Identifying pathways to continued maintenance of school sanitation in Belize

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ABSTRACT

Despite an increasing focus on school-based water, sanitation and hygiene (WASH) interventions in less-developed countries, we lack an understanding of what combinations of conditions are sufficient for their continued maintenance post-implementation. We use a novel method, qualitative comparative analysis, to determine what pathways lead to well-maintained school toilets, as an indicator of continued maintenance of WASH services. Results from 15 case schools in Belize reveal five pathways to well-maintained school sanitation, and three pathways to poorly maintained services. Common conditions in the pathways to well-maintained toilets include local involvement upfront, quality construction, and the presence of a local champion; while conditions common in the pathways to poorly maintained toilets include the absence of the aforementioned conditions, in addition to vandalism and a lack of community support for maintenance. The familiarity of the technology is as common in the pathways to well-maintained toilets as poorly maintained toilets, suggesting that though technology choice is important, quality construction and social conditions may have a stronger influence on maintenance. Qualitative information is presented to support further discussion of the six conditions, including factors linked to their presence that may support improvements in Belize and have implications for school WASH services in other low-income settings.

Key words | Latin America, participation, qualitative comparative analysis, sanitation and hygiene, school sanitation, sustainability

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INTRODUCTION

School-based water, sanitation and hygiene (WASH) interventions have the potential to improve student health and attendance; boosting children's ability to take full advantage of educational opportunities (Bowen et al. 2007; Freeman et al. 2011). Unfortunately, despite increased efforts to improve school WASH in less-developed countries, services are often poorly maintained over time (e.g. Njuguna et al. 2008; SWASH+ 2010). Poor maintenance, resulting in broken down and/or unhygienic facilities, can have multiple repercussions. One, the behavior change necessary to realize the potential benefits of WASH is unlikely if services are unreliable or unhygienic (Cairncross 1990; Cairncross & Shordt 2004); a situation that may even present a health hazard (Koopman 1978; Hunter et al. 2009). Further,

facilities that are not maintained leave children with an exiguous understanding of the importance of WASH, jeopardizing the potential capacity for positive impact at the household-level where behavior change is also desired. Additionally, if facilities break down before their expected lifetime, the effective annualized cost of service provision increases rapidly (Hutton 2012; IRC 2012). Therefore, it is imperative from both a humanitarian and economic perspective to understand what conditions foster the continued maintenance of school WASH services.

Conditions that promote continued maintenance of school WASH services have been posited in prescriptive literature (e.g. IRC 2007; Mooijman et al. 2010; Abraham et al. 2011). However, we lack evidence of their collective effects

and the sufficiency of their aggregated presence to promote continued maintenance (Snel 2004; Saboori *et al.* 2011). Due to resource limitations, establishing all the conditions suggested in the literature may not be feasible and there is a need to identify which combinations of conditions are *sufficient* for a high likelihood of continued maintenance in order to improve effective resource allocation. Further, the pathway (i.e. combination of conditions) most appropriate in each country, district, or even school, may differ due to local management dynamics or economic condition. In these cases, if multiple sufficient pathways are identified, there can be flexibility and adaptability of which conditions are targeted based upon the specific needs and capacities.

As a result, this research investigates the collective effects of conditions that are postulated to influence the maintenance of school WASH services through systematic comparison of pathways to well-maintained facilities that are absent in cases of service neglect. Specifically, we analyze empirical case data from a school WASH intervention in Belize, using functionality and cleanliness of school toilets as an indicator of WASH maintenance. We hypothesize that all sufficient pathways to well-maintained toilets will include both social and technological conditions, with community support for operations and maintenance (O&M) as a necessary condition, particularly since schools in Belize do not receive government support for school operation, leaving schools to rely on often inadequate school fees (e.g. school fees range from 0 USD to 7.50 USD/student/year at case schools) (Ministry of Education Belize 2012). However, beyond these hypotheses, this exploratory research allows conditions to emerge from the empirical cases. Results may inform Ministry of Education (MoE) policy and programming improvements in Belize and provide further insight for school WASH programming on a global level.

Conceptual framework: social and technological drivers of continued WASH maintenance

As an indicator of school WASH maintenance, clean toilets have been associated with water availability and teachers' involvement with the school management committee (SMC) to address O&M needs in Kenya (Njuguna *et al.* 2008), and with active student health clubs in India,

though the authors note the link between student engagement and active teachers and parents, which may be of greater influence (Mathew *et al.* 2009). Expanding upon this work, Saboori *et al.* (2011) highlighted the aforementioned studies as the only school WASH sustainability literature available and contributed further evidence from 55 schools in Kenya identifying common characteristics of the two most successful schools (based on the presence of hand-washing water and treated drinking water). These included the presence of at least one teacher who had been trained during implementation, an active SMC involved in WASH activities, the inclusion of WASH in the school budget, and teachers' observation of health benefits resulting from the intervention. However, the authors identified nine other schools that shared these traits and yet did not meet the majority of their success criteria, suggesting that these conditions are insufficient to enable sustainability. In response, the authors highlight potential drivers such as the suitability of the technology and financial capacity for O&M, including community support. The influence of technology is also suggested by Njuguna *et al.* (2008), where students and teachers identified weak construction of school flush toilets as a reason for frequent breakdown, and the need for community support and associated local participation in planning and construction is posited in a number of school WASH reports (e.g. IRC 2007; Mooijman *et al.* 2010).

