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Health impact of small-community water supply reliability

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ABSTRACT

There is still debate and uncertainty in the literature about the health benefits of community water supply interventions. This paper reports on a changing incidence of self-reported diarrhoea associated with the implementation of two community water supplies. We conducted prospective weekly recording of diarrhoeal disease in three communities. Two of the communities were scheduled to receive an improved water supply and one was expected to continue to rely on an unimproved source during the study period. Data of self-reported diarrhoea was collected from each participating household on a weekly basis for up to 56 weeks, of which some 17 weeks were prior to implementation of the new water supply systems. Data was modelled using Generalized Estimating Equations (GEE) to account for possible clustering within households and within villages. For the two intervention communities in the study, the incidence rate ratio (IRR) for all ages after the intervention was 0.43 (95% CI 0.24–0.79) when compared to the control community (who did not receive an intervention), implying a 57% reduction of diarrhoea. Both of the new water systems were unreliable, one not operating on 4 weeks and the other on 16 weeks. The more reliable of the two intervention systems was also associated with less illness than in the least reliable system (IRR = 0.41, 95% CI 0.21–0.80). We also noted anecdotal reports that during supply failures in the new systems some people were starting to use household water treatment. The implementation of improved water systems does appear to have been associated with a reduction of diarrhoeal disease in the communities. However the health impact was most obvious in the community with the more reliable system. Further research needs to be done to determine whether public health gains from community water supply interventions can be leveraged by occasional use of household water treatment (HWT) during supply failures.

Introduction

The World Health Organisation has estimated that 94% of diarrhoea cases can be prevented through environmental interventions, amongst them increasing the availability of safe drinking water (Bartram and Gordon, 2008). Yet despite general consensus on the importance of safe drinking water, some 272 million rural dwellers in sub-Saharan Africa still lack access to an improved water supply (Rural Water Supply Network, 2009). It is in these areas that one of the key millennium goals of reducing by one half the proportion of people without access to safe water by 2015 is very unlikely to be met (Montgomery and Elimelech, 2007).

While problems with access to safe drinking water for rural communities are not restricted to developing country settings but are also an issue for most western countries (Hunter et al., 2009a), problems related to access to improved safe drinking water are particularly acute for rural communities in developing countries. These communities traditionally have had to obtain their drinking water from untreated surface sources, often situated some distance away from their home (Hemson, 2007). In rural South Africa, where water supply infrastructure has been largely rudimentary or non-existent, small-community water supply systems have become the common mode of water supply (Momba et al., 2008). In these areas, water supply infrastructure is usually in the form of shared facilities such as communal taps (Peter-Varbanets et al., 2009). These supplies have varying reliability, with an unacceptable proportion of apparently improved supplies being non-operational when inspected (Rietveld et al., 2009).

One of the major problems facing the drive to provide access to, and maintain continuity of improved drinking water supplies has been the lack of strong evidence of the effects of system failure on public health gains from these supplies (Lee and Schwab, 2005). There is a great need for effective studies of the public health gains achievable from community safe drinking water supply interventions but more importantly there is also a need to investigate the effect of the reliability of these systems and assess the impact that poor reliability has on the public health objectives (Hunter et al., 2009b).

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The objective of the study presented here was to determine the effect of the reliability of newly established small-community water supply systems on community health gains expected from these interventions, using diarrhoea incidence as an indicator. This submission presents evidence of this effect.

Methods

The study was conducted in a remote and rural area in the Vhembe District, situated in the north-eastern parts of Limpopo Province in South Africa. Diarrhoeal incidence for children under the age of five in the area was 224.3 per 1000 in 2002, compared to the national average of 133.4 per 1000. At the time, the district was also below the national averages in terms access to safe water supply (Gundry et al., 2009).

