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An Investigation of the Linkage between Minimum Household Water Requirement and Health in the Greater Irbid Area

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ABSTRACT

The quantities of water secured for humans for their daily domestic use including hydration and hygiene requirements have an effect on their health conditions. Guidance on the minimum household water requirement to assure good health is lacking. This study aims at the development of such guidance using data for daily water consumption and diarrhea incidences in children below five as an indicator for health conditions. The study area selected is the Greater Irbid area in the northern part of Jordan. Statistical analysis of these data led to the development of a mathematical relationship between the daily water consumption and diarrhea incidences. Using this relationship, a minimum household water requirement can be determined corresponding to an acceptable diarrhea incidence rate as an indication for good health conditions. Data of the study area reflect a need to increase the share of water supplied to the citizens of Greater Irbid area.

KEYWORDS: Water requirements, Domestic water uses, Health, Irbid, Jordan.

INTRODUCTION

Water is the core constituent of the human body and most of the living species in this planet. A minimum quantity of water must be available for individuals not only for their survival but also for their various domestic needs to sustain good health. In its Guidelines for Drinking-Water Quality, the WHO defines domestic water as being *'water used for all usual domestic purposes including consumption, bathing and food preparation'* (WHO, 1996).

Several references report minimum water requirements for hydration of individuals according to their age, health condition, level of activity and environment. However, guidance on the minimum household water requirement for health is not available. International guidelines or norms for minimum water quantities that domestic water supplies should provide are lacking. Several references report different values of minimum water requirements that must be satisfied (Table 1). However, these references did not provide evidence that the reported minimum water requirements assure good health.

The lack of access to adequate water supplies leads to the spread of diseases. In many developing countries, fresh water sources are continuously decreasing in quantity and deteriorating in quality. Children bear the greatest health burden associated with poor water and sanitation. As reported by the WHO, 1.8 million people die every year from diarrhoeal diseases (including cholera); 90% are children under five, mostly in developing countries (WHO, 2004).

The requirements for domestic supply typically constitute a very minor component of total water withdrawals (Gleick, 1996). Sub-dividing uses of domestic water is useful in understanding minimum quantities of domestic water required.

Hydration Water Requirements

Water is a basic nutrient of the human body and is critical to human life. The human body requires a minimum intake of water in order to be able to sustain life before loss of body fluids due to dehydration occurs. Adverse health effects due to dehydration have been noted. Increased risks of urinary stone formation,

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increased risks of urinary tract cancer and poor oral health are examples of these health problems. Several references reported different values of hydration water requirements. The values summarized in Table 2 represent these requirements excluding water quantities derived from food. Despite these reported values, the determination of the hydration water requirements remains elusive, as this is dependent on climate, activity level and diet.

Table 1: Reported minimum water requirements

Minimum water requirements	reference
20 Lpcd from a source within one kilometer of users dwelling	WHO/UNICEF Joint Monitoring Programme, (WHO, 2000)
15 Lpcd for disaster relief	SPHERE Project (SPHERE, 2002)
20 Lpcd minimum criterion for water supply	Carter et al. (1997), WELL (1998)
50 Lpcd basic water requirement for domestic water supply	Gleick (1996)

Table 2: Reported hydration water requirements

Hydration water requirements	reference
2 Lpcd for adult male 1.4 Lpcd for adult female	Kleiner (1999)
2 Lpcd (assumed water consumption for 60 kg adult)	WHO Guidelines for Drinking-Water Quality (WHO, 1996)
1 Lpcd (for a 10 kg child) 0.75 Lpcd (for a 5 kg child)	WHO (1993)
3 Lpcd (for adult)	Gleick (1996)
4.5 Lpcd (for adult, moderate activity in the sun)	White (1972) as reported by WHO (2003)
4.8 Lpcd (adult female during pregnancy) 5.5 Lpcd (adult female during lactation)	WHO (2003)

Quantities of Water Required for Cooking

Water is essential as a medium for preparing food. Defining the requirements for water for cooking is difficult, as this depends on the diet and the role of water in food preparation. Kleiner (1999) suggested that approximately one third of the hydration water requirements is derived from food.

Water Requirements for Hygiene

Water requirements for hygiene can be defined as the quantity of water required for maintaining food and personal hygiene through hand and food washing, bathing and laundry. There are several diseases linked to poor hygiene including diarrhoeal and other diseases transmitted through the faecal-oral route; skin and eye

diseases, in particular trachoma and diseases related to infestations, for instance louse and tick-borne typhus (WHO, 2003).

The minimum water requirement for hygiene is dependent on several factors and conditions. People living in hot weather conditions will need more water for hygiene. Similarly, people who practise a high level of activity will need more water not only for consumption to avoid dehydration, but also for washing their bodies.

