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Water Quality and Health in Egyptian Rural Areas

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Abstract

Safe and clean drinking water and sanitation is a human right. Improved drinking water for the human consumption should be free from pathogens such as bacteria, viruses, protozoan parasites and chemical pollutants to meet the biological, physical as well as chemical standards. However, inadequate sanitation and wastes treatment and disposal are responsible for water resources contamination. The large percentage of population in developing countries especially in villages not having access to safe drinking water and suffering from water-borne and/or related diseases especially diarrhoeal diseases. Egypt in the last decades has made significant progress in terms of direct access to safe drinking water at household level (92.4%) and basic sanitation services (92.9%). Unfortunately, there are many villages in rural Egypt that continue to rely on water delivery and waste disposal systems that are outdated, unhygienic, and therefore unsafe. As a result, the situation with regard to safe drinking water, household sanitation, and the environment within these communities is far from satisfactory. Hundreds of people had contacted typhoid during July-August 2009; the infections have been blamed on sewage contaminating water supplies. Childhood diarrhoea, are often caused by a multitude of factors. Numerous studies have revealed a strong connection between childhood diarrhoea and water quality and sanitation services. Extension programs to educate people on ways of protecting against the disease, improving water quality at the source and access to safe water, treating household water and storing it safely, improving access to adequate sanitation facilities and encouraging good hygiene practices, particularly hand washing are needed.

Keywords

Water and Health, Water in Egyptian Rural Areas, Water Borne-Diseases, Control Measures

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1. Clean-Safe Drinking Water Is a Human Right

Providing the population with clean-safe water is one of the keys for good health and reduction of high mortality rates between children. Thus, it represents one of the goals for many international agencies and institutions programs such as UN, UNICEF and WHO. Globally, safe water is a problem that facing the world in general and the developing countries in particular. Water resources, fund and low cost treatment technologies are necessary to help developing countries to scale up their efforts to provide clean, accessible and affording drinking water as a human right and essential for everyone. The United Nations called on member states and international organizations to offer funding, technology and other resources to help poorer countries.

2. Current Status and Progress of Drinking Water in Developing Regions

2.1. Global Situation

The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) monitors progress towards the Millennium Development Goal (MDG) target (UN, 2011) to halve, by 2015, the proportion of people without sustainable

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access to safe drinking water and basic sanitation. Between 1990 and 2008, the proportion of the world's population with access to improved drinking water sources increased from 77% to 87% which is closed to the MDG drinking water target of 89%. Despite this progress, it is estimated that in 2008, there were still 884 million people (37% of them live in Sub-Saharan Africa, 25% in South Asia, 17% in Eastern Asia and 9% in South-Eastern Asia) that did not use improved drinking water sources. At the current rate of progress, 672 million people will not use improved drinking water sources in 2015. According to JMP, 900 million people worldwide do not have access to "clean water". The indicator used for the MDG target is "an improved drinking water source" which does not necessarily mean access to "clean water". This means that accurate estimates of the proportion of the global population with sustainable access to safe drinking water are likely to be significantly lower than estimates of those reportedly using improved drinking water sources.

Since 2008, the JMP has been reporting access estimates disaggregated into three main water source categories (Table 1):

Table 1. The Tree Main Water Source Categories.

Piped water on premises	Improved drinking water sources	Unimproved drinking water sources
* Piped household connection located inside the user's dwelling, plot or yard	* Public taps or standpipes * Boreholes or tube wells * Protected dug wells * Protected springs * Rainwater collection	*Unprotected dug wells *Unprotected springs *Cars with small tank/drum *Tanker truck *Bottled water *Surface water (river, dam, lake, pond system, canal, irrigation channels)

Piped water on premises is the optimal service level, but in 2008 only 57% and 49% of the global and developing regions population, respectively, had this grade of drinking water. Between 1990 and 2008, the proportion of the population in developing regions using piped drinking water on premises increased from 71% to 73% in urban areas and from 21% to 31% in rural areas.

