to reduce exposure (Steinemann, 2004). Even when dealing with a good sanitation system, which isolates fecal matter from the human environment, other interventions must be simultaneously implemented to prevent other exposure pathways (Garrett et al., 2008; VanDerslice, Popkin, & Briscoe, 1994). For example, combined use of chlorinated stored water, latrines and rainwater may significantly decrease diarrheal risk (Garrett et al., 2008). All of the aforementioned findings are applicable to Mongolian Ger settlements and should be used by policymakers to inform WASH policies and reduce WASH-borne hazards.

Fig. 5 shows the link between sources of WASH-borne hazards and possible interventions and solutions that could be

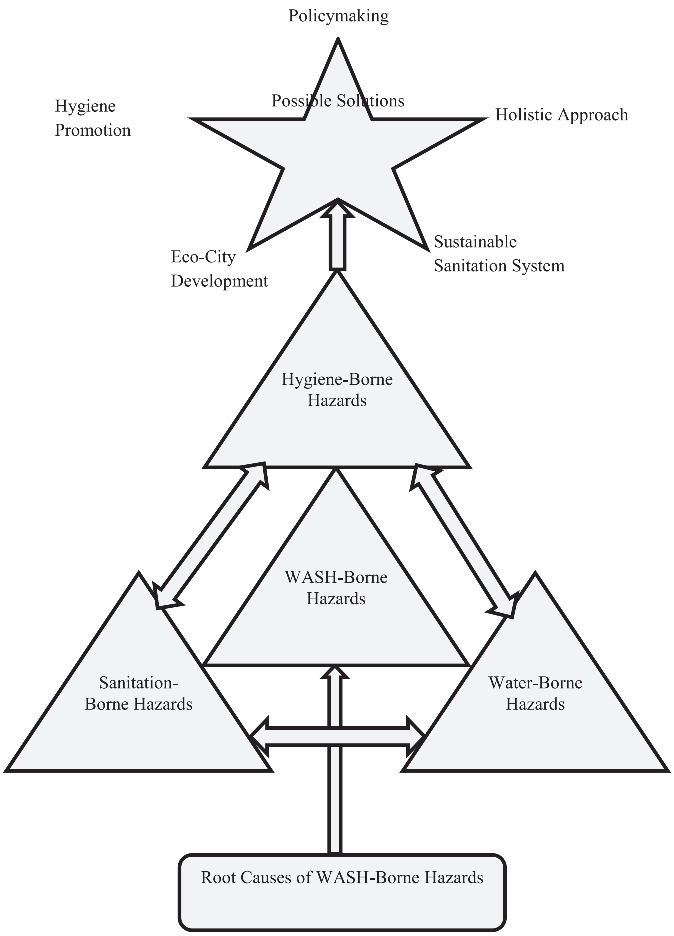

Fig. 5. WASH-borne hazards and possible solutions to reduce hazards.

implemented to reduce them. Strong WASH-related policy making and enforcement would greatly improve environmental health in Ger areas. A holistic/integrated approach to safe water supply and sustainable sanitation practices has the potential to prevent exposure to dangerous contaminants (Uddin, Li, Mang, Huba, et al., 2014). Various media and communication tools and techniques can be used to increase communities' awareness of good hygiene and sanitation practices to reduce exposure to WASH-borne hazards in households, hospitals, and schools. These initiatives will activate the process towards ecological urban development, which, in turn, may reduce WASH-borne hazards in Ger areas. Environmental regulation alone cannot ensure the prevention of hazards nor reduce exposures (Steinemann, 2004). However, a holistic approach to safe water supply and sustainable sanitation systems – coupled with the introduction of appropriate policies and regulations – may reduce WASH-borne hazards (SuSanA, 2014). Scaling up of sustainable sanitation technologies may reduce WASH-borne diseases significantly (Anand & Apul, 2014; Uddin, Li, Mang, & Lapegue, 2014; Uddin, Muhandiki, Fukuda, Nakamura, & Sakai, 2012). Proper sanitation and awareness campaigns are other essential components to encourage appropriate hygiene practices in the school, hospital, and household settings. Innovation in sustainable sanitation through resource/nutrient recovery from organic waste – including human waste – also contributes to preventing WASH-borne hazards. Finally, in order to be sustainable, sanitation systems have to be economically viable, socially acceptable, technically feasible, and eco-friendly (Uddin, Muhandiki, Sakai, Mamun, & Hridi, 2014).

The current study addresses multidimensional problems associated with WASH and exposure risks present in peri-urban areas of Ulaanbaatar, Mongolia. The study revealed that poor infrastructure in the peri-urban settlements is highly correlated with a low standard of living. The transmission of WASH-borne diseases is the gravest human health hazard the study area, which is likewise the case for many low- and middle-income countries in urban and peri-urban settings. Summer is a more hazardous season, as biological pathogens proliferate much faster in summer conditions, thus significantly increasing people's personal exposure levels. To tackle these challenges and problems, a range of appropriate interventions are recommended to reduce the exposure of WASH-borne hazards in the study area and other parts of the world with a comparable context. The development and implementation of a water safety plan (WSP) and effective monitoring system for collection, transportation and storage at both the water kiosk and household levels are essential to protecting water from both biological and chemical contaminants. Unprotected private boreholes and springs should also be considered in the WSP. The users of water containers should be oriented through awareness-building and educational activities on washing and hygiene practices for water collection and transportation from water kiosks and storage at the household level. Effective coordination among stakeholders, including urban planners, may be useful to tackling WASH-borne hazards in an integrated manner. An appropriate water kiosk operational monitoring system should be developed to supply water to communities for a longer period of time and during both summer and winter months. Household greywater disposal should also be planned so as to protect both human and environmental health from chemical and biological contaminants (Uddin, Li, Mang, Ulbrich, et al., 2014). Due to the absence of a drainage system, appropriate decentralized solutions are encouraged to avoid high costs associated with conventional sewage system implementation. An appropriate solid waste management system based on the 3R system (i.e. reduce, reuse and recycle) would improve environmental health in the study area and beyond. Moreover, improving the WASH situation in peri-urban Ger and mountainous areas will ultimately protect communities in the urban center of Ulaanbaatar from runoff water containing both biological and chemical contaminants. A detailed study on the 'peri-urban-to-urban' context is proposed to assess the WASH-borne pollution load/mobilization from peri-urban to central urban areas. More specifically, the study will shed light on waterborne pollutants' modes of action, as well as help to characterize the vulnerability of populations in both peri-urban and urban areas.

Acknowledgments

Support from different departments at ACF Mongolia and ACF France are acknowledged.

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