Evidence from community and household WASH studies echo this intertwined relationship between social and technological conditions and the need to investigate their collective effects. Marks & Davis (2012) found a strong association between user participation in water projects, including decision-making and substantial capital contribution (i.e. the equivalent of a typical household's monthly income), on sense of ownership, which is thought to be linked to service longevity. However, a study in rural Ghana found that despite high participation upfront, including cash contributions beyond the typical household's monthly income, only 60% of latrines were in operation post-intervention (Rodgers *et al.* 2007). As a result, local participation and sense of ownership alone may be insufficient for continued maintenance of WASH infrastructure, with the authors suggesting that inappropriate technology and poor quality construction may lead to breakdown. This

interdependency is further highlighted by WaterAid (2011) who suggests that appropriate technology and quality construction may increase service life despite weaknesses in other aspects of O&M, while poor quality construction can undermine even the best efforts to maintain services over time.

Thus, this study investigates the *collective* influence of social and technological conditions that lead to well-maintained school sanitation as an indicator of likelihood of sustainable school WASH programs. We analyzed six conditions that emerged from theory as well as case knowledge, including four social factors of: (1) local involvement upfront, (2) community support for O&M, (3) the absence of community vandalism of facilities, (4) the presence of a local champion at the school who promotes WASH; and two technological factors of: (5) high quality construction, and (6) implementation of a technology that is familiar in the community suggesting that spare parts and technical know-how are readily available.

METHODS

In order to maintain contextual richness and consideration of multiple conditions, we analyzed empirical data from 15 case schools using qualitative comparative analysis (QCA). We first discuss the research setting, then describe the analytical approach and finally define and describe the conditions and cases analyzed.

Study setting

From 2007 to 2009, the MoE in Belize, with support from UNICEF, implemented phase I of a school WASH program in 36 primary schools in the districts of Toledo and Stann Creek. Program implementation included community sensitization meetings conducted by MoE health and family life education (HFLE) officers, maintenance training attended by a representative from each community, a maintenance manual and kit, and infrastructure varying by school needs, including toilets. Of the 15 case schools, flush toilets to septic tank were constructed at 14, while pit latrines were constructed in one school due to insufficient water supply. The number of stalls constructed at each school ranged

from two to four. All facilities were constructed by hired contractors selected by and reporting to the MoE. Despite the high levels of government involvement and sensitization and training sessions, many schools have struggled to continue maintaining the intervention.

Analytical approach

To date, the majority of sustainability studies in the WASH sector have been based in quantitative analysis methods (e.g. Njuguna *et al.* 2008; Mathew *et al.* 2009; Marks & Davis 2012). Statistical approaches offer concise and systematic analysis, but trade the contextual richness of qualitative approaches (e.g. case studies). However, while case studies allow richness, they lack breadth and generalizability (Yin 2003; Flyvbjerg 2006). In order to identify generalizable determinants of continued maintenance that are also based on in-depth case knowledge, we employ QCA – an analytical method that bridges quantitative and qualitative methods by providing a systematic inferential approach to analyze information collected from a small enough number of cases to maintain data richness and context (Ragin 1987; Berg-Schlosser *et al.* 2009). Because QCA evaluates both the influence of individual conditions, and combinations of conditions, a further advantage is that QCA can link multiple pathways to an outcome. Additionally, QCA uses Boolean minimization logic to reduce conditions to the most logically succinct combinations of conditions that produce the outcome of interest. For these reasons, QCA has been used in a number of sectors to identify pathways linked to outcomes ranging from conflict in developing country pipeline and water infrastructure projects (Boudet *et al.* 2011) to progress in addressing health inequalities in England (Blackman *et al.* 2011). We are not aware of the use of QCA in WASH sector research, but feel this method is well-suited to study the conditions that promote continued maintenance of WASH services because: (1) there are likely multiple pathways to well-maintained WASH facilities, particularly in the school-setting due to the large number and variety of stakeholders; (2) a number of conditions posited in WASH literature may be difficult to measure using traditional quantitative methods, such as the influence of a WASH champion; and (3) a smaller data set allowing for more rich and contextual data

provides an opportunity to identify conditions that may be lost in large-N quantitative studies.