The proportion of the population in developing regions using some form of piped drinking water supply (piped on premises or public taps) increased from 46% in 1990 to 56% in 2008. The proportion of the population of the developing regions that uses other improved sources of drinking water increased in rural areas and remained static in urban areas, while the unimproved drinking water sources users were decreased from 29% to 16%. Use of surface water has declined significantly, but in 2008, 6% of the rural population in developing regions still relied on surface water. In 2008, almost one quarter of the population in developing regions used boreholes or tube wells, making this category the second most commonly used technology after piped on premises. In rural areas it was the most common type of drinking water source. Between 2003 and 2008 aid for basic drinking water and sanitation systems declined from 27% to 16% of total Official Developing Assistance (ODA) for drinking water and sanitation. Only 42% of aid is targeted at least developed countries and other low-income countries (UNICEF/ WHO, 2011).

2.1.1. Rural-Urban Disparities

Strong progress was made in rural areas between 1990 and 2008 and led to an overall reduction in the population without an improved drinking water source in developing regions by 346 million. Despite the fact that the overwhelming majority (84%) of the global population without access to an improved drinking source lives in rural areas, more people in urban areas gained access than did in rural areas (949 million vs. 728 million). Progress in access to improved drinking water sources shows different patterns across quintiles, but in all countries the poorest have the lowest level of service. For rural areas, considerable time and effort are needed to cover the remaining population without access to an improved drinking water source, and to ensure continued access for those who have. Of the 949 million urban dwellers that gained access since 1990, three out of four people gained access to a piped supply on premises (UNICEF/WHO, 2011).

2.1.2. Water Pollution in Egypt

In Egypt 98% of all drinking water comes from the Nile River and its canals. The major challenge facing Egypt now is that of developing and managing better the very limited natural resources of water to meet the needs of growing population (Abdel-Shafy and Raouf, 2002). Drinking water quality depends mainly on the quality of the raw water used, the pollutants content and of course the treatment technology. Clean drinking water is important because even very small amounts of contaminants can accumulate over a lifetime and may lead to serious health problems (Barzilay, 1999).

Industries, seems to escape widespread criticism except in specific cases. Industries in Egypt dump their toxic and untreated waste directly into the Nile River, about 350 industries are discharging their wastes either directly into the

Nile or through the municipal system. The waste produced from these industries contains some of the most hazardous chemicals such as detergents, heavy metals, and pesticides. Some group of pollutants are toxigenic, carcinogens, mutagens, and neurotoxins, are unaffected by the traditional methods of water treatment, which means that some harmful residues are left in drinking water causing health hazards for the consumers (Abdel-Shafy and Raouf, 2002).

Egypt's high population density can affect drinking water quality in a number of ways. One of the main reasons is that infrastructure, including both sewage and drinking water systems, cannot help but lag behind the pace of growth in many areas (Abdel-Shafy and Raouf, 2002). The poor or not-treated sewage as well as solid waste are often directly discharged or dumped into the nearest waterways leads to direct and serious contamination of the drinking water supply.

The agricultural activities, which utilize increased levels of various fertilizers (nitrate, ammonia), pesticides and herb-icides affect the water supplies including groundwater (Abdel-Gawad, 2004).

Underground water is known for its high salinity and is often polluted through mixing with sewage, industrial wastes, and drainage water. Water pollution of some wells led to exclusion of these wells as a drinking water supply.

The prevention of pollution at source, the precautionary principle and the prior licensing of wastewater discharges by competent authorities have become key elements of successful policies for controlling, reducing and preventing the inputs of hazardous wastes, nutrients and other pollutants from point sources into aquatic ecosystems. In terms of legal literature, there are many laws in Egypt that deal with the environment and especially with the water issue. In 1982, law 48 was passed for the protection of the Nile River from pollution (EEAA, 1982).

i. Water Pollution Problem in the Egyptian Rural Areas

In the Egyptian villages where industrial activities are limited or may be not existed, human as well animal wastes and agricultural wastes represent the main sources of water resources pollution.

