Research

Evaluation of a water, sanitation, and hygiene education intervention on diarrhoea in northern Pakistan

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Objective Inadequate water and sanitation services adversely affect the health and socioeconomic development of communities. The Water and Sanitation Extension Programme (WASEP) project, undertaken in selected villages in northern Pakistan between 1997 and 2001, was designed to deliver an integrated package of activities to improve potable water supply at village and household levels, sanitation facilities and their use, and awareness and practices about hygiene behaviour.

Methods A case–control study was conducted during July–September 2001 to evaluate whether, after selected confounders were controlled for, children aged <6 years with diarrhoea were more or less likely to reside in villages that participated in the project than in villages that did not participate. Descriptive and logistic regression analyses were performed.

Findings Children not living in WASEP villages had a 33% higher adjusted odds ratio for having diarrhoea than children living in WASEP villages (adjusted odds ratio, 1.331; $P<0.049$). Boys had 25% lower odds of having diarrhoea than girls (adjusted odds ratio, 0.748; $P<0.049$). A 2.6% decrease was found in the odds of diarrhoea for every yearly increase in the mother's age (adjusted odds ratio, 0.974; $P<0.044$) and a 1.4% decrease for every monthly increase in the child's age (adjusted odds ratio, 0.986; $P<0.001$).

Conclusions The findings in this study may help refine the approach to future water, sanitation, and hygiene initiatives in northern Pakistan. The integrated approach taken by WASEP, which incorporates engineering solutions with appropriate education to maximize facility usage and improve hygiene practices, is a useful example of how desired health benefits can be obtained from projects of this type.

Keywords Potable water; Water supply; Sanitation; Hygiene/education; Diarrhea/epidemiology; Child, Preschool; Evaluation studies; Case-control studies; Pakistan (*source: MeSH, NLM*).

Mots clés Eau potable; Alimentation eau; Assainissement; Hygiène/enseignement; Diarrhée/épidémiologie; Enfant âge pré-scolaire; Etude évaluation; Etude cas-témoins; Pakistan (*source: MeSH, INSERM*).

Palabras clave Agua potable; Abastecimiento de agua; Saneamiento; Higiene/educación; Diarrea/epidemiología; Infante; Estudios de evaluación; Estudios de casos y controles; Pakistán (*fuente: DeCS, BIREME*).

Bulletin of the World Health Organization 2003;81:160-165.

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Introduction

Improvement of public health is the strongest and most frequent argument put forward in support of water and sanitation projects (*1*). Inadequate water and sanitation services adversely affect the health and socioeconomic development of communities, and the two outcomes are related (*2, 3*). An integrated package of activities aimed at improving water supply and sanitation facilities, providing appropriate hygiene education, and building local capacity for the management of water and sanitation resources is more likely to show significant health benefits than a programme that concentrates on one area alone (*2, 4–7*). Expected health benefits rely on water and sanitation programmes containing a combination of components most appropriate to the local context. During 1997–2001, the German Technical Cooperation Agency (KFW) contracted and funded the Water and Sanitation Extension Programme (WASEP) of the Aga Khan Development Network (AKDN) to undertake a project in selected villages in Northern Areas and Chitral in northern Pakistan. The aim was to improve potable water supply at village and household levels, sanitation facilities and their use, and awareness and practices about hygiene behaviour. The health and hygiene education topics addressed included traditional concepts about diseases; promotion of latrine use and the safe disposal of faeces; domestic, environmental, and personal hygiene; food preparation, handling, and storage; transmission routes and prevention of waterborne diseases; and operation and maintenance of water sources.

The Northern Areas and Chitral is a mainly rural, mountainous region approximately 72 496 km^2; the population of 900 000 people live in villages that typically comprise 50–

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Ref. No. **02-0106**

200 households. Villages differ by location in topography and geography, as well as by language, ethnicity, and socioeconomic development. The main health facilities are run by the government and the Aga Khan Health Services, Pakistan (AKHS,P) of AKDN. Initially, WASEP selected 109 villages (population 100 000) based on pre-set criteria. At the end of 2001, 99 villages (population 88 000) were enrolled in the project: 68 from Northern Areas and 31 from Chitral. Intervention components delivered by WASEP using appropriate technologies in an integrated manner were water supply, water quality, drainage, sanitation, and school- and community-based hygiene education.