In QCA, cases are coded for having membership in a set of conditions. Because we are interested in analyzing a dichotomous outcome (i.e. we are interested in the sufficient pathways that explain schools with well-maintained toilets that do not explain schools with poorly maintained toilets), we employ the crisp-set variant of QCA (csQCA). CsQCA uses a binary coding scheme where the outcome and each condition in the analysis are assigned a value of 0 (non-membership) or 1 (full-membership) based on in-depth case knowledge. In order to identify sufficient pathways, we used the crisp-set analysis function in the fs/QCA 2.5 software, which summarizes the information in a table of coded conditions (termed a 'truth table') and uses Boolean logic, rather than correlation methods, to reduce the table to sufficient pathways. We used the recommended approach to present the intermediate solution whereby assumptions are made based on empirical case knowledge and existing theory to simplify the solutions (Ragin 2008). Individual conditions can be further analyzed to evaluate necessity, where necessary conditions are those which must be present to yield a particular outcome, but alone may not be sufficient (Berg-Schlosser et al. 2009; Jordan et al. 2011). The necessity of conditions and sufficiency of pathways are calculated through 'consistency' measures, which evaluate the frequency with which conditions are present when the desired outcome is achieved. Conditions with a consistency score of at least 0.9 are considered necessary, while pathways with a consistency score of at least 0.8 are considered sufficient (Ragin 2008). A second measure of 'goodness-of-fit' used in QCA is 'coverage' which indicates how well the conditions or pathways are represented by the empirical cases (Rihoux & De Meur 2009).

Defining outcomes of interest

Because maintenance is a necessary step to produce health impacts, but is often neglected, we focus on the outcome of continued maintenance of school toilets. Specifically, we define an outcome of continued maintenance where all the program toilets function properly with no repair needs (including secure doors and locks) and are free of visible feces. Conversely, schools where all the toilets are in need

of repair (ranging from broken doors and flush mechanisms to complete breakdown) and have visible feces outside of the toilet bowl are defined as poorly maintained. These schools are considered to have toilets in such poor condition that students do not have access to a functioning, private and clean toilet; a situation known to inhibit use of the facilities (Njuguna et al. 2008; Mathew et al. 2009; Xuan et al. 2012).

Case selection and data collection

Each school is treated as a case. The 36 schools that participated in the first phase of the school WASH program were eligible for inclusion in the study, allowing for the greatest time lapse since implementation, which had occurred two to three years previously. In order to achieve maximum heterogeneity over a minimum number of cases, we purposively selected cases, as opposed to random selection, as recommended by QCA scholars when exploration of pathways to a specific outcome is desired (Berg-Schlosser & De Meur 2009; Glaesser & Cooper 2011). As such, the results presented cannot be viewed as representative of the larger population though they do provide evidence of sufficient pathways to well-maintained school toilets, which may have broader implications. We selected 17 schools based on the following criteria: (1) all the toilets are either well-maintained or poorly maintained; (2) there is someone available who was present during construction of the toilets; and (3) students are permitted to use the toilets when needed. We excluded schools where some of the two to four program toilets were well-maintained and some were poorly maintained, because we are interested in comparing the extreme cases of schools with well-maintained versus poorly maintained toilets, and using the dichotomous variant of QCA. Ultimately, we analyzed data from 15 schools: 13 in rural areas and two in small towns (schools 8 and 14). Facilities at schools 16 and 17 were never completed, making continued maintenance irrelevant; these were removed from the QCA, but quotes and lessons-learned from the planning and construction process are included to provide further insight.

With assistance from the district HFLE officers, we conducted unannounced school visits over 3 weeks during the dry season (March), which is usually the most

challenging time to maintain WASH services in southern Belize. Data were collected through systematic inspection of facilities including a checklist of repair needs, functionality and cleanliness, photographs and interviews with principals and teachers. Additionally, to support triangulation of qualitative data, we interviewed students from standards five and six (age 10–15) at five of the schools where information gathered from other stakeholders was unclear or contradictory. At each of these schools, students were selected at random from the class roster for individual interviews. We continued to interview students until we reached theoretical saturation with a clear pattern of the data needed. As a result, the number of students interviewed ranged between 2 and 10 at each school. Two focus groups were also held at the district level with community leaders, women's group representatives, and teachers. Interview and focus group questions were

specific, based on school WASH sustainability themes promoted in the literature, as well as open-ended, allowing for the emergence of additional conditions. Consent was obtained from all participants and data collection methods were approved by the Institutional Review Board of the University of Colorado for human subjects research (protocol # 0110.37).

Selection of conditions

We chose to focus specifically on social and technological factors to promote coordination between these often divided areas in the development sector. Based on iterative analysis of possible conditions identified in WASH and school WASH literature, as well as during data collection, six conditions that promote well-maintained school toilets were included in the analysis (Table 1). Though

Table 1 | Coding scheme for outcome and conditions included in the csQCA

Condition	csQCA Code	Data source
Outcome: well-maintained toilets	1: All toilets function including doors and locks (only minor repairs needed, if any) and are free of visible feces. 0: All toilets are in need of repair (e.g. broken doors or flush mechanisms) and have visible feces on the floor, wall or seat	Observation Teachers Students
Social conditions		
Local involvement upfront	1: School/community was involved in planning and construction and their input was incorporated 0: School/community was not involved in planning and construction and their input was not incorporated or they felt disrespected	Principal Teachers
Community supports O&M	1: Community/parents provide financial support or unpaid labor to help maintain the school toilets 0: Community/parents do not provide any support (financial or in-kind) for school toilet maintenance	Principal Teachers
Local champion	1: Presence of a WASH champion (person who voluntarily takes extraordinary interest in WASH at the school) 0: Absence of a WASH champion at the school and limited pro-activity toward WASH issues	Observation
No vandalism	1: Vandalism of toilet facilities by the community was not reported as a common reason for toilet repair needs 0: Vandalism is reported as a common reason for toilet repair needs	Principal Teachers Observation
Technological conditions		
Quality construction	1: Poor quality construction was not reported as a common reason for toilet repair needs and quality is confirmed through observation 0: Poor quality construction is reported as a common reason for toilet repair needs and poor quality is confirmed through observation	Principal Teachers Observation
Familiar technology	1: The type of toilet is common in households in the community 0: The type of toilet is not common in households in the community	Teachers Students

