Impact of the Provision of Safe Drinking Water on School Absence Rates in Cambodia: A Quasi-Experimental Study

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Abstract

Background: Education is one of the most important drivers behind helping people in developing countries lift themselves out of poverty. However, even when schooling is available absenteeism rates can be high. Recently interest has focussed on whether or not WASH interventions can help reduce absenteeism in developing countries. However, none has focused exclusively on the role of drinking water provision. We report a study of the association between absenteeism and provision of treated water in containers into schools.

Methods and Findings: We undertook a quasi-experimental longitudinal study of absenteeism rates in 8 schools, 4 of which received one 20 L container of treated drinking water per day. The water had been treated by filtration and ultraviolet disinfection. Weekly absenteeism rates were compared across all schools using negative binomial model in generalized estimating equations. There was a strong association with provision of free water and reduced absenteeism (Incidence rate ratio = 0.39 (95% Confidence Intervals 0.27–0.56)). However there was also a strong association with season (wet versus dry) and a significant interaction between receiving free water and season. In one of the intervention schools it was discovered that the water supplier was not fulfilling his contract and was not delivering sufficient water each week. In this school we showed a significant association between the number of water containers delivered each week and absenteeism (IRR = 0.98 95%CI 0.96–1.00).

Conclusion: There appears to be a strong association between providing free safe drinking water and reduced absenteeism, though only in the dry season. The mechanism for this association is not clear but may in part be due to improved hydration leading to improved school experience for the children.

Introduction

The receipt of a good quality education is one of the most important factors in enabling children to fulfil potential in later life and reduce poverty [1]. Increased educational attainment is also associated with substantial health gains especially on child health in future generations including reduction in child mortality [2,3]. Important gains in child health may be associated even with future mothers improved access to primary education alone [3]. The importance of access to education is reflected within the Millennium Development Goals of the commitment to ensure that all children can complete a course of primary education alone [3]. The importance of access to education is reflected within the Millennium Development Goals of the commitment to ensure that all children can complete a course of primary education alone [3].

The authors pointed out that time spent learning being linked to educational achievement is one of the most consistent findings [5]. However, as pointed out by Abadzi [1], instructional time available to children in many developing countries is often markedly reduced. Indeed Abadzi concluded that “assumptions about the pro-poor poverty alleviation effect of education may be unrealistic”, and that additional public investment may fail to mitigate poverty, unless it improves instructional delivery [1]. There are many reasons for this reduced educational contact time in low income countries, some of which are institutional such as teacher absenteeism, frequent school closures, etc [1]. However, even when schools are open, pupil absenteeism can be high [1]. Clearly reducing student absenteeism is important to improving educational attainment and consequent poverty alleviation.

Recent interest has turned towards the potential role of improving water and sanitation provision in schools as a tool towards improving children’s health and educational achievements. In a recent systematic review, the authors identified 41 studies that reported on the impact of water, hygiene and sanitation interventions on health and educational outcomes of which 8 were concerned with absenteeism [6]. Most of these studies were from developed nations. Although there was some indication of links between water and sanitation provision and
absenteeism, this was strongest around sanitation provision and
absenteeism in menstruating girls. No strong conclusions could be
made around the importance of drinking water. In probably the
largest study of its type Freeman et al. reported on a large cluster
randomised trial in Kenya on the impact of water, sanitation and
hygiene interventions on absenteeism [7]. This study included over
6000 pupils from 135 schools in three study arms: a control with
no intervention, a second study arm with hygiene promotion and
chlorine for drinking water treatment and a third study arm with
sanitation improvement in addition to the hygiene promotion and
water treatment. The authors found no significant difference
between any of the study arms, unless they did further sub-group
analysis. Furthermore, by restricting their drinking water inter-
vention to provision of near-to-use chlorination, Freeman et al.
only tested the impact of drinking water disinfection and did not
undertake an adequate assessment of the value of provision of
drinking water per se in schools on educational outcomes [7].
Furthermore, serious doubts have been raised about the health
value of household chlorination of drinking water as blinded
studies have repeatedly found no benefit [8,9]. The available
evidence of the benefits or otherwise of drinking water interven-
tions targeted at the level of the school in developing countries is,
therefore, weak. We report a quasi-experimental study of the
impact of provision of treated water in containers to schools on
recorded absenteeism.