The planning and implementation methodologies have been described elsewhere (*8*). Implementation schedules were flexible, so the programme could respond to the characteristics and dynamics within each village. The Department of Community Health Sciences, Aga Khan University (AKU-CHS), also of AKDN, helped WASEP in 1998 to develop a planning and monitoring approach for the project. In 2000, AKU-CHS was contracted by WASEP to determine whether, using diarrhoea as the health outcome, the project influenced the health status of villages served by the project. Other institutions conducted evaluations on different aspects of the project, such as hardware performance related to water supply and water quality (*9*).

Methods

Study objectives

In the planning stage, WASEP specifically identified a reduction in incidence of diarrhoea as a project health outcome. The AKU-CHS team focused the evaluation on children, as this age group suffers the greatest health burden from diarrhoea (*10–12*). In children, malnutrition, lack of safe water, poor sanitation, poor hygiene, early motherhood, breastfeeding practices, and inadequate health care are among known risk factors for diarrhoea (*13, 14*). A case–control design was adopted (*15–17*) to determine whether, after controlling for selected confounders, children aged <6 years with diarrhoea were more or less likely to reside in villages that participated in the project than in villages that did not participate. This approach to the evaluation treated the combined "package" of interventions as the main exposure variable — because implementation schedules and sequencing for component interventions were flexible it was difficult to assess the contribution of each component independently. As the study was conducted at the four-year point of a five-year implementation plan, some components were incomplete for some project sites. If the components were considered as part of an integrated whole, however, an interim evaluation of the project in achieving its health outcome could be determined. Data collection was confined to the five districts of Northern Areas and excluded villages in Chitral because of time and budget constraints.

Selection of cases and controls

The evaluation team used health centres of the AKHS,P to identify potential study participants. Four AKHS,P health centres in Ghizer district and two in Gilgit district were selected as recruitment centres on the basis of the location of the target villages that had completed WASEP interventions, the proximity of AKHS,P health centres to completed target villages, the diarrhoea caseload of the health centres (AKHS,P reports, 2000 and first quarter 2001), and logistical considerations.

Children were eligible for the study if they attended the recruitment centres during the study period, were aged 4–71 months, had been resident in the same village for the previous two weeks, and were accompanied by a parent or guardian who was willing to participate in the study (written consent was obtained). Infants aged <4 months were excluded, as diarrhoea may be difficult to differentiate from normal stool. Cases were defined as a child with diarrhoea (three or more loose, watery stools in the last 24 hours) and were episode-based. Children with diarrhoea that lasted two weeks or more (chronic disease) were excluded. Controls were defined as a child with any complaint other than diarrhoea and without a skin condition or worm infestation (skin conditions and worm infestations were excluded from controls because they are associated with poor hygiene, sanitation, or water quality) (*4, 6*). Cases and controls were frequency matched on the basis of health centre of recruitment and time of diagnosis (controls were selected within 24 hours of a case).

Data collection

Data for cases and controls were obtained from the accompanying parent or guardian on residence, sociodemographics, and hygiene behaviour with a pre-tested structured questionnaire delivered at the health centre by trained interviewers. Information was later provided by WASEP on whether a subject's village was in the project or not, the date of completion of a WASEP intervention for the three major components (water, sanitation, and hygiene education), and whether other groups (public or private sector) had health-related activities similar to WASEP's in a village. In addition, AKHS,P indicated whether it had a health facility in the village or not. Interviewers at the health centre were blinded to the exposure status of cases and controls, and staff from WASEP were blinded as to whether a village included in the study was associated with a case or a control. The study was conducted between July and September 2001 — the peak season for diarrhoea. A minimum sample size of 200 cases and 200 controls was calculated as needed based on two-sided testing with α 0.05, power 0.80, and a detectable odds ratio of 2.0. Data were entered into EpiInfo software, version 6.04. The response rate for the study was 100% (although two individuals willing to participate had to drop out because of language difficulties). Overall, 982 questionnaires were completed and returned by 508 cases and 474 controls. Of these, 27 cases and 20 controls were rejected because an old version of the questionnaire was used inadvertently during the initial phase of data collection. Another 27 cases and 57 controls were rejected on the basis of age (<4 months or >71 months), and a further 48 controls were rejected on the basis of exclusion criteria for controls. In total, 454 cases and 349 controls were used in analyses (ratio of case:control, 1.3:1). Data analyses were conducted with SPSS software, version 10 for Windows.