Pollution sources in villages can be identified in five sources, as follows (HCWW, 2008):

a. Different types of wastewater collected by collection networks and discharged without treatment to agricultural drains and canals.
b. Vaults evacuation products directly discharged to waterways.
c. Direct discharge of wastewater from vaults to groundwater through wells.
d. Pouring gray water to village streets or surrounding waterways.
e. Disposal of solid wastes to waterways and leachate may reach groundwater.

Interestingly, despite the availability of piped water, women in a village in Qaliubeya and other in Menufiya Governorates still visited the canal three times daily to wash cooking pots and utensils after meals. They did not want to use too much water in their houses, especially for washing, to make sure that the septic tanks did not overflow and create puddles around the house. Women thought it was easier to wash pots and clothes in the canal, where water is plenty and flowing, and they believed. that contamination of canal water not resulting from washing clothes and utensils in the canal. Visiting the canal was also the only way for women to socialize and it offered a distraction from daily routines. This finding highlights the importance of considering water usage as well as access in the relationship between water supply and child health (Roushdy *et al*., 2012).

The link between poverty and pollution in Egypt is clear and operates on several levels. Firstly, there is association between poverty and dirtiness and dirties in turn associated with pollution (Hopkins and Mehanna, 1996).The second way in which poverty can be linked to pollution, especially with regard to drinking water, is the tendency of the poor to be disproportionately affected by lacking access to clean drinking water (UNICEF/WHO, 2011).

Hopkins and Mehanna (1996, 2000, 2003) note that health problems caused by pollution are not only exacerbates by poverty but it is so far associated with poor infrastructure for delivery clean water and evacuating waste, both of which can lead to increased health risks for individuals living in such areas.

ii. Sanitation in Villages: Problem Analysis

The first root cause of the problem of pollution, hygienic and environmental hazards in rural Egypt is the discharge of most rural wastewater to the environment with little or no treatment. The number of rural wastewater treatment plants in operation may not exceed 500, while the total number of villages exceeds 5,500. Many State-funded village sewer systems were constructed without treatment facilities in order to solve urgent problems of widespread septage ponding in streets and houses collapses. An estimated 89% of household in urban areas are covered by public sewer compared to 37% in rural areas. Only 6% of Egyptian villages are provided with wastewater treatment services (UNICEF/WHO, 2011). Children in rural households are 8.5 timed more likely than their urban peer is have no toilet facilities and nearly 10% of

households in rural areas use shared toilet facilities (UNICEF/WHO, 2011). Moreover, an undetermined number of villages, especially in areas of high water table, which are prone to these types of wastewater up-flow, have used self-help to resolve their problem by installing "informal" sewer on a household, neighbourhood, or village scale. The public sewer systems discharge to agricultural drains, but the informal systems may discharge to drains or canals.

The second root cause of the contemporary rural sanitation problem in Egypt generally and particularly in villages is that population growth, water scarcity, and expanded residential area are bringing wastewater disposal points into closer proximity with water abstraction points. The nexus of factors associated with this root cause is complex:

a. Population growth has led to an expansion of settlements over the waterways. The possibility to dump wastes into a waterway has been increased than before.

b. Water tables are rising as a consequence of perennial irrigation and increased provision of drinking water. These factors lead to the failure of on-site sanitation systems and to the increased exchange of pollutants between surface water and groundwater.

c. Water demands are increasing, resulting in increased need to reuse drain water for irrigation, particularly by tail-end farmers who suffer increasingly from shortages as water scarcity grows. Drain water reuse is not a marginal or deviant phenomenon in Egypt (HCWW, 2008).

iii. Drinking Water in Urban vs Rural Regions in Egypt

Considering the Egyptian water resources, the individual's expenditure in Egypt was around 1200 m^3/yr at a population size of 58 millions. By the year 2000 it decreased to 957 m^3 /yr which can be divided as 7% for the domestic use and 93% for the industrial and agricultural uses (El-kasas, 1998). Now the individual expenditure is reduced to 850 m^3 /yr and expected to reach 650 m^3 /yr in the nearest future. It is worth mentioning that the per capita water income in USA, India, China, and the international level are 10,000, 2430, 2520, and 2500 m^3 /yr, respectively. Thus it can be concluded that the Egyptian water expenditure, is about 30% of the international level.

