AMERICAN UNIVERSITY OF BEIRUT

EFFECTIVENESS OF WASH INTERVENTIONS IN PUBLIC SCHOOLS OF BEIRUT

by
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AN ABSTRACT OF THE PROJECT OF

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WASH services were assessed in 15 out of 19 public schools of Beirut implementing WASH intervention mostly as of 2012-13. Results of the school survey were compared with WASH guidelines to assess compliance. Moreover, findings from the WASH intervention schools were compared with the mean values for Beirut public schools reported by the national school survey 2008-09 to determine improvements in WASH services. Additionally, the schools' water supplies were screened once (June 30, July 1 2015) to determine the physical (color, turbidity, Electrical conductivity, and TDS), chemical (pH, alkalinity, hardness, ammonia, nitrates, chlorides, sodium, sulfates, phosphates, and residual chlorine) and microbiological (total and fecal coliforms) quality. The quality of the water supplies was compared to WASH guidelines and LIBNOR standards to determine compliance and accordingly safety.

Results showed that the major interventions in public schools implementing WASH related mostly to installing FDA approved water storage tanks that safeguards water quality and prevent corrosion and leaching of chemical contaminants. Additionally, onsite water treatment units have been installed in 93.3% (14 schools) of the surveyed schools and 86.7% (13 schools) have onsite UV disinfection units (UV filter). Water quality assessment of samples collected showed that 20% of the schools' water supplies have a high total dissolved solid content exceeding WASH Guidelines and LIBNOR Standard Levels. And, 26.7% of water supplies are microbiologically unsafe. This contributes, and is line with, the reported water complaints relating to water "taste" (high TDS) and safety. Additionally, the number of functional water fountains and basins are not sufficient and need to be increased to meet WASH guidelines. Hot water is not available in any of the schools; while soap is provided in 46.7% (7 schools) of schools and tissue paper in 20% (3 schools) of schools, and 86.7% of schools (13 schools) placed posters that teach students the importance of personal hygiene.

Hence, the implemented WASH interventions are not fully incompliance with WASH guidelines and are not sufficient to address the water, sanitation, and hygiene challenges in public schools. The Ministry of Education and Higher Education should assume ownership of the program to insure the sustainability of WASH services. Financial and technical support should be provided and a surveillance system to monitor, evaluate, and guide public schools should be established. Moreover, the role of the NGOs in supporting WASH interventions is critical and should be clearly defined.

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CHAPTER 1

INTRODUCTION

Safe water supply, sanitation and hygiene (WASH) are essential to children's health and development (Reeves, Priest, & Poore, 2012). Several studies in developing countries revealed that the probability for school children to acquire infections in dense urban areas is higher because two-thirds of the schools lack adequate WASH services (Babalobi, 2013; Sibiya & Ray Gumbo, 2013). Around 1.8 million mortalities occur globally each year from diarrheal illnesses, 1.62 million (90%) of which occur among children; 88% of these cases result from unsafe water supply and inadequate sanitation services which increased the economic burden on families and societies due to tertiary health care costs (Adams, Bartram, Chartier, & Sims, 2009).

Inadequate water supply and sanitation services in schools are increasing the risk of children's exposure to gastrointestinal infections such as diarrhea disrupting student's attentiveness and productivity (Jasper, Le, & Bartram, 2012). The proportion of the reported death attributed to unsafe water supply, inadequate sanitation, and poor hygiene in children under 14 years of age is more than 20% (CDC, 2013). Their vulnerability is mainly due to their underdeveloped immune response against pathogens and lower body weight, inducing immediate infections at low dose.

In the effort to reduce preventable water, hygiene and sanitation related diseases, the United Nations Children's Fund (UNICEF) in collaboration with non-profit organizations, namely World Health Organization (WHO) and Save the Children initiated WASH (water supply sanitation and hygiene) program in schools. WASH program aims to protect children's right to survival and development by insuring equitable access to safe water and use of sanitation services, improving hygienic behavior through education and creating a supportive environment. This enables children to "become agents of change for improving water, sanitation and hygiene practices in their families and communities" which will ultimately reduce microbial contaminations and prevent infectious disease transmission among students and staff (UNICEF, 2012).

Studies done in Kenya in 2008 showed that schools with adequate water supply, hygiene education, and sanitation services showed lower rates of reported illness-related absence by 20 to 51% compared to schools with inadequate water supply, hygiene education, and sanitation services, which witnessed an increase in the school absenteeism by 5% (Freeman, et al., 2012; Reilly, et al., 2008). According to Center for Disease Control and Prevention (CDC), WASH can prevent 9.1% of global disease burden and 6.3% of mortality cases particularly in developing countries (CDC, 2013). Currently, more than 90 countries are implementing WASH program in schools. However, many developing countries face challenges in managing WASH program sustainably. That is why UNICEF in collaboration with WHO developed guidelines to insure sustainability and continual development of these programs (Adams, Bartram, Chartier, & Sims, 2009; UNICEF, 2008).

WASH programs in schools are one of the pre-requisite steps towards insuring a healthy learning environment. Effective implementation of WASH program in schools requires collaboration between various stakeholders like school management, government, and NGOs. School administrators can work with parents and government officials to raise funds for maintaining clean and functional facilities. School officers can work with teachers and staff to conduct regular evaluation on WASH activities, promote hygiene, while ensuring that water, soap, and toilet paper are continually available (Reeves, Priest, & Poore, 2012). Moreover, teachers can provide knowledge, promote attitudes and develop skills on appropriate hygiene behavior through life skills-based hygiene education and child participation to effectively transform knowledge into practice (Reilly, et al., 2008). Government officials can advocate for WASH programs in parliament to set minimum standards, allocate financial resources, monitor coverage and progress, and increase cooperation and collaboration between relevant ministries such as the ministry of education, and finance to design appropriate measures and enforce them by regularly monitoring and evaluating WASH activities in schools (UNICEF, 2008). Moreover, NGOs and community members can assist in maintaining a clean, safe and healthy school by encouraging children to adopt improved hygienic behavior through various WASH activities.

Lebanon, like many developing countries, faces several challenges in sustaining proper water, sanitation, and hygiene services in schools (UNICEF, 2012). Almost one third (30%) of the public school buildings in Lebanon are owned by the government while 70% are either rented from private owners or provided by NGOs in which case they are not conceived as school premise (UNICEF, 2012). In 2012, effort was made by UNICEF in collaboration with the Swiss Agency for Development and Cooperation and the Education Ministry to develop a guide for WASH program in schools. This guide was designed to spread awareness and improve current water, sanitation, and hygiene services in Lebanese schools (UNICEF, 2012). WASH intervention targeted around 19 public schools in the city of Beirut. However, currently there are no documented studies that assess the effectiveness of WASH program in public schools of Beirut. This information is vital for program improvement especially because insufficient financial and human resources create a need to prioritize interventions especially in medium to low income schools that have limited resources.

This project compared the current WASH services in public schools of Beirut that implemented WASH interventions with WASH guidelines to determine compliance. Moreover, the findings from WASH intervention schools were compared to the mean results of Beirut public schools reported in the national survey of public schools in Lebanon 2008-09 to assess whether WASH services have been enhanced. This would enable relevant stakeholders and policymakers to take the required measures needed to improve and sustain water, hygiene, and sanitation services in these schools.

CHAPTER 2

LITERATURE REVIEW

2.1. Background

Provision of adequate water, sanitation, and hygiene (WASH) services is essential component for children's development. In the effort to reduce preventable water, hygiene and sanitation related diseases, the United Nations Children's Fund (UNICEF) in collaboration with non-profit organizations, namely World Health Organization (WHO) and Water Supply and Sanitation Collaborative Council (WSSCC) launched WASH program in schools, on 16 March 2003, during the third World Water Forum in Japan (UNICEF, 2003). Since schools have an important teaching role in the community, such programs would initiate behavioral changes among children, which in turn, act as a model for communities through outreach activities (UNICEF, 2012).

WASH program in schools aims to protect children's right to survival and development by insuring equitable access to safe water and use of sanitation services, improving hygienic behavior through education and creating a supportive environment. This enables children to "become advocates of change for improving water, sanitation and hygiene practices in their families and communities" which will ultimately reduce microbial contaminations and prevent infectious disease transmission among students and staff (UNICEF, 2012).

WASH access was originally integrated in the Millennium Development Goals (MDGs). The MDGs incorporated fundamental lessons learned from previous decades to meet the target in Goal 7, which aims to half the proportion of people without access to an improved drinking water source or sanitation facilities (UN, 2015). However, in 2012 the Joint Monitoring

Program (JMP) assessment found that more work needs to be done in terms of water quality, quantity, and integrating sanitation and hygiene into sustainable programs to achieve desired health outcomes (Nagpal & Radin, 2014). That is why, the WHO and UNICEF have recommended global priorities for the "next iteration of the MDGs" known as the Sustainable Development Goals (SDGs) (Nagpal & Radin, 2014).

The 2030 Sustainable Development Goals (Post-2015) recognizes the importance of safe drinking water and sanitation services to achieve Goal # 3 target # 2 related to ending preventable deaths of newborns and children under the age of 5. The SDGs ensures availability and sustainable management of water and sanitation, which is discussed in Goal 6 and composed of 6 targets (UN, 2015). WASH is a major factor when addressing issues related to children's mortality rate. Since, inadequate and unsafe water, poor sanitation, and improper hygiene services increase children's exposure to gastrointestinal infections such as diarrhea, which results in 801,000 mortalities per year among children less than 5 years of age (CDC, 2013). This will negatively impact the economic growth of families and societies, mentioned in Goal # 8, target # 1 due to an increase in tertiary health care costs particularly in developing countries that witness higher proportion of diarrheal morbidity and mortality reported cases (UN, 2015; Adams, Bartram, Chartier, & Sims, 2009). Besides, there are strong relations between WASH and social and economic development of communities. Poor hygiene, water, and sanitation intensify poverty by reducing productivity and elevating health-care costs (Ready, 2010). On the other hand, a potential return of 5.50$ and 2.00$ can be reached for every one dollar spent on improved sanitation and water, respectively, mounting to $60 billion in total global return (Hutton, 2012).

It is essential to understand the educational and health impacts of school WASH program in order to identify effective strategies for providing and sustaining WASH services in schools with diverse needs. It is assumed that improving WASH in school will improve health of students, increase attendance in schools (Babalobi, 2013; Freeman, et al., 2012; Reeves, Priest, & Poore, 2012; Reilly, et al., 2008), and improve WASH practices in associated communities (Sibiya & Ray Gumbo, 2013). However, the effectiveness of WASH program over time is associated with continuous provision of necessary WASH services, which enable children to practice proper handwashing technique with soap and cold and warm water supplied by water tanks that agrees with safety standards. Functional, private, and clean sanitary facilities are as important in protecting children from several preventable and transmissible diseases that are prevalent in the developing world such as helminth infections, diarrhea, cholera, trachoma, and fluorosis (CDC, 2013). This review will assess the significance of WASH interventions in schools to promote and protect children's health and wellbeing.

2.2. Components of WASH Program in Schools

UNICEF/WHO have set WASH guidelines in schools for every WASH component. Each component has multiple indicators which can be used as checklist to control the quality of WASH services.

2.2.1. Water Supply

Safe drinking water in schools is essential to protect students from exposure to waterborne illnesses that impact their health and cognitive development. Failure to ensure safe drinking water might increase the risk of exposure to water-borne diseases and disease outbreaks (UNICEF, 2012). And, despite continuing efforts by the governments and local NGOs, to improve the quality of water supplies in developing countries, water related diseases caused by contaminated drinking water supplies results yearly in 3.4 million deaths a year, mostly among children (UNICEF, 2008). When piped water supplies are not available, complimentary water sources would be used. These sources might be exposed to harmful contaminates caused by sea water infiltration and sewage intrusions in groundwater aquifers (Korfali & Jurdi, 2009). That is why water quality and water quality monitoring is essential and physical, chemical and microbiological characteristics of water should be routinely inspected (once every week or at least once a month) to protect students from diarrheal diseases (UNICEF, 2008).

- Onsite Water Storage

Water quality should be ensured during storage and as such, water storage tanks made from food grade should be available in schools to protect water from chemical contaminants. Storage tanks made from metals or recycled plastic might lead to water contamination with heavy metal such as Cu, Al, Co, As, and Fe, which might cause health problems upon chronic exposure (UNICEF, 2008; Cheng, H, Adams, & Ma, 2010). The national survey of public schools 2008-09 showed that only 3.3% of the water storage tanks are made from food grade materials. Moreover, storage tanks should be cleaned properly 4 times a year as recommended by WASH guidelines to remove turbidity and any salt deposits that might cause water rejection (UNICEF, 2012). Still, water storage tanks need to be properly closed to protect against contaminants such as dirt and bird feces (UNICEF, 2008).

- Water Fountains

Sufficient water fixtures should be available in schools (1 water fountain for every 20 students) and should be sectioned at different height to allow access to and use of water for drinking for all users of different age groups (UNICEF, 2012).

- Onsite Disinfection

The application of onsite disinfection is a precautionary measure that could further prevent the microbiological contamination due to factors impacting water distribution and water storage. Onsite disinfection is needed to insure safe water and reduce incidence of water-borne infectious diseases and outbreaks such as diarrhea (UNICEF, 2008). Chlorination was reported to be the predominant disinfection method applied in schools at baseline (Jurdi, 2009. It is important to maintain a disinfectant residual throughout the distribution system, which can provide protection against recontamination and limit microbial growth problems. Other benefits of chlorination include ease of use, cost effective, and reduce the incidence of diarrheal disease. However, excess residual chlorine levels will result in water rejection due to undesirable taste and odor and might potentially form harmful by-products and its effectiveness is decreased in turbid water (UNICEF, 2008).

Onsite water treatment filters can also be used to remove large and small particulate matter through 1 and 5 micron rating filters (UNICEF, 2008). Moreover, activated carbon filters are also used to remove combined residual chlorine and taste and color from water supply. The effectiveness of the filters depends on the amount of pressure that flows through these filters and the amount of impurities present in water, which determines the frequency of the cartridge replacement. Additionally, UV lamps are installed to remove microbiological organisms in water supply. These lamps emit ultra-violet germicidal irradiation to kill bacteria after the water passes through UV radiation lamp where the UV radiation will strike the pathogen outer membrane cells and destroys its DNA, preventing reproduction (Hijnen, Beerendonk, & Medema, 2006). However, certain contaminants such as salts and TDS can shield microorganisms from UV light. The effectiveness of disinfection also depends on monitoring the performance of these lamps, which is achieved by assessing microbiological characteristics of water entering and leaving the UV lamp.