It should be noted that the availability of water does not necessarily imply better hygiene. The effective use of both water and cleansing agents and the timing of hygiene practices are more important than volumes of water used (WHO, 2003).

Table 3: Average daily consumption for selected regions within the Governorate of Irbid

Region	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Hakama St.	55	61	57	59	55
Eastern zone	82	79	79	81	77
Barha	77	81	82	84	82
University zone	69	65	66	69	68
Howara	81	86	86	83	83
Bushra	80	85	83	85	82
Sal	75	81	77	82	82
Hakama	80	88	89	85	82
Fou'ara	74	84	79	86	80

Table 4: Diarrhea incidences per 1000 people reported in selected health centers

Region	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Hakama St.	115	93	277	114	43
Eastern zone	30	24	19	9	9
Barha	3	3	0	6	11
University zone	26	16	11	21	12
Howara	9	9	14	16	20
Bushra	7	1	5	9	4
Sal	17	5	6	3	17
Hakama	5	11	23	19	45
Fou'ara	17	8	14	30	51

Table 5: Analysis of variance (ANOVA)

Model		Sum of squares	Df	Mean square	F	Significance
1	Regression	83.088	1	83.088	25.147	.000
	Residual	138.774	42	3.304		
	Total	221.862	43			

GUIDANCE ON MINIMUM WATER QUANTITY FOR HEALTH

Guidance on the minimum household water requirement for health is not available. In order to develop such guidance, a linkage between domestic water consumption and an indicator for the health conditions need to be established. In this study, the incidence of diarrhea among children below five is selected as an indicator for health conditions. The northern part of Jordan including Irbid city and a number of nearby villages were selected as the study area.

Water consumption data were collected from the Water Authority of Irbid for several regions within the Governorate of Irbid including several villages. These data cover a period of five years extending from 2000 to 2004. They include billed water quantities and prices, in addition to other metering fees recorded every three months. Total annual water consumption was computed. The average daily *per capita* water consumption was calculated as follows:

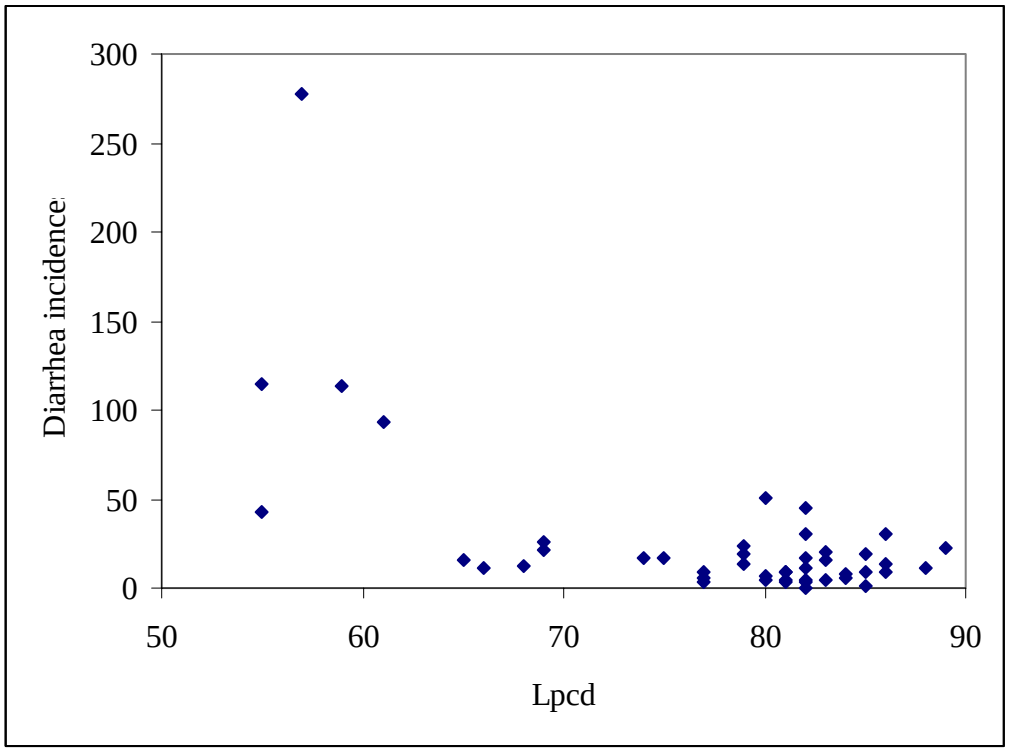

Figure 1: Scatter diagram between daily water consumption and the annual number of diarrhea cases per 1000 people

$$Lpcd = \frac{AC * 1000}{Ns * Nf * 365}$$

where:

Lpcd : average daily *per capita* water consumption, L/capita.day.