only anecdotally discussed in school WASH literature, the conditions of a WASH champion and the absence of vandalism were included based on a focus group we held with HFLE officers in 2010 and case knowledge. Because QCA requires sufficient variance in conditions between cases to analyze the influence of a condition on the outcome (as in statistical methods), we eliminated some conditions that have limited variation between program schools (Rihoux & De Meur 2009). These included (1) students per toilet ratios, which ranged between 22 and 84 with no measurable influence on toilet condition based on correlation analysis ($r_b = 0.125$, $p = 0.329$), which corroborates with findings from similar studies (Njuguna et al. 2008; Mathew et al. 2009; Chatterley 2011); (2) the presence of a specific WASH maintenance plan and budget, because no schools had either; (3) O&M training, since the trained representatives had relocated with the exception of one school; (4) monitoring, as no schools had a WASH monitoring plan; and (5) children's health clubs, which were not present at any school. We recognize that these and many other factors may be at play in promoting the continued maintenance of school WASH and encourage future work to expand the analysis to include additional factors.

Operationalizing the outcome and conditions

The coded outcome and conditions are listed for each school in Table 2 based on the definitions and data sources presented in Table 1. When possible, we used multiple data sources as recommended in QCA literature (Basurto & Speer 2012). Additionally, the first author and HFLE officer conducted observations separately to limit subjectivity and enhance construct validity. Further description of the coding process, including examples from the case schools, follows.

Outcome of interest

Eight schools had toilets that were well-maintained and seven had toilets in poor condition. Not surprisingly, all schools with poorly functioning toilets were also the most unsanitary. Cleanliness was not observed in non-functional toilets since they were not in use by students at the time.

Local involvement upfront

The school and/or community were involved in program implementation at nine schools, including selecting the location of facilities: 'the contractor did a good job of

Table 2 | Truth table for well-maintained school toilets

School	Local involvement	Community support O&M	Local champion	No vandalism	Quality construction	Familiar technology	Outcome
1	1	0	1	1	1	0	1
2	1	1	0	1	1	0	1
3	1	1	1	1	0	1	1
4	1	1	1	1	1	0	1
5	1	1	1	0	1	0	1
6	1	1	1	0	1	1	1
7	1	0	1	0	1	1	1
8	1	0	1	1	1	1	1
9	0	0	0	0	0	1	0
10	0	0	1	0	0	0	0
11	0	0	0	1	0	0	0
12	1	0	0	0	0	0	0
13	0	1	0	0	0	1	0
14	0	0	1	0	0	1	0
15	0	1	0	1	0	1	0

consulting with us; we chose the location – he was very flexible' (Principal, school 7), and in-kind support from parents: '*parents helped to go through the town board for installing the septic tank and some fundraised or volunteered*' (Teacher, school 8). Schools also reported *feeling* more involved when they felt respected by the contractor regarding work hours and consideration of their suggestions. A principal at an Adventist school, where Saturday is considered the day of rest, reported: '*we had quite a bit of consultation throughout the project. The contractor wanted to work on a Saturday, but they respected us and didn't*' (Principal, school 6). In contrast, six schools described frustration that there was no local consultation during implementation: '*by the time it gets here, it's already planned*' (Parent, school 15). In addition, some felt their input was ignored: '*I asked the contractor to put the drinking fountains in a different location where they would be less prone to vandalism but they didn't listen*' (Principal, school 14).

Community support for maintenance

The community supports O&M of WASH services financially or in-kind at seven schools. Parents volunteer their time to assist with repairs at six schools (schools 2, 3, 5, 6, 13 and 15), as explained by the principal at school 6 who said, '*We have reliable [parents] we can call if repairs are needed. They usually do the work for free, but the school gives them a small stipend when they can*'. Three schools receive financial support from the community for repairs (schools 4, 5 and 6), where all three had toilets in good condition. The story is less inspiring at another school where each student was asked to contribute BZ$0.25 (US$0.125) per week to a WASH fund. Unfortunately, '*the students didn't bring the money in*' (Teacher, school 12). Eight schools reported very limited to no community involvement in the school and no in-kind or financial support for O&M.

Local WASH champions

The HFLE officer and first author made separate observations during the school visits to determine if there was a champion present. In each case, it was surprisingly clear when a champion was present and consensus was easily reached between observers. Champions were identified at

nine schools. These were principals or teachers who were creative and pro-active in solving challenges that other schools did not address. For instance, at school 1, the principal replaced the drinking water drainage pipe himself because it was frequently clogging. Conversely, one school without a champion said they did not have trash bins in the toilets because they were not available in the market, while schools with a champion used buckets and empty soda bottle bins as trash receptacles. Despite their obvious positive influence, even schools with a champion sometimes faced challenges they could not resolve, and the presence of a champion did not guarantee continued maintenance in all cases. For example, the champion principal at school 14 hired older students to clean the toilets (with parent permission and her supervision) when hiring a janitor became prohibitively expensive, and pro-actively addressed repair needs. However, she has been unable to tackle the vandalism issues that leave her students without reliable access to services: '*people in the community will tear down the door to use the bathroom or break the pipe to drink water*'.