In Egypt, a plan for large water treatment plants has been proposed since the last two decades to provide safe potable water for rural and secondary cities. This plan was in need of finance, time for design and construction which may be not available. Compact units for water drinking treatment become one of the options for production of potable water as a permanent solution in rural areas of Egypt for both villages and small towns (El-Nadi and Refaat, 1995).

Municipal water demand includes the water supply for major urban areas (217 cities) and rural villages (about 4617), is estimated at about 5.5 billion cubic meters (BCM) per year comes from the Nile system and groundwater sources. A small portion of the diverted water (about 1.0 BCM) is actually consumed, while the remainder returns to the system as polluted water.

Egypt has 217 cities that are 100% covered by potable water network, while the sanitation network covers only 38%. From the 4617 villages, 43% of which is covered by potable water network while sanitation network is extended to only 4% (Attia, 2004). Water production from 2690 water treatment plants is 25 million m^3 /day pumped through 196,000 Km water distribution network. The major factor affecting the amount of diverted water for municipal use is the efficiency of the delivery networks. Recent studies show that the average efficiency is as low as 50% and even less in some areas. The individual expenditure is 210 and 140 litre/day in the urban and rural areas, respectively (Abdl Wahaab, 2013).

The government's plan up till the year 2012 regarding potable water and sanitation (Donia, 2007) is:

*Management of existing use of facilities.

*Replacement of depreciated plants and networks.

*Establishment of new projects for the new communities.

*The plan includes a budget of LE 18 billion and of which 9 billion is allocated for potable water projects while 9 billion will for sewage treatment.

Generally, Egypt in the last decades has made significant progress in terms of direct access to safe drinking water at household level (92.4%) and basic sanitation services (92.9%) (El-Zanaty & Way, 2009). Yet access is uneven and stork geographical and socio-economic disparities persist affecting the living conditions and health of millions of Egyptian children and their families. Progress in access to improved drinking water sources shows different patterns across quintiles, but in all countries the poorest have the lowest level of service.

iv. Drinking Water Problems in Egyptian Rural Areas

Water pollution problem in the Egyptian rural areas is more acute because surface water resources as a result of unsatisfactory waste treatment are usually subjected to high contamination by human and animal wastes, which most probably contains a variety of microorganisms, beside the agricultural and may be some industrial wastes that may include hazardous materials. Some families depend on a private water supply which is not provided by a statutory water undertaker. The responsibility for its maintenance and repair lies with the owner or person who uses it. A private water supply can serve a single household or it can serve many properties. The water source could be a borehole or

well. Most of them bring water with poor microbiological quality and failing to meet the required standards, because the high groundwater level and unavailability of sanitary facilities. There was the possibility that harmful micro-organisms could be present, and that a significant risk to health could not be discounted (Jackson *et al*., 2001).

Purification of water to be used for drinking is therefore necessary and must be controlled by continuous testing. To ensure this, reliance has to be placed on regular bacteriological and chemical analyses to assess potability and to determine the test course of action for protecting the population against health risks and waterborne diseases (Donia, 2007). Egyptian standards for drinking water quality were set by Ministry of Health and Population which takes into account the WHO guidelines (WHO, 2006).