Results

Descriptive analysis

As expected, on the basis of AKHS,P data on reported diarrhoea for 2000, most participants were from Ghizer district. Some control children had multiple diagnoses, and primary and secondary diagnoses were not differentiated during data consolidation. Diagnoses in control children in descending order of frequency were respiratory, gastrointestinal, other

conditions, infectious disease, and nutritional. Respiratory conditions accounted for >50% of control complaints. The boy:girl ratio was higher for controls than for cases (1.7 vs 1.2) (Table 1). In total, 286 (63%) cases and 170 (49%) controls were aged <2 years. Mothers of case children were slightly younger than those of control children: 72 (16%) mothers of case children were aged <25 years compared with 37 (11%) of mothers of control children. Nearly three out of four mothers in both groups had no formal schooling. Travel time from home to the health centre generally was less for cases than for controls. For children aged <2 years, 97% (440) of children in both groups were exclusively or partially breastfed (data not shown). Housing conditions were used as a proxy of socioeconomic status: little variation was found between case and control households with respect to construction materials, number of rooms for sleeping, and number of persons living in the household over the last three months.

Children in the study came from 111 villages and represented a broad cross-section of the project area selected: 90 villages in Ghizer district and 21 in Gilgit district. Forty-three (39%) villages had WASEP interventions. Cases were more likely to come from non-WASEP villages than controls (55% vs 47%) (Table 2). According to AKHS,P, all 111 villages received ongoing hygiene education from their field teams. In addition, 19 (17%) villages had an onsite AKHS,P health facility: 205 (45%) case children lived in a village with an AKHS,P health facility compared with 144 (41%) control children. Approximately one-third of cases and controls came from villages where other groups (public or private sector) were working on water, sanitation, or hygiene-related issues. Data collected by AKU-CHS on knowledge, attitude, and practices about health and hygiene showed virtually no differences between cases and controls (data not shown). Data on length of time since completion of each of the three major intervention components (water, sanitation, and hygiene education) in WASEP project villages were not used in analyses because of the uncertainty over completion dates.

Table 1. **Characteristics of cases and controls**

Characteristic	No. (%)	
	Case (n = 454)	Control (n = 349)
Ghizer district health centre		
Gupis	118 (26)	107 (31)
Jandrote	64 (14)	48 (14)
Sandi	125 (28)	90 (26)
Yasin	102 (23)	64 (18)
Gilgit district health centre		
Gulmit	9 (2)	17 (5)
Hoper	36 (8)	23 (7)
Sex		
Male	252 (56)	218 (62)
Female	202 (45)	131 (38)
Age of child (months)		
4–23	286 (63)	170 (49)
24–71	168 (37)	179 (51)
Age of mother (years)		
<25	72 (16)	37 (11)
25–29	179 (39)	146 (42)
30–34	123 (27)	87 (25)
35–39	72 (16)	71 (20)
40–49	8 (2)	6 (2)
Mother's education		
No formal schooling	336 (74)	260 (75)
Primary	47 (10)	29 (8)
Higher than primary	71 (16)	60 (17)
Travel time to clinic (minutes)		
<30	182 (41)	119 (34)
30–59	88 (19)	81 (23)
60–89	105 (23)	72 (21)
⩾90	79 (17)	77 (22)

Logistic regression analysis

Simple logistic regression with diarrhoea status as the dependent variable was conducted and the crude odds ratios examined. The independent variables used were: village received WASEP intervention (main exposure), any group other than WASEP worked in village, AKHS,P health facility located in village, child's sex, mother's educational level, child's age (months), mother's age (years), and travelling time to reach the clinic (minutes). The last three were treated as continuous variables in regression analyses. Children were more likely to have diarrhoea if they lived in a non-WASEP village, the child was a girl, mother's age decreased yearly, and child's age decreased monthly. These results were statistically significant (P<0.05) (Table 3). Possible interaction effects were examined between WASEP and AKHS,P and between WASEP and other groups that delivered health-related interventions similar to WASEP's in the study villages. These effects were not significant statistically (data not shown), and no interaction terms were included in the final model.