Construction quality

Principals at eight schools reported having to frequently replace parts due to poor quality construction: '*At first I was happy with [the program], but then started to notice the poor quality as things began to break and leak after only five months*' (Principal, school 10). However, seven schools reported that they have had no repair needs due to poor quality. We further confirmed construction quality through inspection. In cases with poor quality construction, we noted issues such as the use of inexpensive light-duty anchor sleeves to attach wooden door frames to concrete, and concrete 'scaling' usually due to poor finishing.

Vandalism

Vandalism from the surrounding community was observed as a major challenge to maintaining the toilets at eight schools. Multiple principals and teachers reported stories of vandalism: '*the bathroom locks were broken off and the toilets were messed up*' (Teacher, school 12) and '*there is a problem with vandalism here – they can break the locks to the toilets*' (Principal, school 13). In the remaining seven

schools, staff reported that they have had no repair needs due to vandalism. Six of these schools were fortunate to be located in communities where vandalism was not a challenge, and school 8 had a high fence around the back of the schoolyard for security after school hours.

Familiar technology implemented

The pit latrines constructed at school 9 are common in the community, and in seven of the 14 schools with flush toilets, flush toilet technology is common locally: '*Most households in [the community] have flush toilets and the rest have pit latrines*' (Principal, school 6). At the other seven schools, flush toilets are not common in the surrounding community: '*Most of the community does not have a toilet…about five pit latrines for 40 families and the rest use the bush*' (Principal, school 10). Spare parts can be found in the capital of each district and in some communities where flush toilets are common, but in other communities schools mentioned that spare parts were challenging to acquire quickly or they had to purchase an entire kit just to get one part.

RESULTS AND DISCUSSION

Pathways to well-maintained school toilets

One necessary condition was identified from the csQCA: local involvement in planning and construction, with a

consistency of 1.0, meaning that all cases with a successful outcome had local participation upfront (Figure 1). Additionally, five sufficient pathways for well-maintained school toilets were identified, as shown in Figure 1, where each series of lines between conditions indicates a pathway. For instance, in addition to local involvement, pathway 2 also includes quality construction, no vandalism and community support for repairs (financial or in-kind). It is interesting to note that the three schools explained by pathway 3 all received financial support from the community, and this pathway is likely only sufficient with monetary community contribution. Quality construction and the presence of a local champion are common among the pathways. The first pathway is the only combination of conditions that does not include quality construction, suggesting that if quality is poor, the presence of both a local champion and community support for O&M, in addition to the absence of vandalism, are needed. Similarly, pathway 2 is the only option that does not include a champion. Familiar technology is less common in the pathways, indicating that technology did not have a strong connection with continued maintenance. Though appropriate design should be considered, results suggest that social factors and construction quality may play a bigger role than the technology itself.

Each solution pathway has a consistency of 1.0 and coverage ranges from 0.25 to 0.38, meaning that all schools with well-maintained toilets are explained by at least one of the
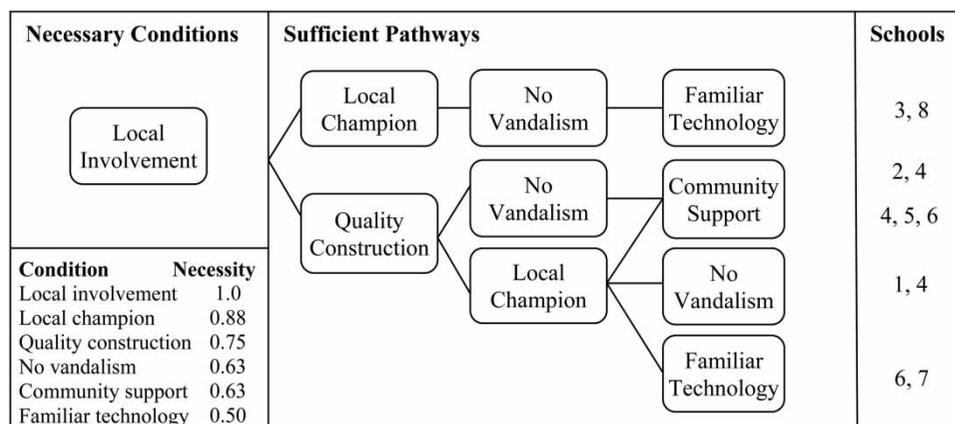

Figure 1 | Pathways to well-maintained school sanitation in Belize (intermediate solution).

pathways, and each pathway explains two to three cases. Because csQCA is a case-oriented method (as opposed to a statistical method), each case matters, and even pathways that explain a single case may be retained in results (Rihoux & DeMeur 2009).