- Water Quality

The quality of drinking water should be safe for consumption. The source of drinking water is considered safe when water meets WASH guidelines for drinking water quality or national standards. Microbiologically, *Escherichia coli* or coliform bacteria should not be detected in any 100ml sample. Physically, water should have no tastes, odors, and colors that would discourage consumption of the water. Moreover, chemical parameters for water quality such as pH, alkalinity, chlorides, nitrates, sulfates, and total hardness should not exceed threshold values of 6.5-8.5, 80-120 mg/L as $CaCO_3$, 250 mg/L as Cl^-, 10 mg/L as NO_3 N, and 250 mg/L as SO_4^{2-}, and <300 mg/L as $CaCO_3$, respectively (UNICEF, 2008).

2.2.2. Sanitation Facilities

Toilets should be sufficient, easily accessible, gender specific, private, secure, clean, properly ventilated, and should have water-basins in close proximity for handwashing with running hot and cold water, soap and tissue paper (UNICEF, 2012).

- Water Basins for Handwashing

Water basins should be in sufficient number to allow students to practice proper handwashing. If water fixtures are not sufficient or broken or inaccessible, students may use water fountains for handwashing or tend to skip handwashing practices and increase the risk of acquiring diarrheal disease (UNICEF, 2012).

- Availability of Running Water, Soap and Tissue Paper

Soap, tissue paper, running hot and cold water should always be available to insure good hygienic practices, which are an essential WASH requirement to help students practice proper hygienic behavior (UNICEF, 2012).

- Toilets

Toilets and urinals should be sufficient in number. According to WASH guidelines 1 toilet cabin and 2 urinals, should be provided for 30 boys (3 toilet cabin and 5 urinals per 100 boys) and 1 toilet cabin for 20 girls (5 latrines per 100 girls) (UNICEF, 2012).

- Proper Ventilation of Toilets

Toilets should be properly ventilated using suction fans to remove bad odor. Other forms of ventilation such as windows as reported in the national study 2008-09 are ineffective and as such vector and vector borne diseases might spread quickly (UNICEF, 2012).

- Toilet Doors

Toilet facilities should be private and secure. The toilet cabins should be equipped with doors to allow privacy and locking systems should be placed to provide security in all schools. Moreover, as toilet doors and door handles are possible sites of disease transmission, self-closing doors should be installed to reduce the contact of students with unclean surfaces (UNICEF, 2012).

2.2.3. Hygiene Promotion

Raising awareness about personal hygiene among students is essential to reduce risks of acquiring infections that can affect performance and well-being (UNICEF, 2012). There are several ways schools can promote hygiene to students. Place billboards and posters about proper hygiene practices at strategic locations near and inside toilet facilities can remind students on proper handwashing techniques, include hygiene education in the school curriculum, and organize extracurricular activities related to hygiene promotion. Still, the effectiveness of hygiene promotion is dependent on availability of sanitary services and functional equipments to change knowledge into practice (UNICEF, 2012).

2.3. Impact of school based WASH interventions on Education and Health

The burden of diarrheal disease is reported to be the highest among children under the age of five (CDC, 2013; UNICEF, 2012). WASH interventions in schools aims to protect children against infections. It is vital to understand how WASH interventions impact illness and educational outcomes among this population.

There are two main ways WASH program can improve health of school children. Firstly, these interventions may result in behavioral changes in hygiene practices; starting in school setting and leading to the community. Several studies have documented how school based WASH interventions lead to transfer of knowledge related to proper hygiene (Patel, et al., 2012; Reilly, et al., 2008) and point of use water treatment practices (Blanton, et al., 2010). Secondly, these interventions, whether in school or community setting, reduce exposure to harmful pathogens causing interruptions in pathogen transmission (Eisenberg, Scott, & Porco, 2007).

Reported studies show that the availability and proper use of WASH services is associated with reduction in absenteeism and improving educational outcomes among school children by reducing risk of acquiring diarrheal illness (Baxter & Royer, 2011; Bowen, et al., 2007; Carroll, 2010; Freeman, et al., 2012; Moonie, Sterling, Figgs, & Castro, 2008; Talaat, et al., 2011).

School-based health programs are an essential component of public health strategies to protect children's wellbeing. One of the critical factors to improve educational performance is reducing absenteeism. Studies on the impact of school absenteeism on children's cognitive, educational, and social development is focus mainly on developed countries. In one cross-sectional study, results of 3812 students who took Missouri Assessment program standardized test showed an inverse relationship between absenteeism and test level performance (Moonie, Sterling, Figgs, & Castro, 2008). Carroll, (2010) studied the effect of children (7 to 11 years) absenteesim on literacy and numeracy among british schools and found that missed school for half a year or more over four year period resulted in a reduction of 0.7 and 1 year loss in reading and mathematics test scores respectively (Carroll, 2010). Another longitudinal study, conducted in United States, showed that children with lower absence had higher literacy gains, while children with high absence had lower literacy gains (Ready, 2010).

Moreover, several studies linked the reduction of absenteeism to proper handwashing in schools. A cluster-randomized experiment was conducted in United States on 290 students (145 test group and 145 controls) in five independent Pennsylvania schools (Guinan, McGuckin, & Ali, 2002). Data was collected by teachers who monitored each episode of illness over the three month study period by asking students about the reason of absence. Results showed 50.6% fewer episodes of absenteeism among children with twice daily mandatory handwashing compared to children in control group. (Guinan, McGuckin, & Ali, 2002). In a similar intervention study in Denmark, two elementary schools were selected to study the effect of mandatory scheduled handwashing on absenteeism due to infectious illness. 290 randomly selected pupils at intervention school, were mandatorily required to hand wash three times daily (before first lesson, before lunch, and before going home), while 362 pupils at the control school continued their usual handwashing practices. The results showed that the odds ratio for absenteeism was 44% lower (OR: 0.69; 95% Cl: 0.52 to 0.92) for the intervention group compared to the control (Nandrup-Bus, 2009).

A similar broader study conducted in China during the academic year 2003-04 selected 87 cluster-randomized Chinese schools to evaluate school-based handwashing program. Two intervention groups were evaluated in this study. The extended intervention group received continuous supply of soap, handwashing promotion program, and recruited monitors to remind his peers about the importance of handwashing, while the standard intervention group received only handwashing promotion program. Data about illness signs or symptoms were recorded by trained teachers in association with student absence. Results indicated that students in the extended intervention group experienced the least absent days (median 1.2 days; P=0.03) compared to control (median 2.6 days) and standard intervention (median 1.9 days; P = 0.14) (Bowen, et al., 2007).

Comparatively, studies in the MENA region have shown similar results. A randomized controlled trial was conducted in 60 Egyptian schools to assess the effectiveness of hand hygiene promotion in reducing the absenteeism of schoolchildren due to diarrhea, influenza, and conjunctivitis Talaat, et al. (2011). Handwashing was enforced twice daily along with hygiene promotion sessions among the intervention group over 12 week period in 2008. Results indicated that absences caused by diarrhea, laboratory confirmed Influenza, and conjunctivitis decreased by 30%, 50%, and 67% respectively (Talaat, et al., 2011). Additionally in Kenya, the impact of school-based Safe Water and hygiene program on school children and their parents was evaluated Reilly, et al., (2008). 9 out of 45 schools were selected to study the effect of the school educational program on students' knowledge and hygienic practices. School absenteeism was found to be less by 35% in the nine selected schools where students were taught about proper handwashing technique, sanitation, and water sources, water storage and water treatment (Reilly, et al., 2008).

2.4. Challenges Facing Implementation of WASH Program in Schools

Early school based WASH intervention frameworks did not reflect the experiences and opinions of local stakeholders such as school officials, students, teachers, and parents, who are responsible for managing WASH services in schools. Lessons learnt from past experiences lead to the integration of several new mechanisms to ensure the sustainability and adaptability of WASH program in diverse settings. Improvement in the framework resulted in progress in WASH program in schools (UNICEF 2012). However, there remains a concern regarding the quality of data related to WASH in school.

Available data are of questionable accuracy and the terminologies used to measure coverage are either unclear, unspecified, or vary between countries or within countries (UNICEF 2015). That is why WHO/UNICEF developed standardized indicators for WASH in school facilities. There are 13 indicators used to monitor WASH in schools at the national level as presented in Table 1. These include: water quality, water quantity, water proximity, functional water facilities, sanitation facilities, sanitation functional equipment, gender specific, sanitation services, hand-washing facilities, and hygiene education.

Table 1: Components of a WASH Program

Component	Indicators
Water	1. Functional 2. Near 3. Sufficient Quantity 4. Safe for consumption 5. Accessible
Sanitation	1. Functional 2. Sufficient quantity 3. Gender specific 4. Clean 5. Accessible
Hygiene	1. Functional handwashing facilities 2. Availability of sanitary services 3. Hygiene Education

Source: (UNICEF, 2015)

On average, only 4 out of 13 indicators are being monitored by countries. However, information gathered was not always analyzed or reported (UNICEF 2015). Despite previous setbacks, UNICEF reported that after WASH in schools gained recognition on the global agenda, more countries are reporting their data each year. From 2008 to 2013 water and sanitation coverage data increased from 57 to 85% and from 49 to 80% respectively; moreover, both adequate water supply and sanitation services increased by 6% (UNICEF 2015).

On the other hand, hygiene indicators such as handwashing with soap are rarely monitored at school. Data on school washing facilities were reported only in 11 out of 149 countries and coverage of handwashing facilities in schools is below 50% in almost all countries; ranging from none to 42% (UNICEF 2015). There are limited data available on other components of school hygiene as well such as hygiene education and handwashing promotion. Monitoring was inconsistent in many countries and had gaps in information (UNICEF 2015). This presents a challenge in quantifying the effectiveness of WASH program in schools in order to mitigate existing challenges.

Many developing countries witnessed slow progress in WASH services in schools. Although access to water and sanitation services have improved over several decades, WHO estimates that 34% of public primary schools are without basic sanitation facilities (WHO, 2014). One reason for this may be due to "urbanization of poverty". Migration to urban areas is resulting in overpopulated schools, which poses challenges for WASH infrastructures that are not originally designed to serve and maintain large influx of students (WHO, 2014).

Other dilemmas include lack of commitment, lack of quality monitoring and quality monitoring programs, no documenting and evaluating systems, lack of awareness, no technical support and inadequate funding (De Albuquerque, 2014).

2.5. WASH in Public Schools of Lebanon

Lebanon, like many developing countries, faces many challenges in providing and sustaining WASH services in schools. One of these dilemmas is overpopulated communities due to the influx of Syrian refugees since 2012.

According to UNHCR, the influx of displaced population, almost half being children, has overcrowded existing school systems; in some cases doubling their student population and increasing the necessity for the rehabilitation of existing WASH facilities or the development of new facilities (UNHCR, 2014). WASH facilities such as water supply and waste management in communities hosting refugees has deteriorated, which increases the risk for the spread of diseases.

According to the World Bank, Lebanon is facing several challenges in terms of provision and management of water and sanitation services. One of these challenges is the result of water scarcity following the Syrian crisis that increased overall population by 20% and which resulted in a decline in estimated water resource per capita, reaching a value significantly below the scarcity threshold. Moreover, exploitation of surface water using large number of private wells exerts stress on groundwater resources affecting coverage of water supply and distribution system, attributing to a 48% loss of water across all systems (World Bank, 2012). Addition, water coverage was 79% before Syrian crisis, but now, almost half of the distribution system needs replacement, which resulted in a decrease in continuous water supply and poor water quality (World Bank, 2012).

There are several factors affecting the quality of water in Lebanon. Fecal contamination is one variable that is caused by disposal of untreated domestic sewage directly to the environment or could be the result of cross-contamination between leaking sewage and water distribution networks. Although bacteriological contamination is low in rural areas, it many reach 90% in dense urban areas. The quality of water is also affected by various sources of pollution. For example increase in the conductivity and salinity is highly attributed to sea water intrusion due to excessive pumping of ground water along the coastal line. Water resources in Bekaa Valley contain high nitrate levels caused by the overuse of fertilizers. Other types of pollution are associated with open dumping of solid waste and direct discharge of sewage and industrial wastewater effluents.

So far, chemical and bacteriological water quality monitoring have not been emphasized enough. Tests on water quality have been performed; however, they have not been performed methodically or to acceptable standards.

In 2013, The Ministry of Education and Higher Education (MEHE) collaborated with UNICEF and Swiss Development and Cooperation Agency (SDC) to produce technical guidelines for improving WASH facilities and infrastructure in schools. This is the bases of the UNICEF WASH Strategy that was developed in 2012 (UNICEF, 2012).

The national survey of all public schools in Lebanon 2008-09 exposed many dilemmas relating to the provision of water and sanitation services. Firstly, the number of water fountains and sanitation fixtures are not sufficient (1:20 schoolgirls; 1 toilet and 2 urinals for 30 schoolboys), sinks (1:15 preschool level; 1:15 above preschool level), and water fountains (1:12 preschool level and 1:20 above preschool level). Water supply system is another WASH factor that was addressed. Lebanese public schools rely on piped networks (67%) and groundwater (18%) as drinking water sources. Sometimes schools use alternative complementary water sources when water supply provided by municipality networks is frequently interrupted due to low pressure and non-continuous circulation, in which case the risk of piped water contamination is high. Additionally, groundwater contamination is caused by unsafe septic tanks or by infiltration of saltwater aquifers (Korfali & Jurdi, 2009).

Moreover, water quality and water quality monitoring, and sanitation services remains an important issue to be addressed. Normally, water quality in Lebanese schools is monitored, though not frequently or after long intervals. Filtration and chlorination are the two main methods used for treatment of drinking water on school premises, reaching around 25% of the institutions. Moreover, Soap is available in less than 50% of the schools, which represents another important risk of diarrheal disease contamination (Jurdi, 2009).

This study assessed the WASH services in Beirut public schools that implemented WASH programs. Data gathered from WASH intervention schools were compared with WASH guidelines to assess compliance. Moreover, information related to WASH services in Beirut schools reported in the national study 2008-09 was compared with the results of the WASH intervention schools to determine improvements in services provided.

CHAPTER 3

METHODOLOGY

3.1. Study Design

A cross-sectional study was conducted in 15 out of the nineteen public schools of Beirut that implemented WASH intervention, during the past 3 years (since 2012), for service improvements. The list of schools that adopted WASH intervention was obtained from the Ministry of Education and Higher Education (environmental health education unit and is presented in table 2.

A total of fifteen schools could be assessed based on acceptance and time scheduling. The schools' environments were assessed to determine compliance to the UNICEF WASH guidelines (Appendix 1) and the degree of WASH service improvements using a structured survey tool that was used in the national survey of public schools in Lebanon that was conducted in 2008-09 (Jurdi, 2009) presented in appendix 2.

The current WASH services were assessed and the data collected was compared with baseline information available for schools from national survey of public schools 2008-09 to determine improvements in services provided. Additionally, the quality of the water supplies in the 15 surveyed schools was determined to assess water quality, safety and compliance with National Drinking Water Standards and WASH requirements. As such, improvement of the quality of the water supply will not be determined as baseline data is not available.