Multiple logistic regression using backward stepwise elimination was conducted with diarrhoea status as the dependent variable. Variables where the crude odds ratio had a P-value <0.20 were included as independent variables: village received WASEP intervention, groups other than WASEP worked in village, child's sex, child's age, mother's age, and time to reach the clinic. Variables were eliminated from the model if they did not meet the criterion of P<0.05. Results for the final model indicated that after age of child, sex of child and mother's age were adjusted for, children who did not live in a WASEP village had 33% higher odds of having diarrhoea than children who lived in a WASEP village (adjusted odds ratio, 1.331; P<0.049) (Table 3). Similarly, after the other variables in the final model were adjusted for, boys had 25% lower odds of having diarrhoea than females (adjusted odds ratio, 0.748; P<0.049). Mother's age and child's age were inversely related to diarrhoeal disease status: a 2.6% decrease was seen in the odds of having diarrhoea for every yearly increase in mother's age (adjusted odds ratio, 0.974; P<0.044) and a 1.4% decrease for every monthly increase in child's age (adjusted odds ratio, 0.986; P<0.001).

Discussion

Throughout the investigation, AKU-CHS remained independent from other agencies including WASEP, so that it could maintain objectivity during the evaluation process. Useful background information and information on the intervention status of villages during data collection were supplied by WASEP during the study's design phase. A rigorous culling of cases and controls took place during data processing on the basis of pre-assigned inclusion and exclusion criteria; this resulted in exclusion of more than 20% of the questionnaires that were administered. The study was able to reveal a

Table 2. **Intervention related status of villages for cases and controls**

Village status	No. (%)	
	Cases (n = 454)	Controls (n = 349)
Water and Sanitation Extension Programme		
Yes	206 (45)	185 (53)
No	248 (55)	164 (47)
Aga Khan Health Services, Pakistan health facility in village		
Yes	205 (45)	144 (41)
No	249 (55)	205 (59)
Other group working in village		
Yes	175 (39)	126 (36)
No	279 (61)	223 (64)

favourable result for WASEP; however, children who resided in WASEP intervention villages had statistically significant lower odds of having diarrhoeal disease than children who resided in non-WASEP villages. Overall, after known confounders were controlled for, the WASEP intervention seemed to account for an estimated 25% reduction in the incidence of diarrhoea in children. In addition, younger children, girls, and children of younger mothers were associated with a higher likelihood of diarrhoea. These findings may help to refine the approach to future water, sanitation, and hygiene initiatives in northern Pakistan.

A detectable odds ratio for the study was estimated as 2.0. WASEP reported a 50% reduction in the incidence of diarrhoea in project villages on the basis of a preliminary pre-intervention post-intervention comparison that used data from their monitoring programme. During the study period, the calculated minimum number of cases (200) was exceeded; this increased the sample size, which resulted in greater statistical power to detect a smaller intervention impact of 25% rather than the 50% reduction originally assumed. The 50% reduction in diarrhoea reported by WASEP may be due in part to an ecological effect caused by a decreasing background level of diarrhoea during the project. Such an ecological effect would not be accounted for in a pre-post analysis, in which only internal comparisons are made over time: a case–control design would more easily account for such trends (*15, 18*). Selection bias may have occurred, because study participants were those attending AKHS,P health centres and may not have fully represented the regional population. However, AKHS,P serves the general population and is the second largest health care provider in Northern Areas after the Government of Pakistan. The use of four preset criteria (target village completed intervention, proximity of health centre to completed target village, diarrhoea caseload, and logistics) to select AKHS,P health centres as recruitment centres also would have limited selection bias. The process identified two out of five possible districts in Northern Areas for the study; differences may exist between districts that are not associated with the selection criteria and this may have influenced results. Misclassification bias with respect to exposure is unlikely: villages were categorized on exposure by WASEP technical staff who would have been familiar with all project villages. Misclassification bias of outcome may have occurred: the nature and extent is difficult to determine.

The inclusion of a laboratory test (e.g. stool culture) in the case definition would have increased the study's difficulty and may have affected participation. Recall bias may have affected study results, but as information used in analyses was mainly sociodemographic, the effect is expected to have been small. Response bias from participants giving socially acceptable answers to questions may have accounted for the small differences observed between cases and controls on the knowledge, attitude, and practices section of the questionnaire. The agreement in knowledge, attitude, and practices results may reflect the presence of organizations, other than WASEP, that delivered similar health-related interventions in the project area. Approximately one-third of cases and controls resided in villages where other groups were working on water, sanitation, and hygiene-related issues, and AKHS,P reported ongoing hygiene education by their field teams in all 111 villages in the study. These activities could also contribute to a decreasing background incidence of diarrhoea. As the number of knowledge, attitude, and practices questions was limited, some caution in interpretation of results is warranted, and a broader evaluation of knowledge, attitude, and practices may have produced notable differences between cases and control. Use of direct observation rather than questionnaires may have provided a more accurate determination of hygiene practices, but the former also has limitations (*19*).