Pathways to poorly-maintained school toilets

We also analyzed the pathways to poorly maintained toilets by negating the outcome in the fs/QCA software. This produces the logical inverse of each outcome score (1s become 0s and vice versa). Analysis of the negative outcome revealed three sufficient pathways to service neglect (Figure 2). Poor quality construction is common to all pathways, with a consistency score of 1.0, indicating that poor quality construction is very likely to lead to facility breakdown over time. In corroboration with results from the positive analysis, familiar technology is only found in one of the pathways. Indeed, roughly half of the schools had familiar technology in both the well-maintained and poorly maintained cases.

Policy and programming implications

The resulting pathways provide alternative solutions depending on local context and program capacities. The frequency of each condition within the pathways may also suggest their level of influence on continued maintenance. Based on stakeholder feedback and case knowledge, a

discussion of how these conditions may be encouraged by policy and programming follows.

Encouraging local involvement

Financial contributions and/or local financial management upfront may increase local participation and hence local buy-in and ownership: '*the PTA should manage the funds so that it is the way we want it, not the way they want it*' (Principal, school 5). An example of local financial management for school WASH implementation is the 'direct transfer' method explained by Breslin *et al.* (2009) where 'communities are in control of the finances and thus in charge of the project', including contracting out construction services. Though authors note that the method is not necessarily simple, they forecast that the strategy will have a greater impact in the long-term as community members will have the skills to manage projects in the future, a real sense of infrastructure cost, and a relationship with service providers that they will likely need for future repairs. Many PTAs in Belize are already managing school operation funds and this could be attached to the existing framework, with the additional training and monitoring necessary. The use of local contractors may also facilitate greater local involvement as one principal explains: '*I would like to see* [*a contractor*] *from the community. Someone closer to home will get more involvement from the community…*' (Principal, school 7). However, the use of local contractors, as well as the
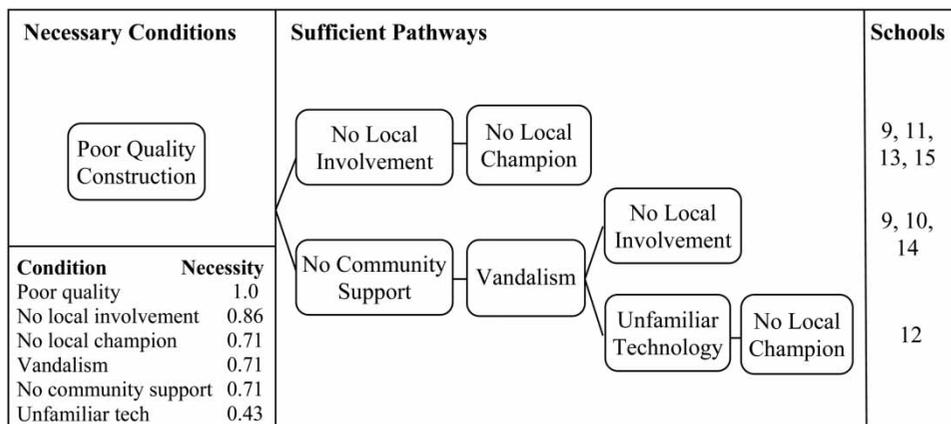

Figure 2 | Pathways to poorly-maintained school sanitation in Belize (intermediate solution).

appropriateness of the 'direct transfer' method, may vary case by case, and training needs and potential local corruption should be considered. The inclusion of a school WASH construction protocol, which incorporates local consultation and input, in national guidelines may also help promote local involvement whether the contractor is local or not.

Ensuring quality construction

It should be noted that 'high quality' construction does not necessarily mean 'high tech' or expensive and there may be simple and locally appropriate approaches to ensuring that whatever technology is constructed, it is of high quality. Principals interviewed suggested hiring local contractors and increasing external monitoring: '[*local contractors*] *have a vested interest* [*and*] *it would be easier to contact them if something didn't go well*' (Principal, school 7), and '*the* [*work*] *was not monitored* [...] *so we ended up with poor quality work*' (Principal, school 17). Coordination with the Ministry of Works (MoW) to ensure proper design and siting for school WASH infrastructure would support quality construction within the current national construction framework. Additionally, construction monitoring that is coordinated with the community may improve construction quality while encouraging local involvement and reducing the demand on government resources. The inclusion of guidelines and training for local construction monitoring in policies and associated district-level support may also encourage more effective decentralized monitoring.

Promoting local WASH champions

Based on the case schools, champion principals and teachers tend to be from the community, long-term (4–18 years) and/or are satisfied with the school WASH intervention and have observed benefits. Promoting local school staff and low turnover rates by prioritizing local teachers during placements and reducing teacher transfers will likely have a positive effect, but reliance on local champions may be beyond the realistic expectations of teachers and easing their responsibilities by enhancing the conditions found in the pathway that does not include a champion

(pathway 2) may give teachers more time to improve other aspects of quality education.