Table 2: List of Public Schools in Beirut Reported to have Adopted WASH Interventions

A	**Public Schools that were Surveyed**	**Educational Level**	**Date**
1	Dr. Hassan Saab Secondary School	Secondary	14-05-2016
2	Rene Mouawad Secondary School	Secondary	14-05-2016
3	Zahiet Kadoura Secondary School	Secondary	13-05-2016
4	Ashrafieh First Secondary School	Secondary	13-05-2016
5	Madam Aoun Secondary School	Secondary	14-05-2015
6	Mousaitbeh Second School for Girls	KG-Intermediate	23-05-2015
7	Jaber Ahmad El-Sabah School	KG-Intermediate	13-05-2015
8	Tariq Jdideh Second Intermediate School (Girls)	Intermediate	20-05-2015
9	Aalamat Soubhy Al-Salh School	KG-Elementary	21-05-2015
10	Amine Bayham Elementary Mixed School	KG-Elementary	23-05-2015
11	Mouhammad Shaml Elementary Mixed School	KG-Elementary	21-05-2015
12	Omar Al-Zaany Intermediate Mixed School	Intermediate	20-05-2015
13	Omar Fakhory Elementary School	KG-Elementary	23-05-2015
14	Ebtihaj Kaddoura School	Intermediate	21-05-2015
15	Omar Al-Ansy Primary School	KG-Elementary	21-05-2015
B	**Public Schools that were not Surveyed**		
16	Jamil Al-Rouas Secondary Public School For Boys	Secondary	
17	Fern Al-Shebak Secondary Mixed School	Secondary	
18	Janah Mixed School	Elementary	
19	Omar Hamad Mixed Elementary School	Elementary	

3.2. Measures

The dependent/outcome variables include: water, sanitary, and hygiene services. Each variable is assessed by several indicators as follows:

3.2.1. Water Services (Appendix 2, Section 2)

The schools, water supplies were assessed using 18 indicators categorized into 7 groups as follows: (a) sources of water supply (b) Onsite disinfection of water supply (c) water quality perception (d) quality monitoring activities (e) location of water fountains (f) number of water fountains and (g) height of water fountains (Jurdi, 2009).

3.2.2. Sanitary Services (Appendix 2, Section 3)

Sanitary provisions at schools were assessed using 20 indicators categorized into 8 groups as follows: (a) number of toilet units (latrines and urinals) for males/females (b) availability of small toilet seats for young children (c) availability of separate sanitation facilities for sexes (d) proper ventilation of toilet (e) availability of self - closing toilet doors (f) provision of running water, soap and tissue paper, (g) frequency of toilet cleaning, and (h) type and management of sewage disposal system (Jurdi, 2009).

3.2.3. Hygiene Promotion (Appendix 2, Section 4)

Hygiene promotion activities were assessed by proxy indicators relating to availability of sanitary fixtures and services in addition to 4 direct indicators relating to: (a) hygiene education in curriculum, (b) hygiene promotion activities, (c) availability of certified health advisor, and (d) functionality of sanitary fixtures (Jurdi, 2009).

Additionally, information on the date of initiation of WASH program in schools, funding agencies, functionality of the program and challenges facing sustainability were also collected during the field visits.

3.3. Data Collection

3.3.1. Survey tool

The survey tool that was used for the assessment of the environmental health profile of public schools in Lebanon (national survey of public schools in 2008-09) was adopted for data collection as presented in Appendix 2 (Jurdi, 2009). Additional questions on the start date of WASH program initiation, type of support provided, and challenges in WASH implementation were incorporated into the survey. Data was collected through direct school visits that were conducted during May 2015. Data on number of students, gender, perceived water quality, water quality and quality monitoring activities, and date of WASH program implementation, and challenges, were obtained from the public schools principals, while other types of data on WASH facilities and services were collected through direct observation. Prior to data collection, approval of the Ministry of Education and Higher Education, division of Environmental Health Educational Unit, and IRB exemption were secured, and the schools were contacted to schedule field visits.

3.3.2. Water Quality Assessment

Water samples were collected from public schools implementing WASH interventions on June 30 and July 1, 2015. Water samples for the physical and chemical quality analysis were collected in polyethylene bottles that were presoaked overnight in

10% nitric acid and later rinsed with distilled water. However, water samples for microbiological testing were collected in sterile borosilicate 300ml bottles (APHA, AWWA, WEF, 2005).

Water sampling was performed in accordance with standards methods recommended by American Public Health Association (APHA), American Water Works Association (AWWA), and Water Pollution Control Federation (WPCF) (APHA, AWWA, WEF, 2005).

Water samples were transferred and analyzed in the Associate Research Unit on Potable Water Quality and Management at the Environmental Health Department of the Faculty of Health Sciences.

Water quality was assessed by determining the water quality indicators recommended by WASH Guidelines relating to:

- Physical characteristics: color, turbidity, conductivity and total dissolved solids (TDS).
- Chemical characteristics: pH, alkalinity, hardness (calcium and magnesium), nitrates, phosphates, sulfates, ammonia, sodium and potassium, chlorides, and free residual chlorine.
- Microbiological characteristics: total and fecal coliforms

Analytical assessment and quality control procedures were performed following standard methods and procedures as presented in table 3.

Table 3: Standard Analytical Methods for the Determination of the Physical, Chemical and Microbiological Water Quality Parameters

Analytical Parameters	**Standard Analytical Method**	**Type of Analytical Equipment**
Physical Parameters		
Color	Platinum-Cobalt Standard Method	DR 2800 HACH Spectrophotometer
Turbidity	Electrometric method	2100P HACH turbidimeter
Electric conductivity	Electrical Conductivity Method	SensIon 7 HACH, Conductivity Meter
TDS	Electrometric method	SensIon 7 HACH
Chemical Parameters		
pH	Electrometric method	SensIon 7 HACH, pH Meter
Alkalinity	Titration Method using Sulfuric Acid Standard Solution (0.02N)	Buret Titration
Total Hardness (Calcium and Magnesium)	EDTA Titration Methods	Buret Titration
Nitrates	Cadmium Reduction Method	DR 2800 HACH Spectrophotometer
Phosphates	PhosVer 3 (Ascorbic Acid) Method	DR 2800 HACH Spectrophotometer
Sulfates	SulfaVer 4 Turbidimetric Method	DR 2800 HACH Spectrophotometer
Ammonia	Nessler Method	DR 2800 HACH Spectrophotometer
Sodium	Flame Photometry	JENWAY Flame Photometer
Chlorides	Mercuric Nitrate Titration Methods	Buret Titration
Free residual chlorine	DPD Method Powder Pillows	DR 2800 HACH Spectrophotometer
Microbiological Parameters		
Total Coliform and Fecal Coliform	Membrane Filter Technique	Millipore Filtration

3.4. Plan of Analysis

Statistical Package for Social Sciences (SPSS) Version 22 was used to analyze the quantitative data as follows:

- The results of WASH intervention schools will be compared with the mean values for Beirut reported in national study at baseline 2008-09 to determine whether there was an improvement of WASH services.
- The assessed WASH services including water quality and hygiene indicators were compared with WASH guidelines as presented in Appendix 1 using non parametric one sample test to check for school compliance.

3.5. Limitations

There were several limitations to this study; among these is the small sample size of only 19 public schools currently implementing WASH intervention which limits the generalization of this study. Furthermore, not all of the indicted 19 public schools were accessible (only 15 public schools) for field visits due to time constraints. Moreover, grab water samples were taken at one point in time during summer 2015; and therefore data is not sufficient to assess the seasonal changes in water quality and its effect on onsite water treatment.

CHAPTER 4

RESULTS AND DISCUSSION

WASH interventions in public schools in Lebanon were initiated during 2012-2013 academic years. WASH guidelines for Lebanese schools were set by UNICEF/WHO in collaboration with the Ministry of Education and Higher Education and the Swiss Agency for Development and Cooperation. The objective of this initiative is to evaluate the performance of schools, identify the priority intervention targets relating to water, sanitation, and hygiene and enhance services provided to promote and sustain the health of the school environment. This section will report on the analysis of the data collected from the 15 surveyed public schools that are implementing WASH interventions. The assessment relates to water quality and quality monitoring, management and available infrastructure, onsite water disinfection, water and sanitation facilities, and hygiene promotion. Findings were compared with WASH guidelines to access compliance and relate to the status of events as reported by the data from the national survey of public schools 2008-09.

4.1. Drinking Water Supply

Safe drinking water in schools is essential to protect students from exposure to waterborne illnesses that impact their health and cognitive development. Failure to ensure safe drinking water might increase the risk of exposure to water-borne diseases and disease outbreaks (UNICEF, 2012). And, despite continuing efforts by the governments and local NGOs, to improve the quality of water supplies in developing countries, water-borne diseases caused by contaminated drinking water supplies results yearly in 3.4 million deaths, mostly among children (UNICEF, 2008).

4.1.1. Type of Water Supply

Data collected shows that the major source of drinking water in 60% of surveyed public schools (9 schools) is the piped water supplies as presented in table 4. The use of well water is next in rank (26.67%) (4 schools) followed by cistern water in 13.33% (2 schools). The use of cistern water purchased by schools was mainly due to breakdown in plumbing system caused by road construction works. As such, when piped water supplies are not available, complimentary water sources mainly well water sources, are used. Such sources might be exposed to physical, chemical, and microbiological contaminants caused by sources of pollution such as sewage and sea water infiltration in costal aquifers, that impact the quality and safety of the water supplies (Korfali & Jurdi, 2009). That is why drinking water supplies in schools should be determined and routinely monitored (UNICEF, 2008).

Table 4: Sources of Drinking Water in the Surveyed Public Schools Implementing WASH Interventions

School Category	Sources of Drinking Water					
	Piped water Supply		Well water		Cisterns	
	N	%	N	%	N	%
Secondary Schools	3	60.0	0	0.0	2	40.0
Intermediate Schools	2	66.7	1	33.4	0	0.0
KG to Intermediate Level Schools	2	100.0	0	0.0	0	0.0
KG to Elementary Level Schools	2	40.0	3	60.0	0	0.0

4.1.2. Onsite Water Storage

As for onsite storage, all categories of surveyed public schools use plastic water storage tanks that are made from U.S. FDA (Food and Drug Administration) approved food safe polyethylene resin as indicated in figure 1. This will safeguard stored water quality and prevent corrosion and leaching of chemical contaminants. Storage tanks made from metals or recycled plastic might lead to water contamination with heavy metal such as Cu, Al, Co, As, and Fe, which might cause health problems upon chronic exposure (UNICEF, 2008; Cheng, H, Adams, & Ma, 2010).

Furthermore, water storage tanks are appropriately covered in all surveyed public school categories except for one school in KG-Elementary category in which the cover of the storage tank was damaged by heavy winds in winter session and needed urgent replacement. This is of major importance as based on WASH guidelines all water storage tanks should be closed and void of cracks to minimize the risk of pathogen contamination such as fecal coliform bacteria resulting from animal wastes such as birds (UNICEF, 2008).

As for water storage tank inspection and cleaning, this should be routinely conducted. According to WASH guidelines, the optimal frequency of cleaning is four times per year and the minimal acceptable is at least once before the beginning of the academic year. This is needed to remove turbidity that can act as an incubating medium to pathogenic water-borne diseases (UNICEF, 2012). Data collected show that all surveyed public schools meet the minimal requirement of cleaning the storage tanks at least once a year (Figure 2).

As such, when comparing the data of the surveyed schools with the baseline levels reported by the national survey of public schools 2008-09, results show that all schools implementing WASH interventions have FDA approved water storage tanks, whereas the mean reported in 2008-09 did not exceed 3.3%. As such, safe water storage is now insured in all surveyed schools.

And, when comparing the frequency of cleaning water storage tanks, results showed that 60% of all public schools implementing WASH interventions clean storage tanks twice per year in comparison to a minimal average of 5.8% reported by the national survey of public schools 2008-09. Still, 33.33% (5 schools) of surveyed public schools implementing WASH interventions clean tanks once per year. This is still not satisfactory especially in schools that rely on untreated complimentary water sources that might be unsafe for consumption. Besides, WASH guidelines require water storage tanks to be cleaned ideally 4 times a year; therefore, schools should increase the routine cleaning frequency of water storage tanks to 4 times a year to comply with the ideal WASH Guidelines (UNICEF, 2012).

Figure 1: Label on Installed Water Storage Tanks of the Surveyed Public Schools Implementing WASH Interventions

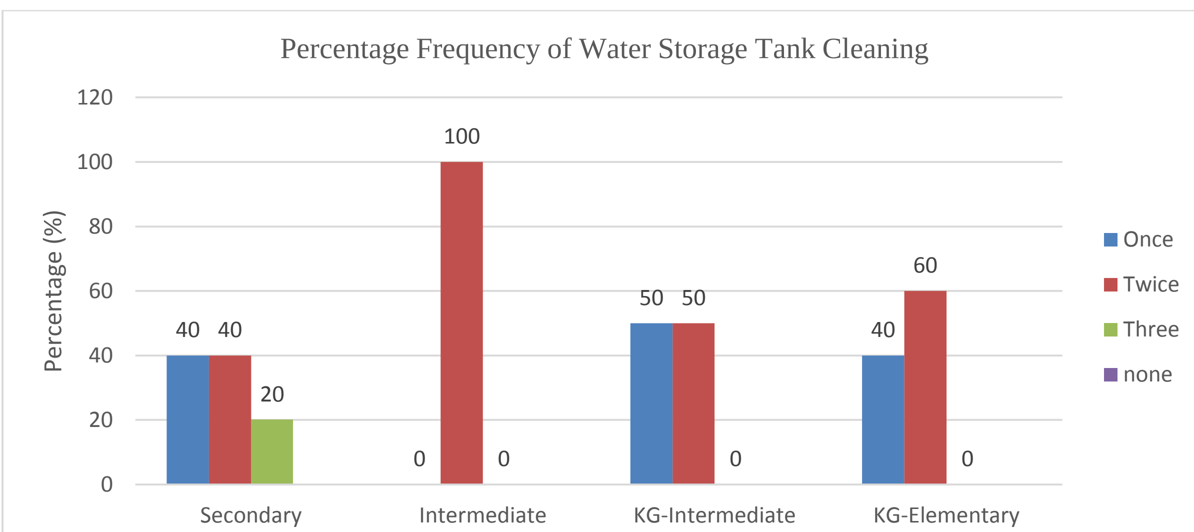

Figure 2: Routine Cleaning of Water Storage Tanks Surveyed Public Schools Implementing WASH Interventions

4.1.3. Water Fountains

Mostly, 1 to 2 functional water fountains are available for every 100 students in all educational categories of surveyed public schools with the exception of secondary schools with higher mean ratio of 0.03 (3 drinking water fountains for every 100 students).
WASH guidelines specify that a total of 1 drinking water fountain for 12 preschool student (0.08) and 1 drinking water fountain for every 20 students after preschool (0.05) should be provided (UNICEF, 2012). Furthermore, water fountains of different heights should adapt to the height of children of different age groups to offer adequate access. However, this was not available in any of the surveyed public schools (UNICEF, 2012).
When comparing the mean ratio of the total number of functional water fountains in surveyed public schools to the total number of students, the data from the surveyed schools indicate that the mean ratio for schools implementing WASH Interventions is 0.02, whereas the mean ratio reported in the national study (2008-09) at baseline is 0.06 and as such the number of water fountains is still deficient. Possible causes for this insufficiency might include increase in number of students especially after the enrollment of Syrian refugees and failure to maintain or to replace damaged or rusted fixtures which was observed during school visits in 4 schools (26.66%). Broken fixtures could be a result of improper handling by the students. On the other hand, rusted or corroded fixtures could be related to unsafe water quality discussed in section 4.2.