Study communities

The study was done across three small communities in close proximity, two of which initially were conveniently selected because of their being provided, by the local service provider, with a piped water supply during the study period. At the beginning of the study, their most consistent water supplies consisted of untreated water from a small nearby river and its tributaries and when available, water from drill-wells fitted with hand-pumps (often subject to breakdown) and a water tanker service often prone to non-delivery. These rudimentary services were unreliable to the extent that the two communities were collecting water for drinking and other domestic purposes from the open untreated sources for more than half of the time. After the first 17 weeks for one and 18 weeks for the other village, these unreliable water supply services (hand-pumps and tanker) were each replaced with a small-community water supply system, distributing potable water through a network of communal taps throughout each community. These new systems were expected to be reliable by continuously supplying safe drinking water.

The third community was studied as a reference group as it never had a formal water supply, nor did it receive any during the period of study, with households continuing their usual practice of collecting and using untreated water from the nearby small river and its tributaries. This community then served as a reference for comparing the data of the other two intervention communities, especially in terms of any effects the data from the intervention communities might show, as well as any possible effects should the new systems fail during the remainder of the study period.

Shortly after commissioning the two small systems, the supplies became intermittent, mainly because of failures in maintenance and operation. During these non-operational periods, the intervention communities – because their initial services were dismantled when their new services were established – reverted to using water from the same small river system as the reference community.

Ethics

Ethics approval was obtained from the Tshwane University of Technology Research Ethics Committee. Consent to work with the communities was granted by traditional leaders in the area. At the households, informed and formal consent was obtained from the household head who then assigned a respondent suitably in a position to provide information related to the study, usually the senior matriarch in the household.

Sampling

In these remote communities, households did not have formal addresses. To facilitate random sampling of the study groups within the selected communities, a GPS (global positioning system) address (a unique waypoint based on its location coordinates) was assigned to each study household using Garmin 60 Csx® GPS devices. These addresses were used to randomly sample households for participation as well as uniquely mark and identify all collected data, its capturing and analysis for the particular household throughout the study.

Data collection

The study was conducted over a period of 56 consecutive weeks (July 2007 to July 2008) and included an initial period of 17 weeks before the intervention (baseline data) and the rest of the weeks comprised the post-intervention period. All data collection sheets, i.e. structured questionnaires and symptom diaries were first compiled in English then translated into the local language of TshiVenda and thereafter translated back to English to verify linguistic and contextual accuracy.

Demographic and socio-economic data were collected during the baseline period by experienced fieldworkers through structured interviews with the respondents. Data on potentially confounding variables were collected, including family size, gender and age as well as education, income, and type of housing.

Data on diarrhoea incidence were collected for each member of each study household over the full period of 56 weeks, including the baseline and post-intervention periods. The case definition for diarrhoea was three or more loose stools within a 24-h period (WHO, year unknown). An episode of diarrhoea was considered to have ended after 48 consecutive hours without symptoms (WHO, year unknown). Respondents were issued with symptom diaries on which they recorded the daily diarrhoea status for each member of the household. The fieldworkers trained respondents on how to record, on a weekly basis, the occurrence of diarrhoea in these diaries. The fieldworkers collected the diaries at the end of each week, double-checked and confirmed the recorded data with respondents and other household members.

The fieldworkers also confirmed with the respondent, the household's water source for every week. This was done to identify the periods of time the household would not have access to an operable system (and safe drinking water) and therefore reverted to use water of poor quality from open sources. During the post-intervention periods the fieldworkers, on a weekly basis, also interviewed the two water supply systems' operators as well as physically checked on the systems to record periods when the systems were not operational.

Statistical analyses

Data analyses were done with SPSS™ 17.0. Comparison of illness rates between intervention and non-intervention communities were done using generalised estimating equations in SPSS to handle possible clustering within communities and households and repeat sampling from individual participants.

The water systems became operational in Intervention Community 1 during week 18 (the first week of November 2007) and in Intervention Community 2 the following week. Analyses prior to the intervention were restricted to weeks 1–17 and then post-intervention analyses from weeks 19 to 56, making up a total of 38 weeks of follow-up. Data from the first week after the intervention were excluded from the analyses as it was not clear when any recorded diarrhoea episodes would have started around the time of the intervention. There were a total of 20,148 person weeks of follow-up data post-intervention available of which 14,948 were in the intervention communities and 5200 in the reference community.