Drinking water problems in some Egyptian rural areas in different governorates are summarized by El-Gamal *et al*. (1985) and Donia (2007) as follows:

a. Problems in network distribution

The survey deducted that the Behira (Damanhour, Edkou, Abis, Garb Nobaria), Kafr elSheikh (Metoubas), Kalioubia (Khanka, Shobra elKheima, Shebin elKanater), Sherbin (Belbis, Zagaziq), Aswan (Abu Ris), Beni Sewif (Samasta), and Elminia (Deir Maus) has the following problems in network distribution:

- Aging of pipes that resulted in cracking and explosion pipes;
- The low water pressure in some regions due to informal pipes connections and population growth;
- Water losses due to the aging of networks and the non maintenance of the public valves;
- The increase of precipitation leading to reduction in the amount of water provided to the consumer and the increase in the probability of pollution due to non existence of cleaning valves;
- No residual chlorine at the end of pipes due to the increase of pollution and biofilm in pipes.

b. Problems in the use of compact water purification units

The following regions, Dakahlia (Gamalia, Samblawin, Belkas, Talkha), Bheira (Domiat, Kafr Batikh, Kafr elShenawy), Kafr elSheikh (Metoubas), Fayoum (Kom Ashim), Kahk, Roashdia), Ismailia (Salam, Abtal,Takadom), Kalioub (Shobra elKheima, Bigam, Kawasim), Sharkia (Roda 1, Roda 2) have the following problems:

- The intakes for compact units exist at the end of canals affected by the low water level resulted by the winter close period;
- The high pollution of the intakes due to the misuse of the inhabitants such as cleaning of dishes, animals and cloths in the river or canals;
- The operation and maintenance is usually done by unqualified person leading to units' breakdown or low treatment efficiency.

c. Problem of well water bacteriological pollution:

- Giza Governorate especially in Badrashin and Hawamdia;
- Sharkia Governorate especially Zagaziq, Abou metna and Fakous;
- Kalioubia Governorate especially in Toukh, Kalioub, Kafr Shebibn and Kafr Ragab.

d. Problems of water pollution by chemicals:

- Water polluted with manganese Giza Govenorate (Bortos and Osim), Gharbia Governorate (Ebn Kared, Elhekma and Kafr Esam), and Assuit Governorate (Kousia, Sadfa, Abou Tig, Badari and Fath);
- Water polluted with iron and manganese in Monoufia Governorate (Tala, Ashmoun and Shebin elkom).

3. Drinking Water and Health

3.1. Water and Health Impact

Some of health hazards that have been linked to drinking water supplies include heavy metals poisoning, carcinogenic, mutagenic, teratogenic effects (from chemical pollutants such as pesticides, chlorinated solvents and disinfection by-products), and bacterial, protozoa and viral infections (*Campylobacter*. *Salmonella*, *E.coli* 0.157, *Giardia*, *Cryptosporidium*, amoebas, enteric viruses). Effects of polluted water are compounded by the tendency of women to reuse the household water they fetch from the pumps or wells in order to avoid the arduous task of carrying of more water. Factors contributing to poor health due to any type of pollution are “compounded in the Egyptian case because of the concentration and density of the population” (Hopkins and Mehanna, 2003).

In rural poor households, children are 8.7 times more likely to drink from unsafe water sources that are open or located a half an hour’s round trip from their home than children who live in urban households, and 6% of women and girls spend time collecting water up to five or six hours daily in some cases (UNICEF/WHO, 2011).

Consequently, lack of access to safe water and proper sanitation services coupled with low level of appropriate hygiene practices lead to the spread of water related diseases and have a significant impact especially on children’s health

and nutrition. According to Ministry of Health and Population (MHP) it is estimated that around 9.1% of the mortality of children less than 5 years old is due to acute diarrhoea disease (MHP, 2009).

Ten percent of the total burden diseases worldwide could be prevented by improvements related to drinking water, sanitation, and hygiene and water resources management. Eighty-eight percent of cases of diarrhoea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene. In Egypt, the total burden diseases that can be alleviated by improving drinking water, sanitation, and hygiene is 25.1 percent (WHO, 2008).

Household water treatment and safe storage can serve as an effective means to remove pathogens and reduce diarrhoeal diseases associated with ingested water, even when drinking water is collected from an improved or unsafe source. Short-term (less than one year) studies link house water treatment and safe storage (HWTS) with a 35 - 44% reduction in diarrhoeal diseases (Waddington *et al*., 2009; Fewtrell *et al*., 2005). Over longer periods of time disease reductions are less (Fischer Walker *et al*., 2011), most likely because of difficulties in sustaining consistent use.