Although a partitioning of any observed effect of WASEP on diarrhoea to each of WASEP's three major component interventions or combination of components was considered, difficulty in defining "date of completion" of an intervention hampered the analysis. In addition, secondary analyses would have suffered from numbers too small for valid subgroup analyses. The observed effect of a 25% reduction in diarrhoea therefore must be considered as the result of all components combined, assessed over the geographical area of the study. A shortage of funds resulted in a planned pilot evaluation study being cancelled, and constrained fieldwork to 10 weeks. If sufficient funds had been available for a pilot phase, it may have been possible to refine the study design to answer questions other than the primary study question. However, WASEP treated the intervention components as an integrated package during project design and delivery; this was consistent with their assumption that community involvement in all phases of implementation was essential for sustainability. The approach allowed for flexibility in implementation to meet the varying needs and capacities of villages. The period July–September was chosen for data collection to maximize the number of diarrhoea cases seen at the health centres and thereby to achieve the calculated sample size. In addition, communication and transportation can be difficult in some parts of the region during the winter months. A seasonal influence on disease incidence is likely if only in terms of caseload, although the greatest public health impact of the intervention on diarrhoea would be during the summer period.

The health impact and outcome indicators of a water and sanitation programme are not easy to define and are difficult to measure (*1, 5, 20–22*), especially if the effect of each component is to be determined separately. It is more feasible to regard such programmes as a "package" of services and actions that, taken together, can influence the health of a person and the health status of a community. The integrated

Table 3. **Odds ratios for diarrhoea in children attending Aga Khan Health Services, Pakistan health centres in Northern Areas, Pakistan**

Variable	Odds ratio[a]		*P*-value
	Crude	Adjusted	
Included in multiple regression analysis[b]			
Water and Sanitation Extension Programme intervention			
Yes	1	1	
No	1.358 (1.027–1.797)	1.331 (1.002–1.769)	<0.049
Other group in village[c]			
Yes	1	NA[d]	
No	0.903 (0.675–1.209)		
Age of child (months)	0.984 (0.975–0.993)	0.986 (0.977–0.994)	<0.001
Sex of child			
Male	0.750 (0.564–0.997)	0.748 (0.560–0.998)	<0.049
Female	1	1	
Mother's age (years)	0.970 (0.946–0.995)	0.974 (0.949–0.999)	<0.044
Time to clinic (minutes)[c]	0.999 (0.997–1.001)	NA[d]	
Not included in multiple regression analysis[d]			
Aga Khan Health Services, Pakistan health centre			
Yes	1		
No	0.853 (0.643–1.131)		
Mother's education			
No formal schooling	1.092 (0.747–1.597)		
Primary	1.370 (0.770–2.438)		
>Primary	1		

[a] Numbers in parentheses are 95% confidence intervals.
[b] $P<0.02$ for crude odds ratio.
[c] Removed from final model during backward elimination regression.
[d] NA: not applicable.
[e] P-value $\geqslant 0.02$ for crude odds ratio.

approach adopted by WASEP, which incorporates engineering solutions with appropriate education to maximize facility usage and improve hygiene practices, is a useful example of how desired health benefits can be obtained from projects of this type. Although the evaluation was made at an interim point of a scheduled five-year implementation plan, some sites had not completed the programme, and unexpected funding difficulties were experienced, our findings indicate that WASEP positively influenced the health status of villages served by the project, by reducing the incidence of diarrhoeal disease. ■

Acknowledgements

We thank the study field interviewers and other faculty and staff of AKU-CHS, especially Zafar Fatmi, Masood Kadir, and Nasiruddin Muhammadali; Inam Yar Baig and Ghulam Abbas from AKHS,P for generously providing access to patients who attended their health centres; and Tameez Ahmad and Karim Alibhoy of WASEP for collegial support.

Conflicts of interest: none declared.

