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A Simple Cost Calculator for WASH in Kenyan Schools

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Master of Public Health

Global Health

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B.S.
Florida State University
2016

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An abstract of
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Abstract

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Introduction: In 80% of countries, WASH funding is inadequate to meet the SDG goals in 2030, and 75% report their WASH programs have either not been fully funded or implemented. Inadequate financing, lack of political will, and a general misunderstanding about budgeting for WASH have been among the critical barriers to establishing quality WASH in schools' programs. Within Kenya, most schools do not have a budgeting plan and report low levels of achieving government standard levels of WASH in schools. The purpose of this study was to identify what the costs are to maintain a "basic" WASH program in Kenyan schools based on each school individual characteristics.

Methods: We used data from 189 rural and urban schools from six different counties in Kenya to determine actual school expenditures on 30 different line items within their respective WASH programs. Data were disaggregated by location, school level, primary water source, and latrine type to ascertain the differing drivers of cost. The costs per pupil for the differing costs were bootstrapped to control for the non-parametric nature of the data in order to provide a more accurate calculation of the mean cost.

Results: The cost per pupil for each line item varied considerably based on the school characteristics. Generally rural schools had lower operating costs but were less likely to have critical hygiene and health products for students. We utilized the recommendations from the Kenyan government to provide assumptions for costs that would allow schools to meet the national requirements. We found schools frequently did not spend enough to meet national targets and there was a large variability in spending based on WASH variables.

Conclusion: Within Kenya, information on budgeting in the WASH sector is limited with some of the least information available for school WASH. There is very limited budgeting done by school officials and inadequate financing available to maintain the existing programs. School leaders need to utilize the budget estimations to both establish a school wide budget and lobby the Boards of Management for increased funding.

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1. LITERATURE REVIEW

1.1 Current School WASH Status

Since the Sustainable Development Goals (SDGs) were enacted to include school-level water, sanitation, and hygiene (WASH) targets, countries are focusing more on school-based WASH programming [1]. The WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation, and Hygiene (JMP), which provides global estimates of WASH related infrastructure improvements at a national, regional, and global levels have expanded their data collection to include WASH specifically in schools to provide estimations on progression to the 2030 SDG deadlines [2]. The JMP established set indicators for schools to achieve at least a basic minimum service level: drinking water that comes from an improved source, sanitation includes an improved facility that is sex segregated and usable, and basic hygiene means handwashing facilities with accessible soap [3].

There are indicators that define “basic” WASH in schools’ coverage, but there is minimal programmatic guidance on maintaining infrastructure and ensuring long term sustainability of facilities. In many countries the increased focus on school facilities improvement has not been met with increased funding to improve infrastructure, thus placing a higher burden on the already dilapidated and low quality WASH facilities [4].

In 2016, 69% of schools had access to improved drinking water, 66% had sanitation facilities that were considered improved at the time of the survey, and 53% of schools had designated handwashing facilities with access to soap [3]. These averages were considerably lower in Sub-Saharan Africa as nearly half of schools did not have improved drinking water sources, one in three did not have basic sanitation, and fewer than half had hygiene services with soap access

[3]. School WASH is historically of lower priority than community WASH, but there is promising improvement in both financial expenditures and coverage level.

1.2 International WASH Standards in Schools

While there are no set international standards for WASH requirement in schools, there are multiple major organizations such as USAID, UNICEF, and the WHO have drafted standards for governments to use in creating or modifying existing policy [4-8].

UNICEF and WHO partnered in 2009 to create a set of nine guidelines for governments to use in establishing their own country specific WASH standards [4]. The guidelines recommend that schools construct sanitation facilities that are child-friendly and inclusive, gender specific, and of high-quality construction [4] and include recommendations for hand washing facilities, appropriate water supply construction, and a system of waste management [4]. Each guideline includes an indicator of performance as well as notes on establishing and following the corresponding guidelines. UNICEF further expanded on existing guidelines by creating the Child Friendly Schools (CFS) Manual, which includes guidance on implementation of WASH programs and a focus on child friendly facilities [5]. The emphasis of this manual was to expand upon the WHO guidelines to provide a more holistic view of WASH in schools, with a goal of making programming more child friendly. Along with providing specific student to latrine ratios and exact quantification of resource availability, this document provides resources on how to engage children and support child adherence to good hygiene behaviors. The JMP guidelines set targets for student to latrine ratio, student water consumption per day, type of menstrual hygiene management supplies that should be available for girls, among others recommendations (Table 1) [4].

Table 1: Guidelines on WASH in Schools Requirements to be Considered “Basic”

Guideline Number	**Target Item**	**Recommendation**
2. Sufficient water	Drinking water	Drinking: 5 L per person daily
	Sanitation Related	Traditional Flush: 10-20 L per person daily Pour-Flush: 1.5-3 L per person daily Anal Cleansing: 1-2 L per person daily
3. Enough water collection points and water use facilities	Handwashing	Water point with soap available at toilet
	Drinking water point	Drinking water point available and accessible
4. Hygiene promotion and sanitation facilities facilitate good hygiene behaviors	Menstrual hygiene management	Facilities must include water within the toilet cubicle Waste baskets for sanitary pad disposal Private spaces to clean cloths
5. Sufficient number of quality toilets	Student to latrine ratio	25 girls to 1 latrine 50 boys to one toilet and urinal
	Gender separation	Male and female toilets are separate Toilets are appropriate for the local culture
	Cleanliness	Toilets are hygienic and readily cleanable
	Toilet quality	Toilets are private and secure There is a handwashing station nearby Toilets are always functional and maintained

In 2010, USAID helped establish WASH-friendly schools, where most of the manual focuses on health and hygiene education as opposed to construction guidelines [6]. Their specific recommendations for student to latrine ratios and drinking water treatment and storage cite their origins in the UNICEF and WHO joint guidelines [6]. Aside from recommendations on infrastructure and water availability, this document also provides tools and guidelines for each step of becoming a WASH friendly school.