AC : annual consumption, m^3.

Ns : number of subscribers in region.

Nf : average family size taken as 5.8.

Computed values of average daily consumption for several regions within the Governorate of Irbid are summarized in Table 3. The average daily consumption for the Greater Irbid area is approximated by the averaging of the values reported in Table 3. This value is estimated at 77 L/capita.day. It should be noted that this figure may be an underestimation of the actual daily consumption because of several reasons. The estimation was based on billed water quantities which can be less than the actual consumption because of malfunctioning meters. In addition, in some cases the consumption is estimated for the subscribers because the water meter reading was not recorded by the water authority

employees. It should also be noted that in some areas, especially in the villages, people depend partially on rainwater collected in underground tanks to supplement their daily needs. Furthermore, increasing numbers of Irbid residences buy their drinking water from local water purification companies.

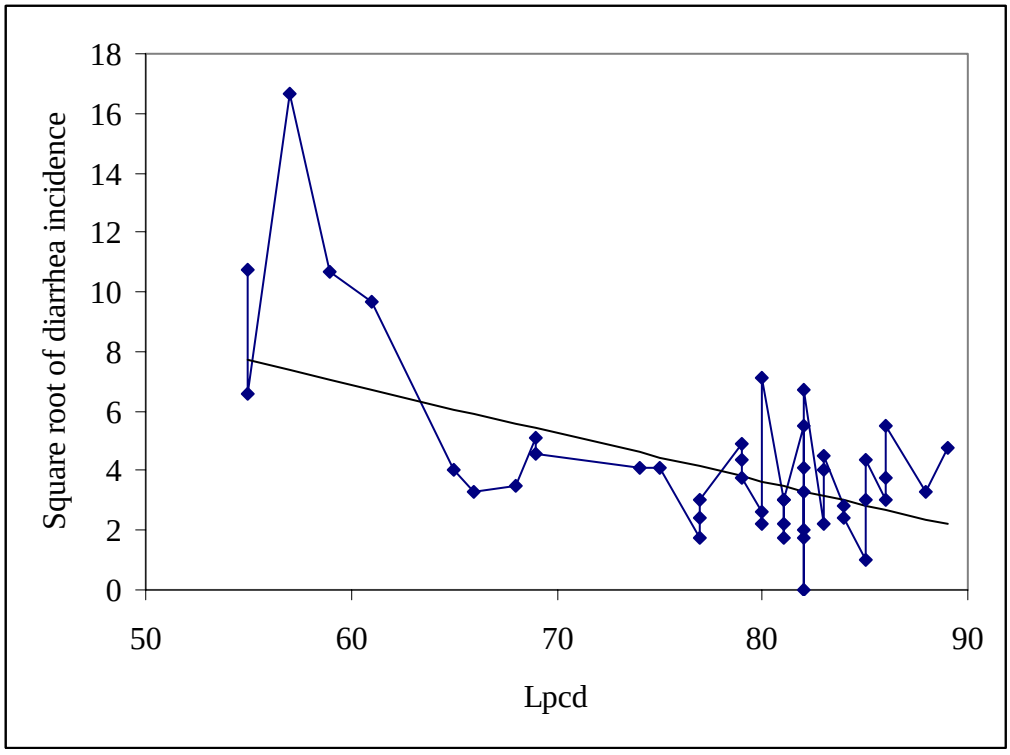

Figure 2: Fitted line between daily water consumption and the square root of the annual number of cases of diarrhea per 1000 people

Health data collected include the number of diarrhea cases reported in governmental health centers in several regions within the Greater Irbid area and the surrounding villages. The regions selected are the same as those in Table 3. These data were obtained form the Irbid General Directive for Health. The numbers of diarrhea cases reported in these regions are summarized in Table 4. It should be noted that these numbers do not represent the actual number of diahrrhea incidences. Irbid General Directive for Health estimates that nearly 50% of the diarrhea patients go directly to Princess Rahma Hospital, and so will not be recorded in health centers.

The data shown in Tables 3 and 4 were statistically analyzed to test their correlation and develop a mathematical expression to relate the daily water consumption and the diarrhea incidences.

To explore the relationship between daily water consumption and the diarrhea incidences per 1000 people for the five-year period from 2001 to 2004, scatter diagrams and regression analysis were used. Figure 1 shows that this relationship is not linear and clustered based on the region. Since the response variable in the study is the number of cases, thus the suitable transformation could be the square root of the response variable.

Figure 2 shows the scatter plot of daily water consumption and the square root of the number of diarrhea incidences per 1000 people and the fitted line using linear regression approach. Clearly, the square root transformation improved the linearity relationship between the two variables which validates the use of regression analysis.