Besides, drinking water fountains are also used for handwashing mostly in all surveyed public schools (93.33%-100% of schools) except one intermediate school category. Such locations do not contain services such as soap, hot water, and paper towels, which are essential for promoting personal hygienic practices (UNICEF, 2012). This is not acceptable WASH service delivery and as such, the number of drinking water fixtures should be increased and leveled at different sections to meet WASH Guidelines (UNICEF, 2012). Moreover, any broken or corroded fixtures should be immediately identified, fixed or replaced, and properly used, cleaned and maintained. Additionally, students should be encouraged to wash their hands in toilet facilities were sanitary services are available.

All surveyed public schools have drinking water fountains installed in the playground areas. Still, 40% of schools (6 schools) do not recommend that students drink from these water fountains. In these schools, students are encouraged to carry drinking water to school or purchase it from school vendors for the fear of acquiring and transmitting water-borne diseases. This is not a good indicator of the safety of the water supplies provided, and is not in line with WASH guidelines and shows that water quality and quality control programs in schools are highly deficient.

4.1.4. Perceived Drinking Water Quality

Furthermore, when questioned about the perceived quality of the water supplies, 53.33% (8 schools) indicated that the drinking water supplies were not safe for consumption as presented in figure 3. The major water complaints leading to rejection of the drinking water related to taste (20%) and safety “bad to health” (33.33%) as presented in table 5.

Despite the negative perception regarding water quality, no action was taken to identify the possible causes contributing to poor water quality and communicate and mitigate the problems. Accordingly, this indicates that schools are in need to establish quality and quality control programs.

Furthermore, comparing the types of water complaints reported by public schools implementing WASH interventions and those reported by the national survey of public schools 2008-09, showed that the same complaints relating to the unacceptable water taste and concerns relating to water safety are still relevant. As such, even after implementing WASH interventions, 46.7% of students and 26.7% of staff of surveyed public schools still perceive water as unsafe (Figure 4). This is not a good performance indicator because it shows that drinking water quality was not targeted effectively to change the negative perception mainly relating to the safety of the water supplies.

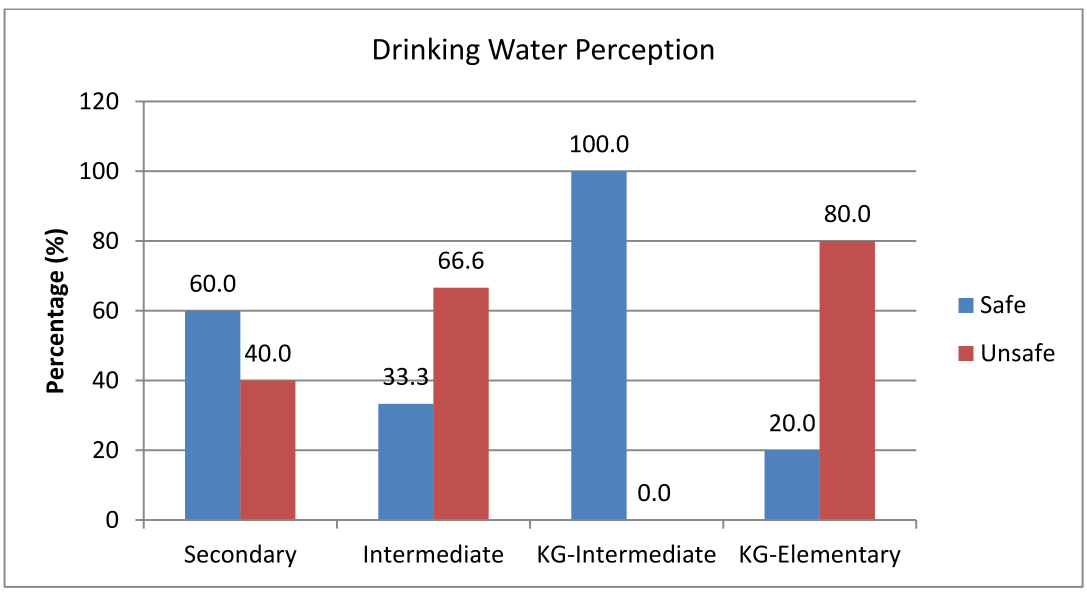

Figure 3: Reported Perceived Quality of Drinking Water Supplies in Surveyed Public Schools

Table 5: Drinking Water Complaints Reported by the Surveyed Public Schools

School Category	"Salty" Taste		Unsafe "Bad to Health"	
	N	%	N	%
Secondary	0	0.00	2	40.00
Intermediate	2	66.66	0	0.00
KG- Intermediate	0	0.00	0	0.00
KG- Elementary	1	20.00	3	60.00

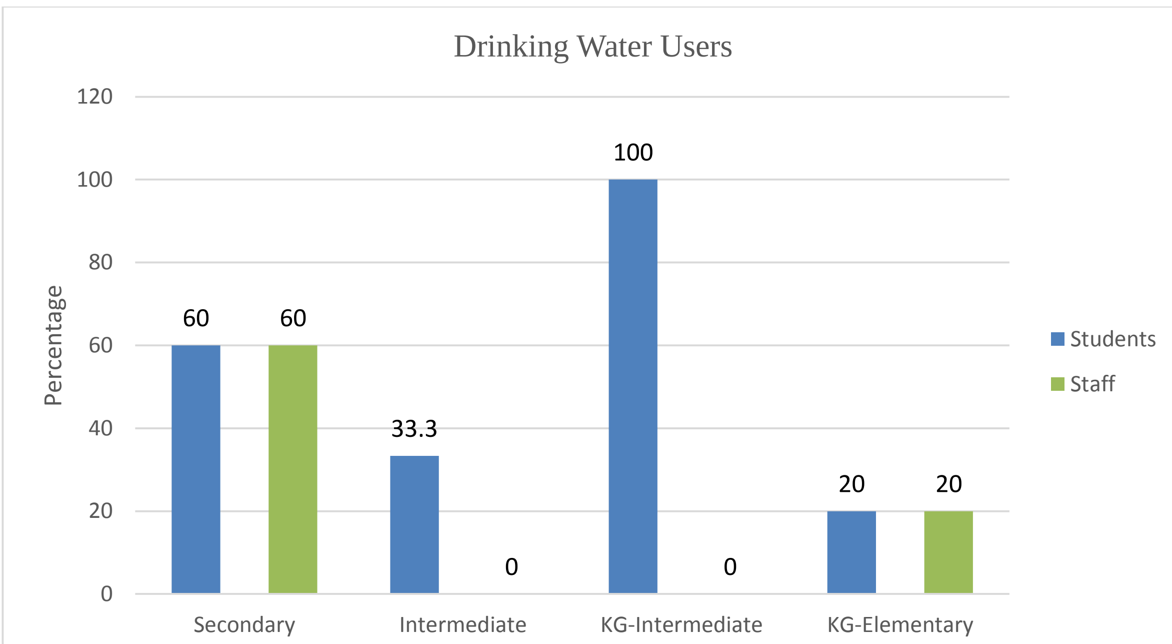

Figure 4: Use of Drinking Water Supplies by School Staff and Students of the Surveyed Public Schools

4.1.5. Onsite Disinfection

The application of onsite disinfection is a precautionary measure that could further prevent the microbiological contamination due to factors impacting water distribution and water storage. Onsite disinfection is needed to insure safe water and reduce incidence of water-borne infectious diseases and outbreaks such as diarrhea (UNICEF, 2008).

The results of the survey showed that 93.3% (14 schools) of surveyed public schools implementing WASH interventions have onsite water treatment systems. Also, chlorination is no longer the only method of water treatment as reported in 19.4% of public schools of Beirut by the national survey 2008-09 in comparison, 86.7% (13 schools) of the public schools implementing WASH interventions have water treatment systems including disinfection. This shows an improvement in WASH services relating to the management of surveyed public schools' water quality.

The onsite water treatment systems are applied to reduce turbidity, remove color, organic substances and destroy pathogenic microorganisms, and as such it is not limited to water disinfection as was mostly reported in the earlier assessment (2008-09). The water treatment systems (Melt Blown Polypropylene filters) currently available at surveyed public schools were installed by the Rotary Club as part of the Mega filter project which aims to install such units in all public schools of Lebanon. The treatment system includes the following processes:

- Filters (1-5 micron):

Melt Blown Polypropylene sediment filters of different sizes (5 and 1 micron rating) are installed to remove large and small particulates entering the storage tank. This is essential to reduce accumulation of particulates in the water storage tank, which might harbor harmful microorganisms, as indicated before (UNICEF, 2008).

- Activated Carbon:

Activated carbon charcoal filters are used to remove organic impurities, volatile organic compounds, and combined residual chlorine residues through chemical adsorption (UNICEF, 2008). The effectiveness of the filters depends on the amount of pressure that flows through these filters and the amount of impurities present in water, which determines the frequency of the cartridge replacement. Water hardness (> 180 mg/L $CaCO_3$) and high TDS (>500mg/L) might form scaling on filter cartridges, blocking the adsorption of chemicals and reducing their effectiveness (UNICEF, 2008).

- UV Radiation:

UV lamps are installed to destroy pathogenic microorganisms in water supply. These lamps emit ultra-violet germicidal radiation would strike the pathogen outer membrane cells and destroys its DNA, preventing its reproduction. The degree of microbial inactivation by UV radiation is dependent on the UV light intensity and exposure time (Hijnen, Beerendonk, & Medema, 2006). Matter might reduce transmission of UV light through water. Furthermore, water hardness and suspended solid substances might shield the pathogenic microorganisms from UV light and pass through the unit unaltered.

As such, the effectiveness of disinfection also depends on monitoring the performance of these filters, which is achieved by assessing microbiological characteristics of water entering and leaving the UV lamp.

Hence, having such onsite water treatment units shows a good improvement in water quality management; however, it is not coupled with routine water quality assessments to monitor the performance of these lamps on continuous basis. As such, schools should develop water quality and quality control programs to insure water safety.

Proper maintenance is also a major requirement to assess the performance of the lamps, clean the glass around the UV lamp from minerals and debris, monitor the UV dosage using the UV light intensity meter, and replacing cartridges and UV lamp when needed. This should be routinely practiced and any problems should be identified, mitigated, and documented.

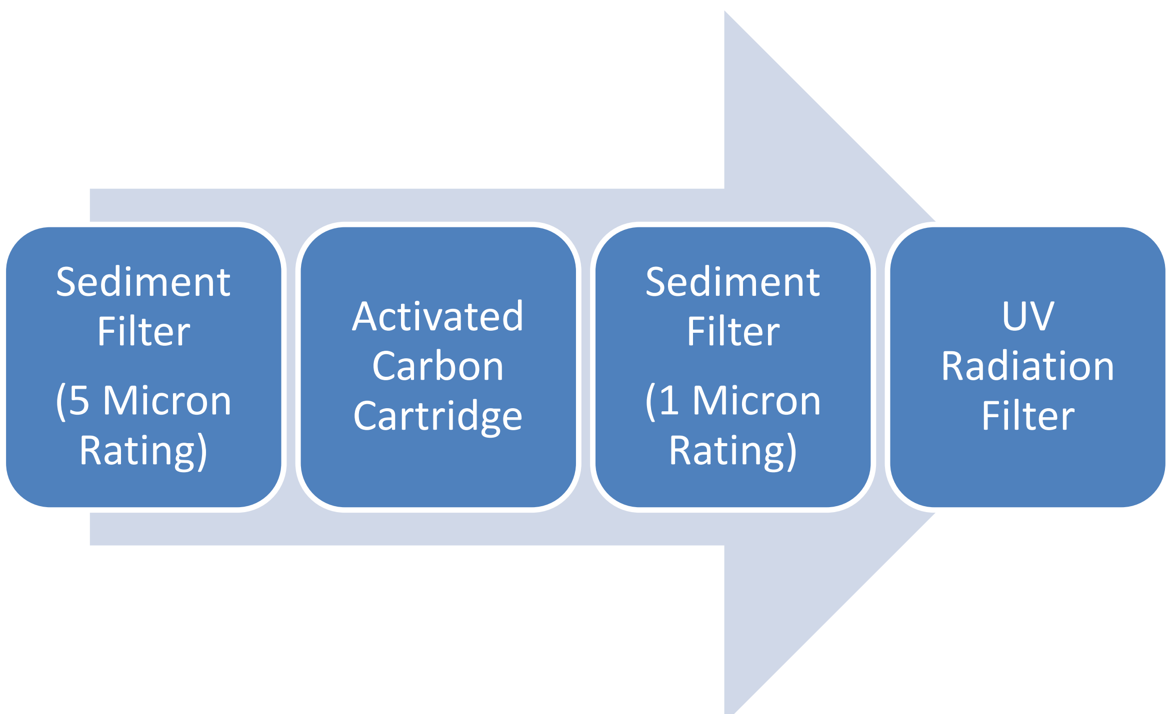

Figure 5: Onsite Water Treatment Unit

4.1.6. Water Quality Monitoring

As indicated before, water quality assessment and control should be instated to insure safety of water supplies; currently, all surveyed public schools just assess the physiochemical (mainly TDS and pH) and bacteriological quality at least once a year in specialized laboratories under the supervision of the Ministries of Education and Higher Education and Public Health. The surveyed public schools reported that they send two water samples, the influent and the effluent of the treatment unit, to the specialized laboratories that test the physical (TDS), chemical (pH), and microbiological (total and fecal coliforms, fecal Streptococci, and *Pseudomonas aeruginosa*) water quality parameters. The result of the water quality assessment would indicate if cartridges need to be replaced or maintained. The May, 2015 water quality assessment showed that 33.3% (5 schools) of surveyed public schools required cartridge replacement. Moreover, the reported results showed that the water supply in 26.7% (4 schools) of schools were contaminated with *Pseudomonas aeruginosa* and had TDS values higher than 500mg/l.