Methods

This study was approved by the University of East Anglia
Faculty of Health ethical committee and the Cambodian National
Ethics Committee for Health Research. Given that we did not
introduce any intervention, only summaries of routinely collected
data were obtained and no person specific data was collected,
there was no requirement for informed consent to be obtained.

The intervention being investigated was delivery of treated
water in containers to schools. These water containers were
provided free of charge to schools and funded by “1001 fontaines
pour demain” (1001F), a non-governmental and not-for-profit
organization based in Caluire, France. 1001F has been working in
Cambodia since 2005. The basic model is to identify local
entrepreneurs and financially support them to build a local plant
to bottle filtered and ultraviolet disinfected water in cleaned and
disinfected 20 L containers. Most of these containers are then sold
to local customers. During and after start-up 1001F technical staff
provide training and an ongoing quality assurance scheme.
Funding for 1001F is mainly from private donors, though it has
also received financial support from French Embassies in the
countries where it works. A video highlighting 1001F’s work can
be seen at the following link: http://fr.youtube.com/
watch?v=8bykbVECVrE. In some of the villages, 1001F paid
the entrepreneur to provide free water to the village school.
Each participating school was provided with 1001F water in containers
to be placed in the classroom so that each child could take water
whenever they wished. For those schools participating in the
scheme one 20 L bottle of water was delivered to each class each
day. Given that the average class size was 38 children, this equates
to approximately 0.53 L per child per day. The overall cost of the
scheme was US$1.4 per child per year.

In this study, we obtained absenteeism data from the four
schools where 1001F were providing free water. In addition we
obtained this same data from four schools not in receipt of free
water. In a related community study of childhood diarrhoea we
were conducting a longitudinal study of childhood diarrhoea and
water use in 25 villages. These villages had been chosen at random
from all villages with an established 1001F presence or through a
process of propensity score matching, the details of which is
described elsewhere [10]. Four schools from these 25 villages were
in receipt of the free school water scheme and willing and able to
provide absenteeism data. Four control schools were chosen from
the other 25 villages based on number of registered students present
and the proportion of students under 14 years closest to those
values of the intervention schools. The head teacher was then
approached and invited to participate.

Data collection was based on routinely collected absenteeism
data provided to the study team by the head teacher. Data was
provided from the week beginning 4th December 2011 to 31st May
2012. This period spread over two school terms one of which was
in the dry season and the other the wet season.

Data analysis was done using STATA version 11. Absenteeism
rates per week were calculated as the number of days absent/
(3×children registered). Random effects negative binomial regres-
sion analyses were done using a generalized linear model with a
random intercept for school. The outcome variable was the
number of days lost in each week from absenteeism and the
number of children enrolled in the school was the exposure
variable. The predictor variables were whether or not the school
received water and season. Interaction terms were included for
intervention and season.

In one school it was discovered that the number of water
containers delivered fell short of the contracted amount. A further
regression analysis was done for this school with days missed in the
week being the dependent variable. The actual number of water
containers delivered in the week and days missed at all the other
schools combined were predictor variables. The analysis was
restricted to the dry season and excluded holiday weeks.