Encouraging community support for maintenance

Responsibilities for on-going O&M were unclear at a number of schools and some were expecting continued external support: '[*The MoE*] *should come back to see it and make repairs*' (Teacher, school 3). On-going O&M needs are typically beyond the available resources of government ministries and may be more effectively managed at the local-level. To aid in the clarification of maintenance roles, one principal recommends '*speak*[*ing*] *with the community upfront and mak*[*ing*] *an agreement*' (Principal, school 16). Publicizing national policies for local O&M responsibilities and agreements pre-intervention may help avoid misunderstandings and could even motivate greater local involvement in design and construction, which may dispel the lack of ownership felt in many communities that hinders on-going financial support. Champions can also raise community support, as in school 5 where the principal shares expense records and plans spending with parents, who now contribute the majority of the BZ$700–800 (US$350–400) per year the school spends on WASH.

Protecting against vandalism

Surprisingly, based on the data, community involvement upfront and support for O&M are not subsets of lower vandalism rates. Most teachers referred to only a few people, not the community as a whole, as responsible for the vandalism and suggested more secure designs, including fencing around the bathrooms and washbasins, so that facilities are protected after hours but hand-washing can still be observed from outside the toilets during the school day. At one school, the toilet block is kept behind a metal gate after school hours and is safe from vandalism, which the principal says is common in the area. The inclusion of secure toilet designs in national school building guidelines may bring this lesson to scale. Outside of physical protection, the principal at school 5 was able to reduce vandalism through community meetings. However, though less frequent, he was still faced with incidence of vandalism to the school facilities.

Study limitations

The study setting must be considered when evaluating the generalizability of findings. There are other conditions posited to influence the continued maintenance of school WASH programs that could not be studied due to a lack of variation between cases or practical limitations on data collection capacities. For example, the fact that school WASH is a government priority in Belize, including district HFLE officers who regularly visit schools, may play a large part in the success of many of the program schools and this and other constants from the study should be considered in the generalization of findings and warrant further investigation. An additional limitation is that data were collected from one point in time and expanding on the methods to include multiple data collection periods would increase the validity of results. Future research that includes schools with toilets in 'moderate' condition, using fuzzy-set QCA, which permits ordinal or scale coding, may also provide further insight.

CONCLUSION

Based on empirical evidence from case schools in Belize, csQCA reveals that local involvement in planning and implementation is necessary for continued maintenance of school toilets years after completion. Though necessary, local participation is not sufficient for continued maintenance and must be combined with other conditions in one of five pathways.

Results confirm the hypothesis that both social and technological factors are important in the continued maintenance of school toilets and quality construction or the implementation of a familiar technology is included in each of the five pathways. However, the familiarity of the technology is not as influential as construction quality: in all four case schools with a high quality flush toilet in a community with only basic pit latrines, the outcome was well-maintained facilities. This does not mean that technology choice is not important, but suggests that infrastructure quality and social factors may have a stronger influence than the specific technology selected.

The hypothesis that on-going support from the community for O&M is a necessary condition is not confirmed, but the absence of support from the community must be compensated by having a local champion, which may not be a reasonable expectation for already time-strapped school staff. Without a local champion, community support for O&M may become necessary. Further, this study is based on infrastructure that is only 2–3 years old and as time goes on and even high quality construction degrades, community support for maintenance may be needed. Results provide multiple pathways and in-depth qualitative information to support decision-making in the implementation and management of WASH in Belizean schools, and may have implications for improving school WASH on a global level.

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REFERENCES

Abraham, B., Fogde, M., Von Muench, E. & Wendland, C. 2011 *Sustainable Sanitation for Schools.* Sustainable Sanitation Alliance, http://www.susana.org/lang-en/library/rm-susana-publications?view=ccbktypeitem&type=2&id=1188.

Basurto, X. & Speer, J. 2012 Structuring the calibration of qualitative data as sets for qualitative comparative analysis (QCA). *Field Methods* **24** (2), 155–174.

Berg-Schlosser, D. & De Meur, G. 2009 Comparative research design: case and variable selection. In: *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques* (B. Rihoux & C. C. Ragin, eds). Sage Publications, Thousand Oaks, CA, pp. 19–32.

Berg-Schlosser, D., De Meur, G., Rihoux, B. & Ragin, C. C. 2009 Qualitative comparative analysis (QCA) as an approach. In: *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques*

(B. Rihoux & C. C. Ragin, eds). Sage Publications, Thousand Oaks, CA, pp. 1–18.

Blackman, T., Wistow, J. & Byrne, D. 2011 A qualitative comparative analysis of factors associated with trends in narrowing health inequalities in England. *Soc. Sci. Med.* **72** (12), 1965–1974.

Boudet, H. S., Jayasundera, D. C. & Davis, J. 2011 Drivers of conflict in developing country infrastructure projects: experience from the water and pipeline sectors. *J. Constr. Eng. Manage.* **137** (7), 498–511.

Bowen, A., Ma, H., Ou, J., Billhimer, W., Long, T., Mintz, E., Hoekstra, R. M. & Luby, S. 2007 A cluster-randomized controlled trial evaluating the effect of a handwashing-promotion program in Chinese primary schools. *Am. J. Trop. Med. Hyg.* **76** (6), 1166–1173.

Breslin, N., Mukherjee, R. & Duey, M. 2009 Gender & water: rethinking women, girls and water supply and sanitation. *Water Wastewater Int.* **24**, 36–39.