As such, and as a precautionary measure, the school administrator in one of the schools placed signs "Not Drinkable" on top of the water fountains and the other three schools did temporarily cut the drinking water supply from the storage tanks until the problems relating to the water quality are resolved. However, lack of water in water fountains would make students drink the water supplied to water basins. This was observed three times in two KG-Elementary category of schools during field visits.

As such, all the surveyed public schools monitor water supply at least once (73.3%) and twice (26.7%) per year. In comparison, only 6.94% of all surveyed public schools reported monitoring the quality of water supply as documented by the national survey of public schools 2008-09.

Still, water quality monitoring is deficient and should be increased to once every week or once a month as per WASH guideline (UNICEF, 2012). So it is important to increase the monitoring frequency as the water supply is exposed to seasonal quality variability and is further exposed to quality deterioration due to sea water infiltration and sewage intrusion in Beirut (Korfali & Jurdi, 2009). Besides, the intermittent water distribution results in low water pressure which allows contaminants present in soil to enter the water distribution system through cracks and pinholes. This may be further elevated seasonally as soil moisture conditions increase the probability of pressure gradient, developed from the soil to the pipe (UNICEF, 2008). That is why water quality control programs should be developed at schools and water quality monitoring should be sustained, ideally once a week or minimum once every month as indicated in WASH guidelines. And, any observed disturbances in quality should be immediately reported, addressed, and mitigated to ensure safety of the students, staff, and teachers (UNICEF, 2012). However, risk assessment and management programs are not designed and practiced in any of the surveyed public schools.

4.2. Water Quality Assessment

The results of the water quality (physical, chemical and microbiological) of samples collected from the surveyed public schools' supplies are presented in tables 6-8. The results were then compared to WASH Guidelines and LIBNOR standards to assess water quality and safety (UNICEF, 2008; WHO, 2011).

4.2.1. Physical Water Quality

4.2.1.1. Color

Drinking water should be free from color. Results showed absence of color in drinking water supplies. Most people can detect colors above 15 TCU, which may be subject to water rejection (UNICEF, 2008). The main component of color is dissolved organic matter such as humic and fulvic acids. Their presence in treated water may suggest formation of toxic byproducts following disinfection such as Haloacetonitriles (HANs), Trihalomethanes (THMs), Haloacetic Acids (HAAs) (WHO, 2011). Moreover, carbon adsorption filters discussed earlier in section 4.1.3 addresses these problems.

4.2.1.2. Turbidity

Turbidity is the result of suspended particles in water due to insufficient filtration during water treatment or presence of mineral precipitates and sediments in the distribution system. High levels of turbidity can protect pathogens from disinfectants. That is why it is recommended that turbidity should be less than 1 NTU in treated water (WHO, 2011). Findings indicate that all water supplies have turbidity levels below 1 NTU, (ranging from 0.14 to 0.72 NTU), which is in line with WASH requirements (UNICEF, 2012).

4.2.1.3. Electrical Conductivity (EC) and Total Dissolved Solids (TDS)

Analysis of the physical parameters indicates that Electric Conductivity (EC) and Total Dissolved Solids (TDS) range from 311 to 8610 µS/cm and 218 to 6350 mg/L, respectively. Dissolved ions such as Cl^-, Ca^{2+}, and Mg^{2+} increase the TDS of water. Sodium and chloride are the main constituents of TDS, an indicator of salinity, which has an important effect on the taste of drinking-water (WHO, 2011). According to WASH guidelines and LIBNOR standards, EC and TDS values should not exceed 1000μS/cm and 500mg/L, respectively. Findings show that 73.33% (11 schools) provide water with high EC (>1000 μS/cm) and (>500 mg/L) TDS out of which 3 schools (20%) have TDS greater than 1000mg/L, suggesting that drinking water is not in compliance with WASH guidelines and LIBNOR standards. Besides, lack of rainfall and excess pumping may lead to sea water intrusion increasing conductivity and total dissolved solids of freshwater aquifers (UNICEF, 2008). This is impacting the effectiveness of the installed water treatment systems in surveyed schools. However, there are no documented health-based hazards from consuming water with high EC and TDS value. Still, high levels will cause sensitivity of gastrointestinal system.

Table 6: Physical Characteristics of the Surveyed Public Schools' Drinking Water Supplies

School Ref #	Color TCU	Turbidity NTU	Conductivity µhs/cm	TDS mg/L
1	0	0.31	456	315
2	0	0.25	1676	1226
3	0	0.25	1250	919
4	0	0.29	1275	918
5	0	0.29	311	218
6	0	0.23	1147	815
7	0	0.14	1085	756
8	0	0.35	1258	897
9	0	0.31	1198	847
10	0	0.21	8610	6350
11	0	0.37	1376	950
12	0	0.33	1351	775
13	0	0.16	342	221
14	0	0.14	340	220
15	0	0.72	2920	1850
WASH Guidelines	**15**	**1**	**1000**	**500**
LIBNOR Standards	**NA**	**NA**	**1000**	**500**

4.2.2. Chemical Water Quality

4.2.2.1.Alkalinity & pH

According to WASH guidelines, the alkalinity in drinking water should range from 80-120 mg/L as of $CaCO_3$ and the pH from 6.5-8.5 (UNICEF, 2008). However, findings show that all water supplies higher alkalinity levels ($CaCO_3$) ranging from 182-236mg/L, while only one schools had pH level higher than WASH guidelines (pH: 8.6). Water with high alkalinity has a "soda-like taste", which cause skin dryness and scaling of calcium carbonate deposits on water distribution systems and onsite filters reducing its effectiveness (UNICEF, 2008). Moreover, this scaling will decrease pumping efficiency of water supply system, increasing power costs due to greater energy consumption. On the other hand, low alkalinity decreases the ability of water to resist pH changes, which means that pH will fluctuate from acidic to basic rapidly. This might decrease effectiveness of chemical disinfectants (chlorine), since chlorination is most effective at pH from 6.5 to 8.5 (WHO, 2011). Furthermore, water with low alkalinity can irritate eyes and have corrosive properties (UNICEF, 2008).

Since water sources in Lebanon are mostly groundwater, high alkalinity is expected. The main sources of natural alkalinity in water are the rocks such as limestone containing carbonate, bicarbonate, and hydroxide compounds. When water passes through limestone bedrocks containing carbonates, alkalinity and water hardness will be increased. Onsite filters (sediment, granular activated carbon, and UV filter) are not used to remove mineral salts such as carbonates that are the main constituents of alkalinity. Accordingly, the frequency of cleaning and maintenance of the water storage tanks and filter cartridges should be increased due to possible formation of mineral deposits on cartridge adsorption pores which will reduce the effectiveness of chemical adsorption and disinfection.

4.2.2.2.Sulfate

According to WASH guidelines, high concentrations of sulfate in drinking water (above 250mg/L) can lead to unpleasant taste (UNICEF, 2008). Moreover, bacteria may convert sulfate to hydrogen sulfide in the absence of oxygen and free chlorine, which will give rise to "rotten-egg odour" even at low sulfate concentrations (0.05mg/L) (UNICEF, 2008). All surveyed public schools had acceptable levels of sulfate that ranged from 14 to 180mg/L with the exception of one school that had higher concentrations of sulfate (320mg/L). Accordingly, water supplies in 93.33% of the surveyed public schools meet WASH guideline level for sulfate. Moreover, currently placed onsite water treatment systems do not remove salts such as sulfate. That is why sources for high sulfate salts should be investigated and filters installed should be checked and cleaned or replaced if any mineral deposits are observed.

4.2.2.3. Hard water (Calcium and Magnesium)

Hardness is expressed in mg/L of $CaCO_3$. According to WASH guideline, hardness of water is classified as soft (0-60mg/L $CaCO_3$), Modernity hard (61-120mg), Hard (121-180 mg/L $CaCO_3$), and very hard (>180 mg/L $CaCO_3$) (UNICEF, 2008). Findings show that water supply in all schools is very hard (>180 mg/L). Problems resulting from hard water include more soap to form a lather and scale deposits on pipes and basins. On the other hand, soft water causes corrosion of metal pipes which might increase the concentration of heavy metals such as lead, copper and zinc in drinking water (UNICEF, 2008). Despite this, there are no documented health hazards resulting from consumption of hard water. However, according to WASH guidelines, taste threshold for calcium ion is between 100-300 mg/L (UNICEF, 2008). Findings show that the water supplies of 86.66% (13 schools) of schools, is within that range. Still, water hardness above 15mg/l would lead to filter failure due to scaling on adsorption sites. As such, the water treatment systems should be in line water quality.

4.2.2.4. Nitrate ($NO3^-$ N)

Two major sources of nitrate are fertilizers and human or animal excreta. Nitrates ($NO3^-$) are converted to nitrites ($NO2^-$) in surface water, pipes distribution systems, ground water, or in the body in the presence of bacteria. According to WASH guidelines, Nitrate $NO3^-$ -N levels (as total nitrogen) should not exceed 10mg/L to protect children from methaemoglobinaemia “blue baby syndrome” especially among infants from 6 to 12 months of age (UNICEF, 2008). Findings show that levels of $NO3^-$ -N are below WASH guideline level of 10mg/L (UNICEF, 2008).

4.2.2.5. Sodium (Na^+) and Chloride (Cl^-)

Sodium and chloride give water a salty taste. According to WASH guidelines, water might be rejected if concentration of chloride exceeds 250 mg/L. Findings show that 73.3% (11 schools) of the surveyed public schools exceed this limit. Possible contributing factors include use of private wells (groundwater sources), lack of rainfall during dry session, and excess pumping may lead to sea water infiltration in underground freshwater aquifers increasing Na^+ and Cl^- (Korfali & Jurdi, 2009). Although people with hypertension are susceptible to high levels of sodium in drinking water, no health based guideline values have been set for both sodium and chloride (UNICEF, 2008). Furthermore, high levels of Cl- may indicate utilization of municipal water with well water especially during dry session (Korfali & Jurdi, 2009).

4.2.2.6. Ammonia ($NH3^-$ N)

Ammonia includes NH_3 and $NH4^+$ species. It originates mainly from metabolic, industrial and agricultural processes (WHO, 2011). Findings show that 93.33% (14 schools) of the surveyed public schools had levels of 0.13 to 0.25mg/L of NH_3 N and one school had higher concentration of ammonia (3.07 mg/L of NH_3 N). Natural levels of ammonia are usually below 0.2mg/L in groundwater and surface water may contain up to 12mg/L. Ammonia in water may indicate possible sewage and microbial contamination because it is a major mammalian metabolic constituent (WHO, 2011). Despite this, there are no proposed health-based guideline values for ammonia in drinking water since toxicological effects are only observed at exposures above 200mg/Kg body weight (WHO, 2011).

4.2.2.7. Phosphate (PO_4^{3-})

Phosphate is originated from phosphorous (P), which is present in plants, microorganisms, and fecal matter. Phosphate is used extensively in agricultural fertilizers and is a major component in detergents. Findings show that concentration of phosphate (PO_4^{3-}) range from 0.27-1.38mg/L. According to WASH guidelines there are no health-based guideline values for phosphates (WHO, 2011). However, high concentrations of phosphorus in water distribution systems might suggest wastewater intrusion (WHO, 2011).

4.2.2.8. Residual Chlorine

Residual free chlorine is important to protect water supply throughout distribution network. Public water authorities might apply large doses of chlorine to ensure residual chlorine in all distribution systems. However, effectiveness of chlorination is dependent on pH (6.5-8.5), turbidity (<1 NTU), and ammonia (WHO, 2011). It is important to monitor residual chlorine levels frequently in the water distribution system, which might become a major source of complaint above threshold values (5 mg/L) (UNICEF, 2008). Findings show that residual chlorine in schools ranged from 0 to 0.08mg/L. This is expected since chlorination is no longer applied in surveyed public schools. Currently, disinfection is through onsite UV radiation lamps as discussed earlier. However, the risk of recontamination in water storage tanks would increase especially if not properly maintained and cleaned (failure to properly clean water storage tanks or repair broken or rusted pipes which are potential sites of pathogen entry). Furthermore, onsite activated carbon treatment removes combined residual chlorine forms from the water supply.

Table 7: Chemical Characteristics of the Surveyed Public Schools' Drinking Water Supplies

School Ref #	**pH**	**Alkalinity** mg/L as $CaCO_3$	**Chlorides** mg/L as Cl^-	**Ammonia** mg/L as NH_3N	**Nitrates** mg/L as NO_3N	**Phosphate** mg/L as PO_4^{3-}	**Sulfates** mg/L as SO_4^{2-}
1	8.45	202	52.5	0.18	1.1	0.87	23
2	8.2	236	554.8	0.19	1.2	0.51	130
3	8.21	232	362.4	0.13	1.1	0.46	74
4	8.07	220	367.4	0.15	1.1	0.27	112
5	8.39	206	20.0	0.13	1.4	0.5	14
6	8.23	192	342.4	0.18	1.5	0.39	58
7	8.32	182	314.9	0.25	1.1	1.38	58
8	8.24	212	367.4	0.16	1.2	0.55	67
9	8.38	200	379.9	0.15	1.1	0.47	63
10	7.73	214	3324.0	3.07	5	1.02	320
11	8.35	226	2121.8	0.14	1	0.78	65
12	8.35	184	1594.5	0.15	1.1	0.53	58
13	8.44	198	40.0	0.14	1.4	0.57	15
14	8.66	202	20.0	0.14	1.2	0.32	14
15	8.03	226	857.2	0.2	1.6	0.72	180
WASH Guidelines	**6.5-8.5**	**80-120**	**250**	**NA**	**10**	**NA**	**250**
LIBNOR Standards	**6.5-8.5**	**NA**	**NA**	**NA**	**10**	**NA**	**NA**

Table 7: Chemical Characteristics of the Surveyed Public Schools Drinking Water Supplies

School Ref #	Total Hardness	Calcium hardness	Magnesium Hardness	Sodium	Free Residual Chlorine
	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg/L	mg/L as Na^+	mg/L
1	240	190	50	7.95	0.04
2	470	270	200	45.25	0.01
3	400	260	140	38.46	0.02
4	385	270	115	35.07	0.03
5	255	200	55	2.86	0.04
6	380	250	130	35.07	0.04
7	345	230	115	33.37	0.02
8	390	250	140	40.15	0.02
9	360	250	110	40.15	0.03
10	1835	1400	435	123.2	0.04
11	405	280	125	48.63	0.02
12	325	210	115	29.98	0.01
13	240	200	40	1.17	0.08
14	245	180	65	2.86	0
15	610	430	180	48.63	0
WASH Guidelines	**300**	**100-300**	**NA**	**NA**	**< 5 mg/L**
LIBNOR Standards	**NA**	**NA**	**NA**	**NA**	**< 5 mg/L**

4.2.3. Microbiological Water Quality

The highest microbiological health risks are associated with consumption of water that is contaminated with faeces from humans or animals (WHO, 2011). Moreover, microbial quality of water might be altered depending on pathogen concentrations, which might increase risks of acquiring infections and trigger water-borne outbreaks (UNICEF, 2008).