Results

Table 1 shows certain key characteristics of to the villages where
each of the eight schools were based. It can be seen that across
most characteristics the intervention and control schools were
generally very similar. The main exception is that very few people
in intervention villages have access to improved water or sanitation
compared to the control villages. This is not too surprising as the
1001F had primarily targeted its intervention at schools in areas
where it was known that the local community had poor access to
improved drinking water. Also of note was that rather more of the
populations of the intervention villages were reported as being
migrants. The predominant source of drinking water in the control
schools was whatever the children brought in from their home. In
one control school (C2) children also had access to a hand pump
and jar in a pagoda about 100 m from the school and in another
(C3) there was a rainwater harvesting tank for which children were
reported to have some use.

Data was collected for 26 consecutive weeks. Three schools
were closed during week 18, all schools were closed during week
19, and all but one in week 20. The dry season was taken to
include all the weeks before the break in week 19 and the wet
season in weeks subsequent to this holiday. Across all eight schools
this represented 60,194 child weeks of follow-up. The overall
absenteeism rate was 5.57%. Figure 1 shows the absenteeism rate
for each school by week. The most obvious finding was the
dramatic increase in absenteeism during the wet season, towards
the end of the study period. This was not surprising given the fact
that in many villages, children would be kept off school at this time
to help in the fields.

Table 2 shows the results of the negative binomial regression
analysis comparing absenteeism rates using whether or not the
school received free 1001F water and season as predictor variables. In addition we investigated the interaction between season and receipt of 1001F water. It can be seen that absenteeism was less than half in the intervention schools compared to those who did not receive 1001F water. Given the significant interaction term the association between having 1001F water and reduced absenteeism was restricted to the dry season with no such association in the wet season (as was also clear in figure 1).

At the end of the study period it became clear that one of the suppliers was not fully fulfilling their contract as they did not have sufficient capacity to provide water to the school and to their paying customers. Although container water was provided this fell short of the contracted amount. The remaining three schools received all their assigned supplies. Table 3 shows the results of the regression analysis of absenteeism in the school with incomplete water delivery adjusted for within week absenteeism in other participating schools. There was a significant association between the number of containers of water delivered in the week and reported absenteeism. For every extra container delivered there was a 2.9% reduction in absenteeism (95% confidence intervals (CI) 0.5 to 5.1%). The association was also tested between absenteeism and delivery in the previous week. Absenteeism was not associated with the number of containers delivered in the previous week.

Discussion

In this study we have shown lower absenteeism in schools receiving free containers of 1001F water. However, this association was only seen in the dry season and not in the wet season. There were also strong seasonal effects as absenteeism in several of the schools increased dramatically during the wet season, irrespective of water delivery. We were informed that this increase in absenteeism during the early wet season was partly because children were frequently kept off school to help in the fields. We have, furthermore, shown that in one school where delivery of water containers fell short of the contracted amount, absenteeism rates were associated with the number of containers delivered in the week. As far as we are aware this is the first study to show that provision of adequate safe drinking water in school can affect attendance in a developing country.

Clearly one has to be cautious when interpreting the results of an observational study like this. Nevertheless, taking both analyses together, this gives a fairly strong indication that provision of safe palatable drinking water is indeed associated with reduced absenteeism. Firstly although this study was not blinded and so potentially open to some form of reporting bias, school absenteeism rates are not subjective and so our results should not be at risk of reporting bias that has affected many other studies of water and health in low income countries [8]. We cannot, of course, exclude bias in the way the classroom teacher records the daily attendance register or in how the school compiles absenteeism data from the class registers. However, any such bias is far less likely when based on register records than may be expected by asking children to recall their absence history during interview as was done in the only other study of school absence and WASH [7]. Secondly, although it is plausible that selection of schools for the intervention may have led to a degree of bias, it is difficult to see how this would have affected the association found between number of containers delivered and absenteeism in the school with incomplete contract fulfilment. Of particular note here was that the intervention schools were generally in areas with poor domestic access to improved drinking water supplies and sanitation. If inadequate drinking water and sanitation does
impact of school absenteeism, then if anything this source of bias would be expected to increase absenteeism in the intervention schools rather than reduce it. It is not clear what effect if any the greater number of migrants in some villages would have on absenteeism in school. We would however suggest that further randomised studies are required before a more definitive conclusion can be made.