3.2. Water and Health Impact Cases

The following are examples for water and health impact on villagers:

3.2.1. Typhoid Fever

A report in Al-Ahram Weekly newspaper (2009) mentioned that hundreds of people have infected by typhoid during July-August, 2009. The infections have been blamed on sewage contaminating water supplies. Qalioubya with 276 cases was the worst hit governorate. In Sharqiya Governorate, 13 villager from Abou Kebir and Faqous were admitted to hospital. Abou Qurqas, in the El-Minya Governorate, has reported 53 cases, and 28 people have been hospitalised in Fayoum Governorate. While the Egyptian government official blamed the cases that appeared in Qualioubiya on groundwater pumps, widely used in rural areas where treated drinking water is not available, residents of Al-Baradaa village, where the high number of cases were confirmed, believe the contamination occurred in the potable water network. The contractor responsible for installing Al-Baradaa water network is currently being questioned over allegations that for test system fitness sewage was pumped into drinking water system without thoroughly cleaning and disinfection afterwards, leading to the contamination of potable water. The number of patients diagnosed with typhoid since the beginning of the year 2010 was 3,298 which cannot be considered an epidemic. The Ministry of Health says that the cause of the spread of the disease is drinking water contaminated with sewage. The water company stresses that it is not responsible for the contamination and the local authorities in Qalioubiya Governorate blame it on groundwater pumps. Eighty five percent of inhabitants of rural areas have access to sanitation facilities, and even then they are usually primitive. All houses should be connected to a functional sewage network since proper disposal of waste would help protect people from water borne diseases including typhoid, diarrhoea, protozoa and enteric viruses.

3.2.2. Children Diarrhoea

Childhood diarrhoea diseases are often caused by a multitude of factors. Numerous studies have revealed strong connection between childhood diarrhoea and the quality of water and sanitation services (WSS). According to the World Health Organization (WHO) and the United Nation Children's Fund (UNICEF), an estimated 88% of diarrheal deaths worldwide are attributable to unsafe water, inadequate sanitation, and poor hygiene, indicating that WSS intervention can play an important role in combating the incidence of this disease among children. These interventions include improving water quality at the source, improving access to safe water, treating household water and storing it safely, improving access to adequate sanitation facilities, and encouraging good hygienic practices, particularly hand washing (WHO/UNICEF, 2004).

A large number of studies have investigated the impact of WSS interventions on child health worldwide (Jalan and Ravallion, 2003; Glado and Briceno, 2005; Kolahi *et. al.,* 2009). A comprehensive review conducted by Waddington *et al.* (2009) on the impact of water, hygiene, and sanitation interventions on diarrhoea morbidity highlighted the fact that water quality is more important than water supply in reducing diarrhoea. Additionally, the authors found sanitation facilities to be as effective as hygiene in reducing diarrhoea morbidity.

Research investigating the effect of water and sanitation quality on child health and mortality in Egypt is limited. Ashour and Ahmed (1994) conducted a study in randomly selected urban and rural areas of Dakahlia Governorate in Lower Egypt and Sohag Governorate in Upper Egypt. A total of 1,020 mothers were interviewed in the study areas. Using logistic regression, the probability of diarrhoea was found to be high among children whose family disposed of refuse near the house or in surface water. The probability of diarrhoea decreased with household ownership of land, mother's knowledge of symptoms; causes of diarrhoea, and previous use of oral rehydration for treatment.

More recently, Abou-Ali (2003) used data from the 1995 Egyptian Demographic and Health Surveys (EDHS) to examine the impact of water and sanitation on infant and child mortality in Egypt. The study applied several methods, including parametric and nonparametric duration models.

Results indicated that access to municipal water and having a modern toilet facility decreased the risk of child mortality; sanitation was found to have a more pronounced impact on mortality than water.