Analysis of variance (ANOVA) was conducted. The results shown in Table 5 indicate that the daily water consumption is a highly significant factor for the number of diarrhea cases among children in Irbid. ANOVA shows that the coefficient of determination is 38%. This implies that 38% of the variation in the square root of the number of diarrhea cases can be

explained by the daily water consumption. It is sufficient to say that there are other factors affecting the number of diarrhea cases among children in Irbid which could improve the percentage of the variation in the number of diarrhea cases.

As a result of the regression analysis of the annual number of diarrhea incidences per 1000 people versus the daily water consumption in liters per capita per day (L/capita.day), the following fitted model is obtained:

$$y = 16.607 - 0.162\,x$$

where:

y = square root of the number of diarrhea cases per 1000 people.

x = Lpcd.

A representation of the daily water consumption and health data is shown in Figure 3.

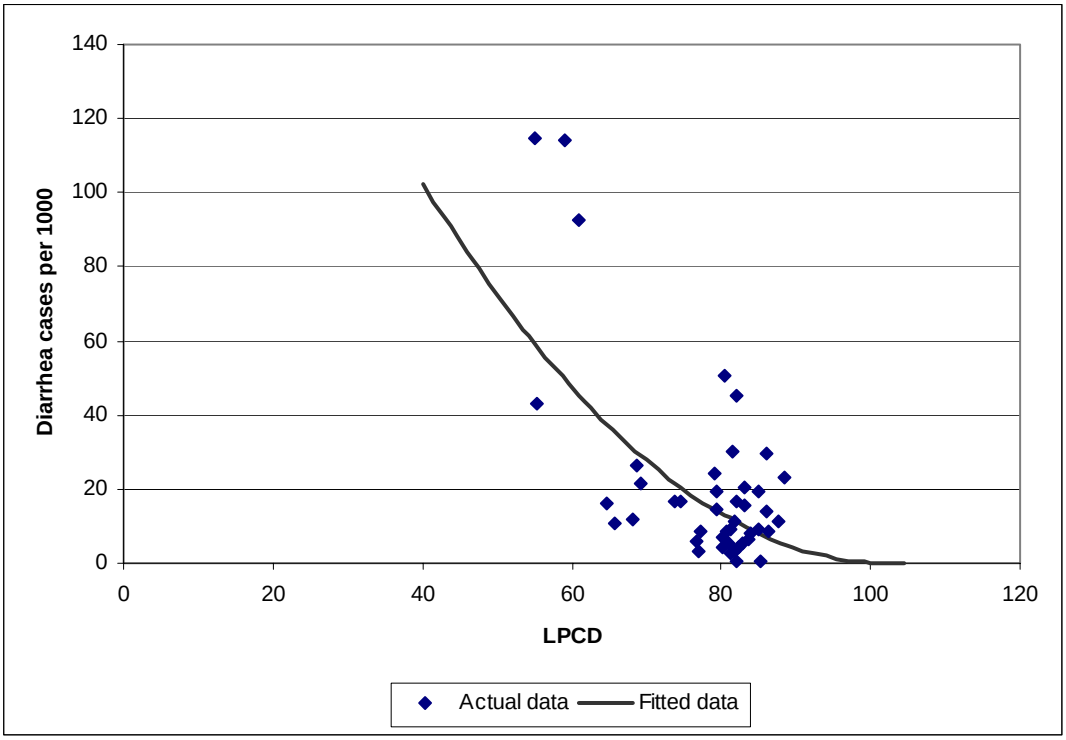

Figure 3: Actual and fitted annual diarrhea incidences *versus* daily water consumption

As shown in the Figure, the population of Irbid with an average daily water consumption of 77 L/capita.day will experience 20 incidences of diarrhea for each 1000 people. However, as mentioned earlier, approximately 50% of the diarrhea incidences are not recorded at health centers. As a result, the number of diarrhea incidences should be doubled.

The WHO considers 19 incidences of diarrhea per year for each 1000 people an acceptable health level. In comparison with this figure, Irbid seems to experience a higher number of incidences of diarrhea. The authorities should consider increasing the water pumping rate to the residence of Irbid.

Increasing the daily water consumption will result in a decrease in the incidences of diarrhea. A benefit/cost analysis is vital to determine the optimum daily water consumption. In such analysis, the reduction in the number of diarrhea cases will result in a reduction in the financial burden of the disease which is considered a benefit. The cost in this analysis will be the cost of increasing the daily water consumption.

CONCLUSIONS

A linkage was established between the daily water consumption and the incidence of diarrhea among children. This linkage was expressed in a mathematical form using water and health data for the Greater Irbid area. This mathematical relationship was used to provide guidance on the minimum household water

requirement that must be supplied to assure good health. The study recommends that more quantities of water need to be secured for the citizens of Greater Irbid area to improve health conditions.

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