This leaves the question of what was the mechanism between water supply provision and absenteeism. In this study we were not able to collect any data on the reasons for the absenteeism. Given the fact that the association was between absenteeism rates and water delivery in the same week and not the previous week, we are not suggesting that this association was primarily due to a reduction in waterborne infectious disease. A possible explanation in our view may be that by providing readily available palatable and safe water in the classroom, children are more likely to drink during the school day and so not become dehydrated. Even mild dehydration in vulnerable groups such as young children has been suggested as being associated with various adverse health effects [11]. Furthermore, in a recent study from a hot dry region of Italy, the authors showed that supplementary drinking water was associated with improved cognition and an improved subjective sense of vigour [12]. This Italian study is in line with similar findings from several previous researchers [13,14]. What this suggests therefore is that provision of supplementary water sufficiently improves the child’s general wellbeing as well as the learning and experience of the school day as he/she is better hydrated. Consequently they are more likely to attend school the following day if they had felt good at school the previous day.

Even if, as we suspect, the main reason for the reduced absenteeism in the intervention group is due to improved hydration rather than a reduction in waterborne disease, this should not be taken as an indication that the provision of water of any quality would be acceptable. The link between contaminated

![Figure 1. Absenteeism rate by school and week. Solid line shows rates for intervention schools and broken line for control schools. doi:10.1371/journal.pone.0091847.g001](image)

<table>
<thead>
<tr>
<th>Table 2. Risk factors for absenteeism rates in schools.</th>
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<tbody>
<tr>
<td>Predictor</td>
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<tr>
<td>-----------</td>
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<tr>
<td>Receives 1001F Water</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Season</td>
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<td></td>
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<tr>
<td>Season-1001F water interaction</td>
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| doi:10.1371/journal.pone.0091847.t002 |
Safe Drinking Water and School Absence Rates

Table 3. Risk factors for absenteeism in school with incomplete delivery of water containers during the dry season.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Incidence Rate Ratio</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water delivered in week/container</td>
<td>0.971</td>
<td>0.949</td>
<td>0.995</td>
<td>0.016</td>
</tr>
<tr>
<td>Absenteeism days in other schools/days missed in week</td>
<td>1.000</td>
<td>0.992</td>
<td>1.007</td>
<td>0.976</td>
</tr>
</tbody>
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doi:10.1371/journal.pone.0091847.t003

drinking water and disease risk is well accepted and it is clear that the main risk falls on young children [15]. Any scheme to increase drinking water provision in the classroom that does not ensure that water is safe to drink is likely to put the children at risk of waterborne disease. However, providing safe water in the school environment does not necessarily mean children will drink it. Indeed taste appears to be a major determinant affecting whether or not people continue to use safe drinking water sources [16,17].

Chlorination of drinking water is associated with poorer taste for many people [18,19]. On the other hand filtration can be associated with improved taste [20]. The fact that 1001F water uses filtration and Ultraviolet disinfection but not chlorination would mean that it would have better taste qualities than other water sources. The environment does not necessarily mean children will drink it. Indeed taste appears to be a major determinant affecting whether or not people continue to use safe drinking water sources [16,17].

In conclusion, we have shown a significant association between provision of supplementary water in the classroom and reduced absenteeism rates. With the delivery mechanism in this study the cost per child is modest, but the potential benefit to children’s education and subsequent life potential could be extremely large. There is a great need for further research in this area, especially randomised control trials and studies aimed at determining the biological mechanisms behind this reduction in absenteeism.

Acknowledgments

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Author Contributions

Conceived and designed the experiments: PRH HR FJ HL MY PH C. Longuet. Performed the experiments: MY HL C. Lo. Analyzed the data: PRH FJ. Wrote the paper: PRH HR MY HL C. Longuet PH C. Lo FJ.

References