Total coliform group, can survive and grow in water distribution systems, particularly in the presence of biofilms. Yet, their existence is not directly related to sewage intrusion since total coliform bacteria also exist in natural environment (UNICEF, 2008). On the other hand, the presence of fecal coliforms (E.coli) provides evidence of recent fecal contamination through possible breaches in water distribution system or contaminated ground water sources caused by sewage intrusion (UNICEF, 2008). Besides, the presence of total and fecal coliforms in treated water indicates inadequate treatment, possible ingress of foreign materials such as soil and waste through damaged pipes, failure to clean and cover the storage tank as per WASH requirements and possible recontamination during storage.

Determining the microbiological quality of schools' drinking water supplies showed that total coliforms are present in 26.7% (4 schools) of surveyed public schools, while fecal coliforms were present in 20% (3 schools). According to WASH Guidelines and LIBNOR standards, total and fecal coliforms should not be detected in the drinking water supplies (UNICEF, 2008; WHO, 2011). As such, water supplies in these schools are not safe for consumption. This shows that UV radiation unit is not being properly maintained. Other possible reasons might include the presence of mineral salts and total dissolved solids that protect pathogens from UV radiation (WHO, 2011). Still, schools might not be maintaining or replacing the UV lamp when UV irradiance drop below 30000μWs/cm^2, which is the minimum dosage needed to kill pathogenic microorganisms at a wavelength 254nm (WHO, 2011). Moreover, irregular electrical shortage and power cuts significantly decrease the UV lamp life and performance. That is why UV radiation lamp should be tested using UV light intensity meter to determine the need of UV lamp replacement.

As such, microbial water quality monitoring of drinking water supplies should be conducted routinely, ideally every week or once a month based on WASH guidelines, as discussed in section 4.1.6, and any variations from WASH guidelines should be immediately addressed and possible causes should be identified, mitigated and documented for future reference; however, this was not currently practiced in any of the surveyed public schools. Hence, further action is required by the schools' administration, with the support of the Ministry of Education and Higher Education and NGOs, to increase the sampling frequency and the cleaning and maintenance of the UV units.

Table 8: Microbiological Characteristics of the Surveyed Public Schools' Drinking Water Supplies

School Ref #	T. Coliforms	F. Coliforms
	/100 ml	**/100 ml**
1	0	0
2	0	0
3	0	0
4	0	0
5	105	87
6	4	0
7	0	0
8	0	0
9	32	15
10	0	0
11	0	0
12	63	39
13	0	0
14	0	0
15	0	0
WASH Guidelines 2008	**0**	**0**
LIBNOR Standards	**0**	**0**

4.3. Sanitation Services

As for sanitation services, WASH Guidelines specify that toilets should be easily accessible, gender specific, sufficient, private, secure, clean, properly ventilated and should have water-basins in close proximity for handwashing with running hot and cold water, soap and tissue paper (UNICEF, 2012). Results of the surveyed public schools implementing WASH services showed the following.

4.3.1. Water Basins for Handwashing

On average, 2 to 5 water basins for handwashing are available for 100 students for all school categories implementing WASH Interventions as presented in figure 6. The mean ratio of water-basins for males range between 0.02 to 0.03 (around 2 to 3 water basins for 100 boys for all school categories) and 0.02 to 0.04 for girls in all school categories with the exception of secondary school category that provide 6 water basins for 100 girls. According to WASH guidelines, 1 water basin should be provided for 8 preschool students and 1 water-basin for 15 students above preschool (UNICEF, 2012). As such, the number of functional water basins is not sufficient and need to be increased to meet WASH guidelines (UNICEF, 2012).

Hence, among schools implementing WASH interventions the mean ratio is 0.03 which is still less than the mean average (0.04) reported by the national survey of public schools 2008-09. Possible causes might include an increase in number of students (influx of Syrian refugees) and failure to maintain or replace the fixtures as noted earlier in section 4.1.5.

Additionally, some of the fixtures were broken while others were not functional in around 13.3% (2 schools) of the surveyed public schools. Upon further inquiry about the probable reasons, it was noted that there were leaks in these systems which the maintenance team were trying to resolve. As a temporary solution, the water supply was cut to prevent further leaks, but the time needed to resolve the problem was not determined.

All water-basins are located in a room leading to the toilets in close proximity to the toilet cabins and urinals. This agrees with UNICEF guidelines which is essential for good hygienic practices (UNICEF, 2012). Still, as indicated before, water fountains are also used for handwashing in all surveyed schools. This could be due to the insufficient number of water basins located in toilet facilities, which will lead the students to either skip handwashing or use water fountains for that purpose (UNICEF, 2012). However, such settings do not support the provision of sanitation services such as cold and hot water, soap, and tissue paper, which are essential to promote hand washing and ultimately improve hygienic practices (UNICEF, 2012). As such, this indicates that students are not performing proper hygienic practices in surveyed public schools.

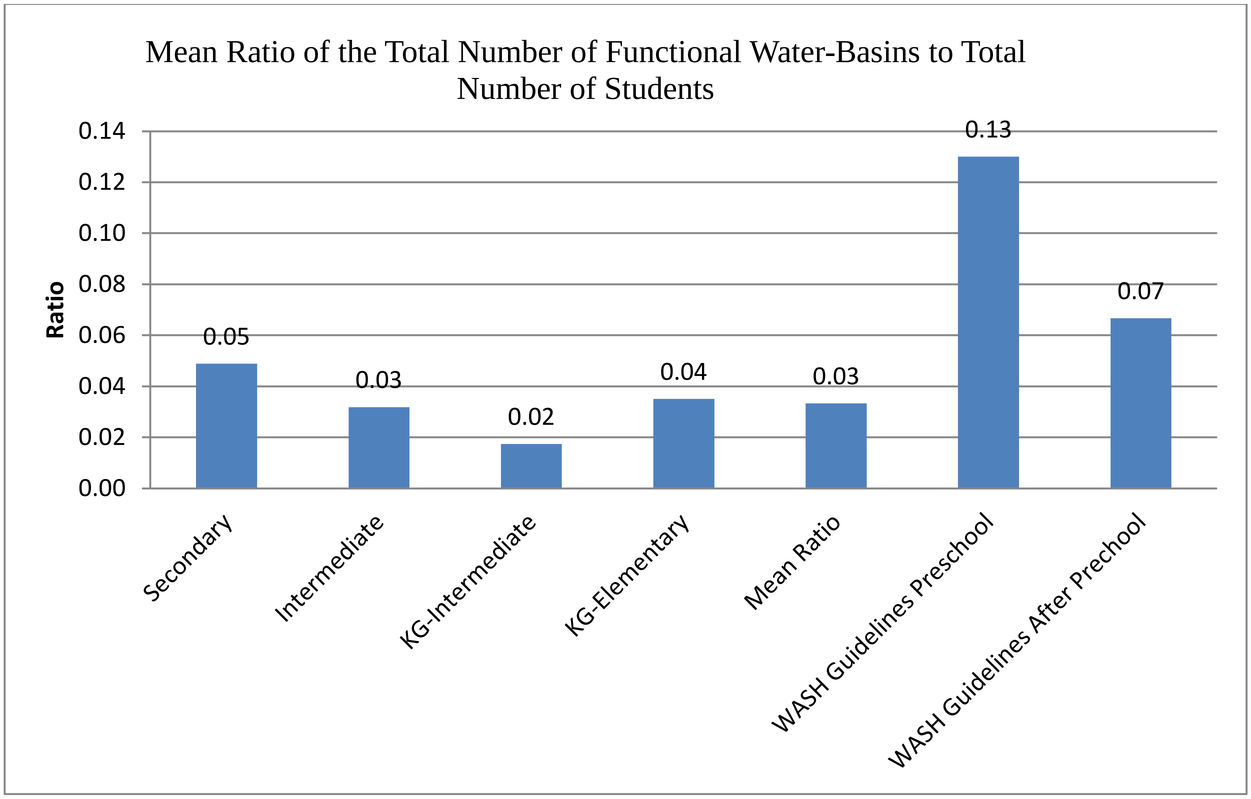

Figure 6: Ratio of the Total Number of Functional Water-Basins to Total Number of Students

4.3.2. Toilets

The mean ratio of the total number of toilets to total number of students is 0.04 (4 latrines for every 100) in all surveyed public schools implementing WASH interventions. However, the secondary school categories have the highest ratio (0.07) (7 latrines per 100 students). As for toilet cabins being gender specific, the mean ratio of the total number of toilet cabins and urinals for males to total number of male students is 0.04 and 0.03 respectively (4 toilet cabins and 3 urinals per 100 boys) and the mean ratio of the total number of toilet cabins for female students to total number of females is 0.04 (4 latrines per 100 girls) as presented in figure 7.

These results are not in line with WASH guidelines, which state that 1 toilet cabin and 2 urinals, should be provided for 30 boys (3 toilet cabin and 5 urinals per 100 boys) and 1 toilet cabin for 20 girls (5 latrines per 100 girls) (UNICEF, 2012). Deficiencies were mainly noted for Intermediate (3/100 latrine and 2/100 urinal) and KG-Intermediate school category boys (2/100 latrine and 1 urinal). For girls, insufficient numbers of toilet cabins were observed in KG-Intermediate (2 latrine per 100 girls) and KG-Elementary (3 latrine for 100 girls) school categories. And as such number of toilet cabins (boys and girls) and urinals for boys should be increased to meet WASH guidelines (UNICEF, 2012).

Hence, among the surveyed public schools implementing WASH interventions the mean ratio is 0.04, which is still less than the mean average (0.06) reported by the national survey of public schools 2008-09. As a result, number of toilet cabins and urinals are still deficient. Possible reasons might be due to the increase in number of students and failure to maintain toilet cabins. And, major problems in toilets include clogging, broken seat latrines and urinals, and water leaks from water tank, which was observed in some of the toilet cabins in around 27% (4 schools) of surveyed public schools. As a result, schools placed “out of order” signs on the malfunctioned toilet cabins until the plumbers are able to fix these problems. To add to the problem, it was also reported that some toilets (located at each floor level near classrooms) and utilized by students are now strictly reserved for teachers.

As for hygienic conditions of toilet facilities, toilet facilities should be clean at all times. According to WASH guidelines, toilet facilities should be cleaned three times a day, especially after each break (UNICEF, 2012). Results indicate that 20% (3 schools) of schools meet WASH guidelines as presented in figure 8.

4.3.3. Availability of Running Water, Soap and Tissue Paper

Additionally, soap, tissue paper, running hot and cold water should always be available to insure good hygienic practices, which are an essential WASH requirement to help students practice proper hygienic behavior (UNICEF, 2012). Results indicate that hot water is not available in any of the surveyed public schools; while soap and tissue paper are available in 46.7% (7 schools) and 20% (3 schools) of the surveyed public schools, respectively (figure 9). However, soap and tissue paper were not available on all the water-basins and toilet cabins during field visits. As such, soap and tissue paper are present in 46.7% and 20%, respectively in public schools implementing WASH interventions but none of the public schools have hot water; whereas, soap, tissue paper, and running hot water are present in 51.4%, 38.9%, and 4.16%, respectively reported in the national survey of public schools 2008-09.

This is still not an acceptable performance indicator of proper WASH services and indicates that students are not practicing proper hygiene which might increase the risk of acquiring diarrheal illness (UNICEF, 2012).

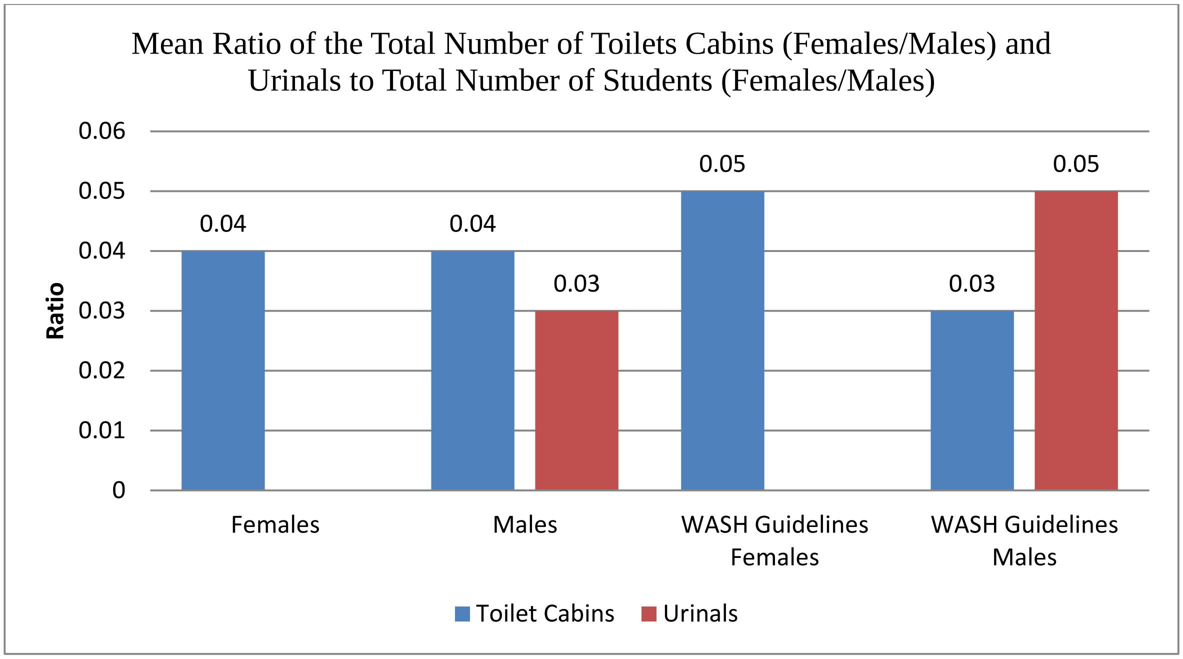

Figure 7: Mean Ratio of Gender Specific Toilet Cabins to Total Number of Female and Male Students