Cairncross, A. M. 1990 Health impacts in developing countries – new evidence and new prospects. *J. Inst. Water Environ. Manage.* **4** (6), 571–577.

Cairncross, S. & Shordt, K. 2004 It does last! Some findings from a multi-country study of hygiene sustainability. *Waterlines* **22**, 4–7.

Chatterley, C. 2011 *National Assessment of WASH in Schools – Belize: Analysis of 2009 Survey Data to Assess Water, Sanitation and Hygiene in Belizean Schools.* Ministry of Education and UNICEF, Belize City.

Flyvbjerg, B. 2006 Five misunderstandings about case-study research. *Qual. Inq.* **12** (2), 219–245.

Freeman, M. C., Greene, L. E., Dreibelbis, R., Saboori, S., Muga, R., Brumback, B. & Rheingans, R. 2011 Assessing the impact of a school-based water treatment, hygiene and sanitation programme on pupil absence in Nyanza Province, Kenya: a cluster-randomized trial. *Trop. Med. Int. Health.* **17** (3), 380–391.

Glaesser, J. & Cooper, B. 2011 Selecting cases for in-depth study from a survey dataset: an application of Ragin's configurational methods. *Methodologic. Innov. Online* **6** (2), 52–70.

Hunter, P. R., Zmirou-Navier, D. & Hartemann, P. 2009 Estimating the impact on health of poor reliability of drinking water interventions in developing countries. *Sci. Total Environ.* **407**, 2621–2624.

Hutton, G. 2012 *Global Costs and Benefits of Drinking-water Supply and Sanitation Interventions to Reach the MDG Target and Universal Coverage.* WHO, Geneva.

IRC 2007 *Towards Effective Programming for WASH in Schools: a Manual on Scaling Up Programmes for Water, Sanitation and Hygiene in Schools (No. 48).* IRC, Delft.

IRC 2012 *Providing a Basic Level of Water and Sanitation Services that Last: Cost Benchmarks.* (WASHCost Infosheet 1). IRC, The Hague.

Jordan, E., Gross, M., Javernick-Will, A. N. & Garvin, M. J. 2011 Use and misuse of qualitative comparative analysis. *Constr. Manage. Econ.* **29** (11), 1159–1173.

Koopman, J. S. 1978 Diarrhea and school toilet hygiene in Cali, Columbia. *Am. J. Epidemiol.* **107** (5), 412–420.

Marks, S. & Davis, J. 2012 Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Dev.* **40** (8), 1569–1576.

Mathew, K., Zachariah, S., Shordt, K., Snel, M., Cairncross, S., Biran, A. & Schmidt, W. P. 2009 The sustainability and impact of school sanitation, water and hygiene education in southern India. *Waterlines* **28** (4), 275–292.

Ministry of Education Belize 2012 Improving Access, Quality and Governance of Education in Belize. Education Sector Strategy 2011–2016.

Mooijman, A., Snel, M., Ganguly, S. & Shordt, K. 2010 *Strengthening Water, Sanitation and Hygiene in Schools – A WASH Guidance Manual with a Focus on South Asia.* IRC, The Hague.

Njuguna, V., Karanja, B., Thuranira, M., Shordt, K., Snel, M. & Cairncross, S. 2008 *The Sustainability and Impact of School Sanitation, Water and Hygiene Education in Kenya.* UNICEF and IRC, New York and Delft.

Ragin, C. C. 1987 *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies.* University of California Press, Berkeley and Los Angeles.

Ragin, C. C. 2008 *Redesigning Social Inquiry: Fuzzy Sets and Beyond.* University of Chicago Press, Chicago.

Rihoux, B. & De Meur, G. 2009 Crisp-set qualitative comparative analysis (csQCA). In: *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques* (B. Rihoux & C. C. Ragin, eds). Sage Publications, Thousand Oaks, CA, pp. 33–68.

Rodgers, A. R., Ajono, L. A., Gyapong, J. O., Hagan, M. & Emerson, P. M. 2007 Characteristics of latrine promotion participants and non-participants; inspection of latrines; and perceptions of household latrines in Northern Ghana. *Trop. Med. Int. Health* **12** (6), 772–782.

Saboori, S., Mwaki, A., Porter, S. E., Okech, B., Freeman, M. C. & Rheingans, R. D. 2011 Sustaining school handwashing and water treatment programmes: lessons learned and to be learned. *Waterlines* **30** (4), 298–311.

Snel, M. 2004 *The Worth of School Sanitation and Hygiene Education (SSHE): Case Studies.* IRC, Delft.

SWASH+ 2010 Quality: Several Far-ranging Factors Drive the Success of School WASH.

WaterAid 2011 *Sustainability Framework.* WaterAid, London.

Xuan, L. T. T., Hoat, L. N., Rheinlander, T., Dalsgaard, A. & Konradsen, F. 2012 Sanitation behavior among school children in a multi-ethnic area of Northern rural Vietnam. *BMC Public Health* **12**, 140.

Yin, R. 2003 *Case Study Research: Design and Methods.* Sage Publications, Thousand Oaks, CA.