Résumé

Evaluation d'une intervention portant sur l'eau, l'assainissement et l'éducation en matière d'hygiène contre la diarrhée dans le nord du Pakistan

Objectif L'insuffisance des services d'approvisionnement en eau et d'assainissement nuit à la santé et au développement socio-économique des communautés. Le projet WASEP (Water and Sanitation Extension Programme), mis en œuvre dans quelques villages du nord du Pakistan entre 1997 et 2001, visait à offrir un ensemble cohérent d'activités destinées à améliorer l'approvisionnement des villages et des ménages en eau potable, les installations d'assainissement et leur utilisation et les connaissances et pratiques des communautés en matière de comportements liés à l'hygiène.

Méthodes Une étude cas-témoins a été réalisée de juillet à septembre 2001 pour examiner si, après exclusion de certains facteurs de confusion, les enfants de moins de 6 ans atteints de diarrhée avaient une plus grande probabilité de résider dans les villages couverts par le projet que dans des villages non couverts. Des analyses descriptives et des analyses par régression logistique ont été effectuées.

Résultats En ce qui concerne la diarrhée, les enfants ne résidant pas dans les villages couverts par le WASEP avaient un odds ratio ajusté supérieur de 33 % à celui des enfants résidant dans les villages couverts par le projet (odds ratio ajusté : 1,331 ; p<0,049). La probabilité d'avoir la diarrhée était plus faible de 25 % chez les garçons que chez les filles (odds ratio ajusté : 0,748 ; p<0,049). Elle présentait une relation inverse avec l'âge de la mère et de l'enfant, diminuant de 2,6 % par année d'âge de la mère (odds ratio ajusté : 0,974 ; p<0,044) et de 1,4 % par mois d'âge de l'enfant (odds ratio ajusté : 0,986 ; p<0,001).

Conclusion Les résultats de cette étude peuvent servir à affiner l'approche des initiatives futures en matière d'eau, d'assainissement et d'hygiène dans le nord du Pakistan. L'approche intégrée adoptée par le projet WASEP, qui allie des solutions techniques à une éducation appropriée en vue de maximiser l'utilisation des installations et d'améliorer les pratiques d'hygiène, constitue un exemple utile de la façon dont les avantages recherchés sur le plan de la santé peuvent être obtenus grâce à des projets de ce type.

Resumen

Evaluación de una intervención de educación en materia de agua, saneamiento e higiene para combatir la diarrea en el norte del Pakistán

Objetivo Los servicios inadecuados de agua y saneamiento perjudican a la salud y el desarrollo socioeconómico de las comunidades. El proyecto Programa de Extensión de Agua y Saneamiento (WASEP), emprendido en determinadas aldeas del norte del Pakistán entre 1997 y 2001, se concibió para hacer llegar un paquete integrado de actividades encaminadas a mejorar el suministro de agua potable a las aldeas y hogares, las instalaciones de saneamiento y el uso de las mismas, y las prácticas higiénicas y la sensibilización al respecto.

Métodos Durante los meses de julio a septiembre de 2001 se emprendió un estudio de casos y controles para evaluar si, después de controlar el efecto de algunas variables de confusión, los niños menores de 6 años con diarrea tenían más o menos probabilidades de residir en aldeas que participaban en el proyecto que en aldeas que no lo hacían. Se efectuaron análisis descriptivos y de regresión logística.

Resultados Los niños que no vivían en aldeas abarcadas por el proyecto tenían una razón de posibilidades ajustada de padecer diarrea superior en un 33% a la de los niños que vivían en las aldeas abarcadas por él (razón de posibilidades ajustada, 1,331; $P < 0,049$). Los niños tenían un 25% menos de probabilidades de padecer diarrea que las niñas (razón de posibilidades ajustada, 0,748; $P < 0,049$). Se observó una disminución del 2,6% de las probabilidades de sufrir diarrea por cada año adicional de la edad de la madre (razón de posibilidades ajustada, 0,974; $P < 0,044$) y una disminución del 1,4% por cada mes adicional de la edad del niño (razón de posibilidades ajustada, 0,986; $P < 0,001$).

Conclusión Los resultados de este estudio pueden ayudar a enfocar mejor las futuras iniciativas en materia de agua, saneamiento e higiene en el norte del Pakistán. El enfoque integrado adoptado por el WASEP, que complementa las soluciones técnicas con una educación apropiada para maximizar el uso de las instalaciones y mejorar las prácticas de higiene, es un valioso ejemplo de las posibilidades de mejora de la salud que brindan los proyectos de ese tipo.

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