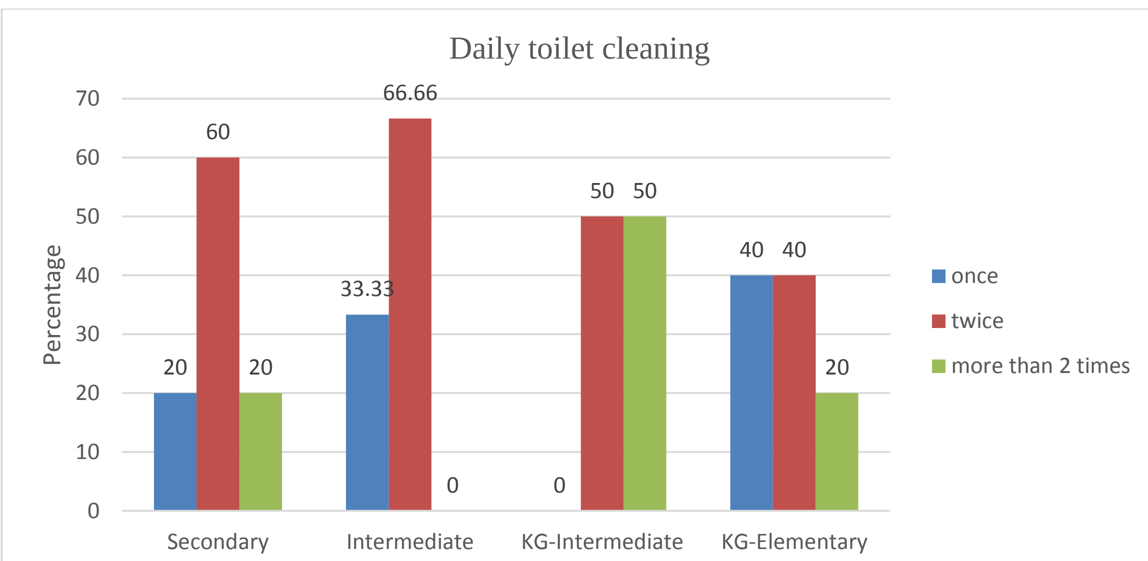

Figure 8: Daily Toilet Cleaning Schedule

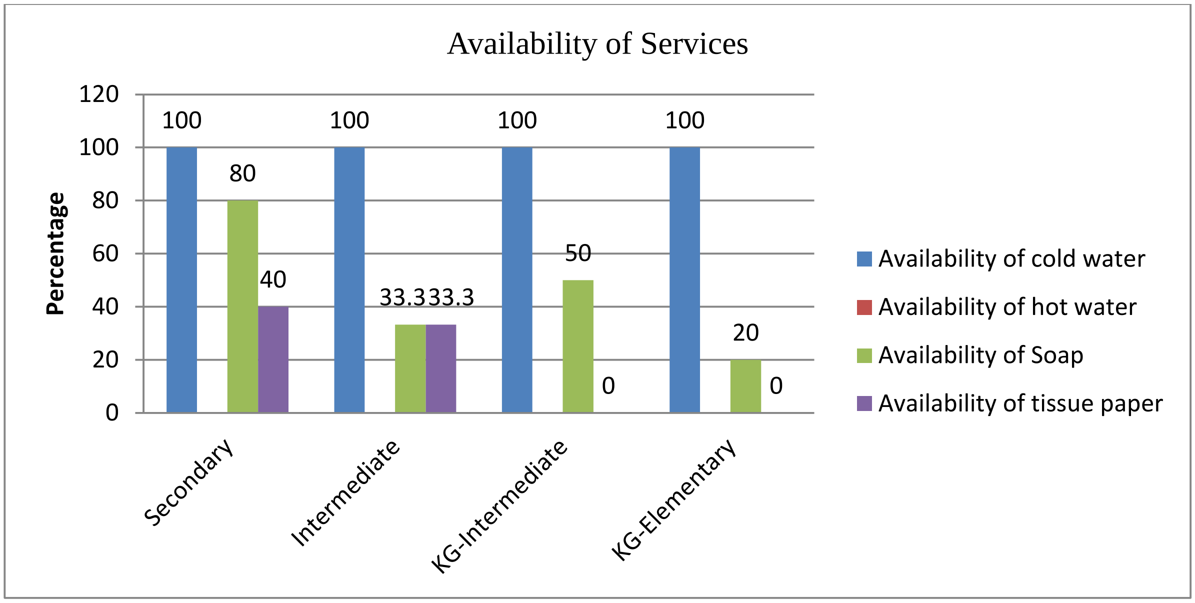

Figure 9: Provision of Running Water (Cold and Hot), Soap and Tissue Paper

4.3.4. Proper Ventilation of Toilets

To add to the problem, toilet facilities are not properly ventilated. The main method of ventilation is through windows in 80% (12 schools) of surveyed public schools, while 20% (3 schools) of the surveyed public schools have no ventilation (figure 10). This is an improper method of ventilation since bad odors will not be effectively removed as noted during the field survey; suction fans should be installed to keep toilet facilities properly ventilated. Improper ventilated toilets were also reported by the national survey of public schools 2008-09 in which 61% (44 schools) use windows, 29.2% (21 schools) do not have properly ventilated toilets and 4.2% (3 schools) have small windows on top of the toilet doors, while only 5.6% (4 schools) use fans. This is not an acceptable WASH service indicator because vectors and diseases are spread and transmitted quickly in poorly ventilated toilets, unclean, and with deficient handwashing services such as soap (UNICEF, 2012).

4.3.5. Toilet Doors

As for privacy and security of toilet facilities, the toilet cabins are equipped with doors to allow privacy and locking systems are placed to provide security in all surveyed public schools. Moreover, as toilet doors and door handles are possible sites of disease transmission, self-closing doors should be installed to reduce the contact of students with unclean surfaces. Currently however, not all schools implementing WASH interventions equipped self-closing doors in the toilet facilities. Among the surveyed public schools implementing WASH interventions only 20% (3 schools) of public schools have proper self-closing door in comparison to 15.28% (11 schools) reported by the national survey of public schools 2008-09. As such, this issue has not been addressed and is still not in compliance to WASH Guidelines.

4.3.6. Wastewater Disposal

Wastewater of all surveyed public schools is properly discharged in sanitary sewerage systems. This is a major WASH requirement to protect students against vectors and vector-borne diseases (UNICEF, 2012).

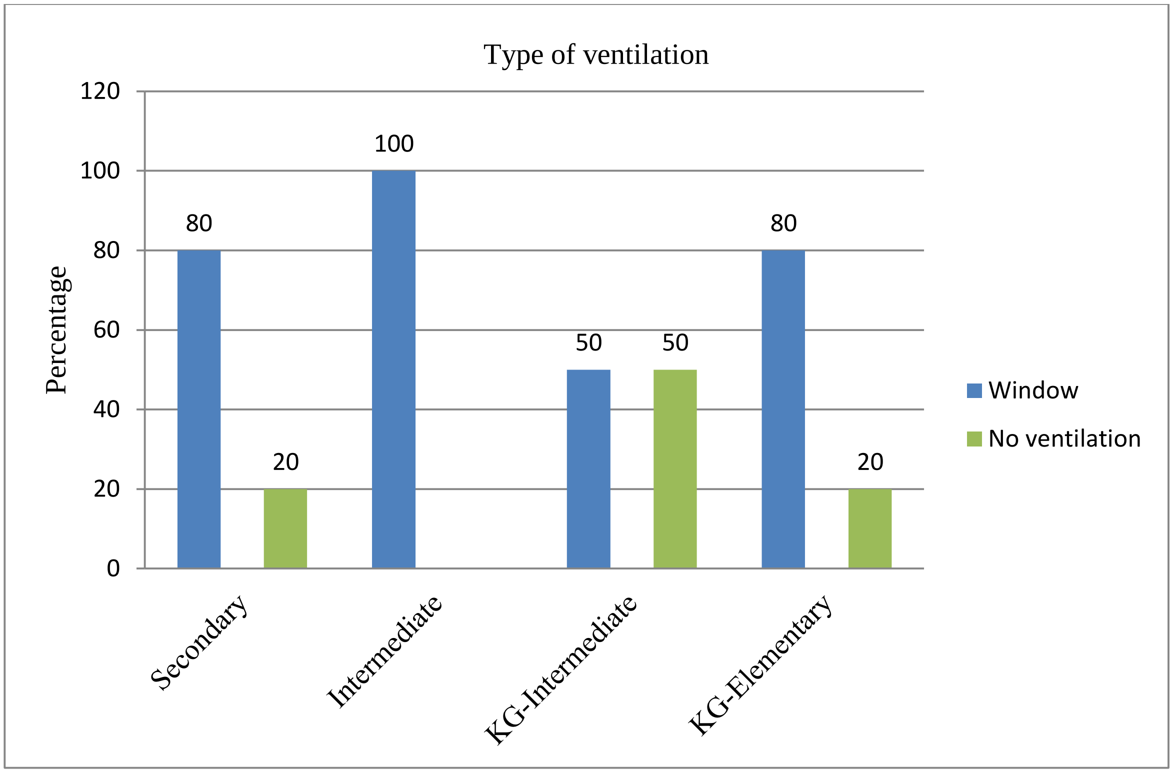

Figure 10: Type of Toilet Ventilation

Other reported surveys in developing and developed countries found sanitation services to be inadequate. A survey of 12 schools in Nigeria showed that only 3 schools (25%) had access to drinking water, 40% of schools had no private latrines, and only 1 school had hand-washing basin but without soap. Moreover, 9 schools (75%) were overcrowded with ratio of toilets to students range from 1:70 to 1:320 (Olukanni, 2013). A survey of WASH facilities in 68 schools in New Zealand found that 6 schools had no hand drying services (8.88%), 34 schools had no access to hot water (50%), 5 schools had no toilet paper in some toilets (7.3%) while only one school (1.4%) had no available liquid or bar of soap (Reeves, Priest, & Poore, 2012).

4.4. Hygiene Promotion

Hygiene promotion is essential to help students improve their hygienic practices and become "agents of change" in their community (UNICEF, 2012). Several studies established the importance of school-based hygiene promotion in transferring knowledge from students to their community (Patel, et al., 2012; Blanton, et al., 2010; Reilly, et al., 2008). A longitudinal study in Kenya in 2012 showed that WASH program demonstrated sustained improvements in hygiene knowledge among students in interventions schools that installed and maintained handwashing stations near latrines and drinking water stations near classrooms with provision of soap and hygiene promotion instructional materials for students (Patel, et al., 2012). In 2007, a school-based program in 17 Kenyan schools installed water drinking and handwashing stations and trained teachers to promote water treatment with disinfection powder and hypochlorite solution to pupils. This resulted in a significant increase in parental awareness of disinfectant (49-91%, $P<0.0001$) and household use water treatment practices such as disinfection (1-7%, $P<0.0001$) and hypochlorite solution (6-13%, $P<0.0001$) (Blanton, et al., 2010). In 2006, the results of a survey of 390 students from 9 schools showed significant improvement in students' knowledge of correct water treatment procedure (21-65%, $P<0.01$) and an increase in household water treatment was reported from 6 at baseline to 14% ($P<0.01$) (Reilly, et al., 2008).

Results of the survey showed that all surveyed public schools implementing WASH services are educating students on the importance of personal hygiene and are conducting regularly personal hygiene related activities organized by certified health advisors. Moreover, personal hygiene billboards are placed in 86.7% (13 schools) of surveyed schools as illustrated in figure 11.

Still, posters that teach proper handwashing practices should also be placed in the toilet facilities to remind the children of proper hygiene practices such as handwashing technique. Besides, teaching students on the importance of good hygiene should also be coupled with functional water and sanitation fixtures that should be properly maintained at all times. And, students might skip some essential hygienic steps if toilet facilities are not clean and properly ventilated.

Figure 11: Sample of Handwashing Posters

4.5. WASH Intervention

The WASH program in public schools was mostly initiated and implemented during 2012-13 academic year, as indicated before. It is supported by the Ministry of Education and Higher Education, NGOs and UN organizations such as UNICEF and Rotary club. The support that was provided mainly related to upgrading water services; attempting to improve water quality by installing FDA approved storage tanks and onsite treatment units, and replacing the old drinking water fixtures. Moreover, awareness sessions were conducted to inform schools about the WASH guidelines that were adapted specifically for Lebanese schools. Still, majority of the surveyed public schools implementing WASH guidelines reported financial and technical challenges as hereby reported:

- Financial challenges:

Although some funds have been allocated to improve WASH services, these funds are limited and not enough to upgrade and maintain WASH facilities. To add to the problem, overcrowded schools (especially after the progressive influx of Syrian refugees) lead to overuse and misuse of WASH facilities; recurring broken fixtures, leaking latrines and increased cost of sanitary services such as soap and toilet paper. Additionally, surveyed public schools reported facing financial difficulties in replacing onsite filter cartridges as often as 3 times a year as the first year replacements is only covered by the NGO (Rotary club). Moreover, schools are responsible for maintaining and replacing the filter cartridges and testing water quality. This adds on the financial burden on schools.

- Technical challenges:

Technical difficulties in sustaining WASH services highlight the importance of low cost durable technologies to avoid break down of WASH facilities. Furthermore, technical issues and challenges such as onsite cartridge maintenance, storage tank cleaning, disinfection, and repairing water and sanitation facilities have to be addressed and mitigated on daily basis. Due to financial barriers, it is difficult to respond and address repair and maintenance problems in a timely manner before water and sanitation infrastructure breaks down. To add to the problem, there are no specialized people or technical experts who are knowledgably in onsite water treatment, water quality, water quality monitoring. As such, the majority of schools do not know how the water treatment unit functions and how it should be maintained. They rely on external party (NGOs) to maintain the systems. Moreover, failure to solve problems quickly would expose students to health risks such as diarrhea and vector borne diseases from leaks in toilet facilities.

The support on WASH services was mainly focused on water services. Still, water services were not properly maintained and sustainable to meet WASH guidelines. Water storage tanks, filter cartridges, and water fountain fixtures were not routinely cleaned, inspected and maintained. Besides, the water quality should be routinely monitored in all schools due to the reliance on deteriorated ground water sources and as such water quality and quality control programs is still deficient as surveyed in the national study of 2008-2009.

Government, schools, NGOs, and communities should follow a planning process to assess and analyze WASH related services, set targets and develop plan of action, allocate roles and responsibilities and monitor and evaluate implementation process.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

WASH services in the surveyed public schools are still deficient and not fully in compliance with WASH guidelines. This is mostly due to the limited allocated financial resources and deficient technical support needed to upgrade WASH facilities and sustain services.

- Water Supply

Major interventions in public schools implementing WASH since 2012 related mostly to installing FDA approved water storage tanks that will safeguard stored water and prevent corrosion and leaching of chemical contaminants. Additionally, onsite water treatment units have been installed in 93.3% (14 schools) of the surveyed schools where 86.7% (13 schools) include onsite disinfection unit (UV filter). The treatment process removes turbidity, color, dissolved organic substances, and pathogenic microorganisms. Still, surveyed public schools are unable to technically manage the treatment units and conduct routine maintenance and as such are highly dependent on the supporting NGO. Moreover, schools still lack proper water quality assessment and water quality monitoring. The extent of water quality assessment is highly limited (TDS, pH and total and fecal coliforms) and is limited to once/year (73.3% of schools) and twice/year (26.7%).