Fuentes *et al* (2006) addressed WSS services and child mortality in Egypt in a multi-country project that used a set of Demographic and Health Surveys (DHS) and conducted in Cameroon, Egypt, Peru, Uganda, and Vietnam. The authors explored the linkages between mortality in the first year of life and different types of water sources and sanitation facilities. The investigation highlighted some seemingly consistent findings across the study countries; access to safe water was generally found to be more important for infant survival in rural areas, whereas access to improved sanitation facilities increases the chances of survival in urban areas. In Egypt, however, sanitation was not found to be significant under any specification, although there was some evidence of the effects of having access to a modern toilet facility in reducing the risk of death.

Qualitative fieldwork was conducted (Roushdy *et al.,* 2012) in eight randomly selected rural areas of three governorates (Menufiya, Qaliubeya, and Sixth of October) in Egypt's Delta area. These study locations were chosen because, as highlighted in the literature, rural areas often suffer from inferior access to improved water and sanitation facilities. The presumption was that the impact on child health of poor WSS access would be more pronounced in these areas. The qualitative data indicated that the quality and regularity of WSS services is a significant problem in Egypt, despite widespread access to improved services. Residents complained of poor water quality, low pressure, and frequent stoppages; as a result many stored water in preparation for service cut-offs. In terms of sanitation, it was found that even when households were equipped with a flush toilet; septic tanks and bayara which are quite common in Egypt were emptied infrequently, leading to leakages. Some local disposal services are dumping the waste into local waterways. Access to an improved-uninterrupted water source was found to have a significant negative effect on the incidence of childhood diarrhoea. Not storing water, a practice that is likely related to the consistent availability of water, was also found to have a significant negative effect on the incidence of childhood diarrhoea. The negative effect of improved-uninterrupted water supply on childhood diarrhoea was found to be strongest among children whose mothers had little or no education. These results indicate that interrupted water supply is an important child health issue in Egypt, particularly in rural areas and among families with mothers who had little education, and needs to be addressed.

The limited scale of awareness campaigns regarding childhood diarrhoea in the study areas indicates that more resources need to be devoted to disseminating health messages. Health messages regarding diarrhoea need to stress the seriousness of the disease and disseminate accurate information about causes. The fact that improved-uninterrupted water services have a greater effect on the health of children of mothers with limited education may also have something to do with health behaviours among this demographic group.

Quality of service issues are another important factor mediating the effect of improved WSS services on child health. At least one such quality issue cuts in water supply were shown to have a significant effect on child health.

On a policy level, these results indicate that interventions are needed to improve the quality of service delivery for both water and sanitation, particularly in rural areas. In addition to affecting health, inadequate water-service delivery appears to reinforce improper health practices, such as washing dishes in canals and storing water in ways that are not sanitary. Qualitative evidence that sanitation disposal services are inadequate for the large population of children whose households are not connected to the public sewer system is also a cause for concern. The study results, and particularly the positive treatment effect found for improved-connected sanitation, also indicate that current data regarding WSS service delivery is inadequate.

4. Conclusions

The following tasks are urgently needed in order to achieve the objective of better health for people living in the Egyptian rural areas:

1. Improvement projects necessary for wastewater collection, conveyance, and treatment in rural Egypt.
2. Operate wastewater projects in rural Egypt effectively and in a sustainable manner.
3. Implement projects necessary for collection, transfer, and safe disposal of solid waste generated in rural areas of Egypt.
4. Operate rural solid waste management projects effectively and in sustainable manner by rural local administration units.
5. Support the role of institutions responsible for environmental monitoring and enforcement of environmental health criteria.
6. Enable civil community to play a role in solving problems of rural sanitation and solid waste.
7. Support the role of institutions responsible for providing and development of human forces and conducting applied

research that serve the implementation of this strategy.

8. Raising family awareness on better hygiene and environmentally-friendly by practices, with special focus on hand-washing with soap, proper disposal of wastewater and home waste, food hygienic behaviour, rational use of water and preservation of the environment. This intervention could be carried out through community mobilization efforts such as, community gathering, festivals, women group meeting, child-to-child approaches, women-to-women approaches as well as house visits.

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