Mostly schools depend on water distribution systems (60% of surveyed schools), private wells (26.7% of surveyed schools) and cistern water (13.33% of surveyed schools). The quality of all these sources should be determined on continuous basis to prevent exposure to disease. Water quality assessment of samples collected July 2015 showed that 20% of the schools' water supplies have a high total dissolved solid content exceeding WASH Guidelines and LIBNOR Standard Levels. And, 26.7% of water supplies are microbiologically unsafe. This contributes and is line with the reported water complaints relating to water “taste” (High TDS) and safety. Moreover, this shows that the water treatment unit is not being properly operated and maintained. And, 40% (6 schools) of schools do not recommend that students drink from these water fountains. In these schools, students are encouraged to carry potable water to school or purchase it from school vendors for the fear of acquiring and transmitting water-borne diseases. This is not a good indicator of the safety of the water supplies provided, and is not in line with WASH guidelines and shows that water quality and quality control programs in schools are deficient.

All surveyed schools have drinking water fountains installed in the playground areas; 1 to 2 functional water fountains for every 100 students in all educational categories of surveyed public schools with the exception of secondary schools with higher mean ratio of 0.03 (3 drinking water fountains for every 100 students). This is not adequate and drinking water fixtures should be increased and leveled at different sections to meet WASH Guidelines. Moreover, broken or corroded fixtures should be immediately identified, fixed or replaced, and properly used, cleaned and maintained.

- Sanitation

The mean ratio of the total number of toilets to total number of students is 0.04 (4 latrines for every 100) in schools implementing WASH interventions except for the secondary school category (0.07). As for toilet cabins being gender specific, the mean ratio of the total number of toilet cabins and urinals for males to total number of male students is 0.04 and 0.03 respectively (4 toilet cabins and 3 urinals per 100 boys) and the mean ratio of the total number of toilet cabins for female students to total number of females is 0.04 (4 latrines per 100 girls). These results are not in line with WASH guidelines and the number of toilet cabins and urinals is still deficient. Possible reasons might be a result of an increase in number of students and failure to maintain toilet cabins. 20% (3 schools) of surveyed public schools clean toilets three times a day and reported problems include toilet clogging, broken seat latrines and urinals, and water leaks from water tank. Moreover, only 20% (3 schools) of surveyed public schools have proper self-closing doors and not all toilets have proper self-closing doors

Additionally, the number of functional water basins is not sufficient and need to be increased to meet WASH guidelines (UNICEF, 2012). Hot water is not available in any of the schools; while soap is provided in 46.7% (7 schools) and tissue paper in 20% (3 schools) of surveyed public schools.

Moreover, water fountains are also used for handwashing in all schools. Such settings do not support the provision of sanitation services such as cold and hot water, soap, and tissue paper, which are essential to promote hand washing and ultimately improve hygienic practices.

However, wastewater is properly discharged through sewage systems in all schools, which is a WASH requirement. This is a preventive measure to protect students against vectors and vector-borne diseases.

- Hygiene Promotion

Activities mainly relate to personal hygiene promotion activities organized by certified health advisors. And, personal hygiene billboards are placed in mostly all schools (86.7% of schools). Still, the improperly maintained water and sanitation facilities would not enhance proper hygiene practices such as handwashing technique. And, students might skip some essential hygienic steps if toilet facilities are not clean and properly ventilated.

Hence, as presented, the WASH interventions in public schools are not sufficient in addressing water, sanitation, and hygiene challenges. As such, the following is recommended to support the implementation and ensure the sustainability of WASH programs in public schools in Lebanon.

- Have the Ministry of Education and Higher Education assume ownership and commit to the development and sustainability of WASH programs in public schools by establishing a surveillance and management unit that will monitor, evaluate, and guide schools.
- Develop an implementation priority plan (prioritize short term, intermediate and long term WASH interventions). Short to intermediate interventions would include mitigating maintenance and repair of WASH facilities; broken latrines and water fixture, and maintenance of onsite water treatment units. On the other hand, intermediate to long term interventions would relate to upgrading (quality and quantity) of water and sanitation facilities and infrastructure (number of toilet cabins, urinals, water fountains and basins).
- Increase funds and allocate sustainable resources to upgrade and sustain WASH services in public schools given the increase in student body (influx of Syrian Refugees).
- Empower public schools with the needed technical expertise needed to monitor, manage and maintain WASH facilities quickly and effectively without reliance on external resources that may be neither reliable nor sustainable.

  Train staff (certified health advisor) of public schools to identify problems and gaps in the delivery of WASH services. And accordingly, recommend appropriate interventions.
- Mobilize stakeholders (local and international NGOs, water authorities, community, and municipality) to contribute to the provision and sustainability of WASH programs in private schools.

APPENDIX 1

UNICEF WASH Guidelines for Schools

	Indicators	Guidelines
Drinking Water Quality monitoring and perception	1. Microbiological quality of drinking-water 2. Treatment of drinking-water 3. Acceptability of drinking-water (No tastes, odors, colors)	• Water quality testing: at point of delivery, Ideally once a week, minimum once a month • Chlorination: Regular measurement of Chlorine level (Chlorine level <5mg/liter) • Turbidity: < 5NTU ; preferably <1 NTU for chlorination to be effective • Suspended solids: less than 5 NTU (directly related to Turbidity) • Microbiological analysis of water sample: 0 coliforms /100ml • Alkalinity/Acidity: pH between 6.5 and 8.5 • Hardness: 100–300 mg/L (Hardness levels above 500 mg/L are generally considered to be aesthetically unacceptable) • Conductivity (measure for TDS): less than 1000mS/cm (TDS under 1000mg/L) • Salinity: 200-300mg/L • Maintenance of water distribution points: Daily cleansing of the taps and basins • Maintenance of storage tanks: (4 times a year, minimum once before the beginning of academic year) • Maintenance of the water network: Once a year during summer breaks, immediately repair any leaks once observed.
Access to Water (Sufficient water-collection points and water-use facilities are available in the School)	1. Hand Washing (Functional water point, with soap is available at all the critical points within the school, particularly in toilets.) 2. Drinking water (Functional water point is accessible for schoolchildren)	• Number of sinks: 1 sink for every 8 students at preschool level 1 sink for every 15 students above preschool level • Number of fountains: 1 fountain for every 12 students at preschool level 1 fountain for every 20 students above preschool level The height of the taps should vary based on the size of children
Sanitation Facilities (toilet facilities should be sufficient, accessible, clean, private, secure, and gender-specific)	1. Sufficient number of toilets 2. Privacy 3. Availability of Hygienic materials 4. Gender specific 5. Accessibility	• Sufficient number of toilets: 1 toilet for every 8 preschool students 1 toilets for every 20 schoolgirls 1 toilet and 2 urinals for 30 schoolboys • Privacy Cabins are equipped with doors with locking system • Hygiene: Availability of soap, toilet paper, running hot and cold water Toilets are cleaned three times a day after each break Toilets have hand washing facilities in close proximity • Gender specific Strict gender separation between toilet boys and girls • Accessibility For sitting toilets: Max height 30cm ; Max diameter 15cm For Wash basin: Max height 50 cm Pre-school toilet block should be close in proximity to the classroom
Hygiene promotion (Appropriate use and maintenance of water and sanitation facilities is ensured through hygiene promotion)	1. Curriculum 2. Behavior 3. Environment	• Hygiene education is part of the curriculum • Teaching proper hygiene behavior through billboards presented on strategic places on school premises • All infrastructure and materials such as water taps, sanitary equipments, should be functioning to ensure children practice what they learn

(UNICEF, 2012; UNICEF 2008)

APPENDIX 2

Survey tool

Name of School:
Telephone Number:
Email:

1. **School Size**

Q1. Number of students (Total):	**Q2.** Number of males	**Q3.** Number of females
St_total	St_male	St_Female

2. **Water services**
   a. Access to water

Q4. Sources of drinking water	**Q5.** Water Tank (If applicable)	**Q6.** Water tank covered safely (if applicable)	**Q7.** Number of drinking water fountains	**Q8.** Drinking water fountains height appropriate for all ages
Source_drkwt	Source_st	St_cover	Tot_nofoun	Waterfoun_hgt
01. Public water 02. Well water 03. Water Gallons 04. Water cistern 05. Other ………..	01. Concrete 02. Metal 03. Plastic 04. Agrees with safety standards 05. Others……..	01. Yes 02. No		01. Yes 02. No

Q9. Location of drinking water fountains (if applicable)	**Q10.** Drinking water fountains also used for hand washing (mixed use)	**Q11.** School drinking water
Watfoun_loc	Mix_use	Pro_water
01. In Playground 1. Yes 2. No 02. Near Playground 1. Yes 2. No 03. Near Cafeteria 1. Yes 2. No 04. Near administrative offices 1. Yes 2.No 05. Other:………	01. Yes 02. No	01- Provided by school 02- Purchased by student 03- Not provided by school

b. Onsite Disinfection

Q12. Water onsite disinfection (chlorine)	**Q13.** Disinfection technique (chlorine addition)	**Q14.** Measure chlorine levels (If applicable)	**Q15.** Who measures chlorine residual levels
Source_chl	Chl_type	Res_chl	Mea_chl
01. Yes 02. No **(Q17)**	01- Chlorine added manually in water tank 02- Chlorine Added Automatically in the water tank 03- Other…….	01- Yes 02- No	01- School 02- Municipality 03- Water authorities 04- NGOs 05- Other………

c. Water quality monitoring and perception

Q17. Water microbial quality monitoring	**Q18.** Assessment of water microbial quality is conducted by	**Q19.** Water quality perception	**Q20.** Drinking water users	**Q21.** Reasons for not drinking	**Q22.** Students carry water to school
Bacqual_drkwt	Bacqual_drkwt	Perqual_drkwt	Users_drkwt	Nowat_reasons	Carry_water
03. Yes 04. No **(Q19)**	01- School 02- Municipality 03- Water Authority 04- NGOs 05- Other…….	01- Drinkable 02- Not Drinkable	01- Students 1.Yes 2. No 02- Teachers 1.Yes 2. No 03- Staff 1.Yes 2. No	01- Color 02- Water turbidity 03- Taste 04- Unsafe	01- Yes 02- No

3. Sanitation Services

Q25. Total number of water-basins	**Q26.** Water basin location	**Q27.** Total number of water basins (Kindergartin)	**Q28**. Number of water-basins for kindergartin males	**Q29.** Number of water-basins for kindergartin females	**Q30.** Total number of water basins (Elementary)	**Q31.** Number of water-basins for Elementary males	**Q32.** Number of water-basins for Elementary females	**Q33.** Total number of water basins (Intermediate)	**Q34.** Number of water-basins for Intermediate males
Tot_bsn	Watbsn_loc	Pre_bsnT	Pre_bsnM	Pre_bsnF	Ele_bsnT	Ele_bsnM	Ele_bsnF	Int_bsnT	Int_bsnM
	01- Near the toilets 02- In a room that leads to the toilet								

Q35. Number of water-basins for Intermediate females	**Q36.** Total number of water basins (Secondary)	**Q37.** Number of water-basins for Secondary males	**Q38.** Number of water-basins for Secondary females	**Q39.** Availability of cold water	**Q40.** Availability of hot water	**Q41.** Availability of soap	**Q42.** Availability of tissue paper	**Q43.** Water basin placed at low height for kindergarten students	**Q44.** Latrines placed at low height for kindergarten students
Int_bsnF	Sec_bsnT	Sec_bsnM	Sec_bsnF	Cold_water	Hot_water	Soap	Tissue	Prebasin_low	Cls_low
				01- Yes 02- No	01- Yes 02- No	01- Yes 02- No	01- Yes 02- No	01- Yes 02- No	01-Yes 02-No 03-Not applicalble

Q45. Toilet self-close doors	**Q46.** Toilet ventilation	**Q47.** Type of toilet ventilation	**Q48.** Sewage disposal type	**Q49.** Total number of latrines and urinals	**Q50.** Total number of latrines and urinals for kindergarten students	**Q51.** Total number of latrines and urinals for kindergarten boys	**Q52.** Total number of latrines for kindergarten girls	**Q53.** Latrine Type for kindergarten students
Toi_selfclose	Toi_vent	Toivent_type	Swgdis_type	Tot_clsno	Pre_clsnoT	Pre_clsnoM	Ele_clsnoF	Pre_ty_cls
01- Yes 02- No	01- Yes 02- No	01- Window 02- Fan 03- Other …………	01- Sewerage network 02- closed pit 04- open pit 05- Other…..			Latrine Number: ….. Urinals Number: ……		01- Hole 1-Yes 2- No 02- Seat 1-Yes 2- No

Q54. Total number of latrines and urinals for Elementary students	**Q55.** Total number of latrines and urinals for elementary boys	**Q56.** Total number of latrines for elementary girls	**Q57.** Latrine Type (Elementary)	**Q58.** Total number of latrines and urinals for Intermediate students	**Q59.** Total number of latrines and urinals for Intermediate boys	**Q60.** Total number of latrines for Intermediate girls	**Q61.** Latrine Type (Intermediate)
ele_clsnoT	ele_clsnoM	Ele_clsnoF	Pre_ty_cls	Int_clsnoT	int_clsnoM	int_clsnoF	Pre_ty_cls
	Latrine Number: ….. Urinals Number: ……		01- Hole 1-Yes 2- No 02- Seat 1-Yes 2- No		Latrine Number: ….. Urinals Number: ……		01- Hole 1-Yes 2- No 02- Seat 1-Yes 2- No

Q62. Total number of latrines and urinals for secondary students	**Q63.** Total number of latrines and urinals for secondary boys	**Q64.** Total number of latrines for secondary girls	**Q65.** Latrine Type (secondary)	**Q66.** Cleaning toilets daily
sec_clsnoT	sec_clsnoM	sec_clsnoF	Pre_ty_cls	daily
	Latrine Number: ….. Urinals Number: ……		01- Hole 1-Yes 2- No 02- Seat 1-Yes 2- No	01- Yes 02- No

4. Hygiene Promotion

Q67. Hygiene education	**Q68.** Certified health care adviser	**Q69.** Billboards that teach proper Hygiene behavior	**Q70.** Sanitary equipments are functioning properly
Hyg_Edu	Cert_hlthadv	Hyg_bill	San_infs
01- Yes 02- No	01- Yes 02- No	01- Yes 02- No	01- Yes 02- No

5. WASH Interventions

Q71. WASH interventions	**Q72.** When was it implemented?	**Q73.** WASH interventions supported by:	**Q74.** Type of support	**Q75.** Is the program still working?	**Q76.** Problems in maintaining WASH interventions
WASH_int	WASH_imp	WASH_support	WASH_Type	WASH_work	WASH_problems
01- Yes 02- No	…….Year	01- NGOs support 02- Governmental support 03- Community support 04- Other…	01- Financial contribution 02- Awareness campaigns 03- Personal training 04- Other…	01- Yes Why? …… 02- No Why? ……	01- Lack of financial support 02- Lack of technical expertise 03- Other………

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