The now defunct Alliance of Religions and Conservation (ARC) created their own set of guidelines and technology recommendations for WASH in schools [8]. The manual was designed to aid schools by providing technology options of WASH infrastructure along with reiterating UNICEF’s WASH in schools guidelines and recommendations.

The predominant commonality among the various organization's guidelines are there ability to be readily adapted to most developing countries. This flexibility is highly useful in creating WASH policy standards in governments where there is minimal guidance or precedent. Many standards are generic and readily modifiable to serve as a backbone in policy creation. Their primary limitation is in this flexibility there is not concrete data on costs or exact necessities of WASH related goods and services. For instance, several guidelines discuss girls having appropriate access to sanitary pads during menstruation, do not provide specific numbers on what constitutes appropriate within age groups [4, 5]. Many of the guidelines discuss maintenance of facilities or recurrent costs, but most do not provide an explicit time frame or the costs associated with infrastructure maintenance [4-6]. The existent recommendations also do not consider specific costs of goods, as making the standards more country specific would restrict their applicability. The strength of international school WASH guidelines is also the greatest weakness as their generic nature allows them to be easily applied but is frequently too vague for direct country application.

1.3 SWASH Program and Its Effects in Kenyan School WASH Policy

The School Water, Sanitation and Hygiene plus Community Impact (SWASH+) project was established to provide solutions for improving WASH in Kenyan schools. The first phase of research lasted from 2006-2012 and demonstrated the positive impact of WASH services in schools and its connection to improving attendance and reducing the burden of disease among students [9]. The Kenyan government responded to the results by doubling the subsidy to public schools WASH programs [9, 10]. Following this, the SWASH+ program consulted for the Ministry of Education in Kenya to create modules on educated students and teachers on school WASH [9].

In partnership with Sanergy, a Nairobi based social enterprise specializing in private sector sanitation, and the Government of Kenya, the SWASH+ project worked to create guidelines for schools to use in managing a relationship with private sector solutions for WASH programs and infrastructure [9]. The goal in this project is to aid schools in improving their school WASH programs cost effectively and levering private sector partners to help solve sanitation issues in schools.

During the second phase from 2012-2019, two life cycle cost studies were done in Kenyan urban and rural schools to determine estimates of school WASH expenditures annually [9, 11]. The results of the first rural life cycle cost study were used as a baseline in the Kenyan Governments "Standards and Guidelines For Wash Infrastructure In Pre-Primary and Primary Schools In Kenya" document [12]. In partnership with the Government of Kenya, SWASH+ worked on "governance trials" in 360 primary schools to test new ways to improve WASH services sustainably [10]. The collaborative nature between SWASH+ program and the Government of Kenya allowed for the program to have a strong impact on Kenyan school WASH policy.

1.4 Kenyan WASH Standards in Schools

The Government of Kenya has instituted several polices to increase school enrollment. In 2003 and 2008 respectively Kenya saw the institution of Free Primary Education (FPE) and Free Day Secondary Education (FSE) plan. allowing children to attend both primary and secondary schools free of cost, with government funding supporting the schools in the form of a block payment per pupil [13]. Providing free primary and secondary education produced an increase of enrollment, with a marked increase of 16.9% between 2009 and 2014 [13]. The increasing student population was not met with a corresponding investment in WASH infrastructure thus more strain was placed on an already poor system, leading to a need for increased spending on supplies and general maintenance [12, 14].

In 2018 the Kenyan ministries of Education, Health and Water and Irrigation established the "Standards and Guidelines For Wash Infrastructure In Pre-Primary and Primary Schools In Kenya" [12]. This document serves to break down the national requirements of WASH standards in schools, complete with itemization of WASH infrastructure as well as estimated costs [12]. The Standards provides recommended funding sources when the WASH portion of the government FPE or FSE grant is insufficient. The Standards additionally utilize the previous life cycle costing study done in rural areas in Kenya to provide an estimate of the expenditure necessary per pupil per year on WASH relating construction and system maintenance [11, 12]. The Standards provides a breakdown of scheduled maintenance, cleaning frequency suggestions, and general ideas on the responsible party for carrying out the task. This provides a tremendous level of clarity to schools who may be been inadvertently neglecting their infrastructure. There is a strong push in the document by the Kenyan government to ensure schools engage in primary and preventative maintenance and avoid catastrophic maintenance only. The Standards recommendations on regular repairs can be used as an advocacy tool by schools whose infrastructure has reached a state of disrepair. They have the capacity to argue for increased funding to meet the set requirements of the Kenyan government.

The bulk of the Standards document hones in on the varying types of WASH infrastructure, their layouts, their costs, and the process of obtaining a construction contractor [12]. This provides a useful marker for school decision makers to use in planning for major construction projects, notably to meet the set school WASH standards in the first part of the document. The Government of Kenya leverages the 2009 WHO recommendations (Table 1) but provided the additional requirement of 1 latrine plus 1m of urinal per 35 male students. In comparison to many other Sub Saharan Countries, the Kenyan government has placed a major emphasis on bringing schools up to among the highest WASH standards in the developing world.

1.5 Costs of Building and Maintenance of Programs and Infrastructure

There is considerable literature on school WASH interventions, but little information regarding costs of infrastructure, maintenance, and program fidelity [15]. The available costing guidance frequently relates to construction of large items, such as boreholes, latrines, etc.; there is less information on maintenance and operations costs [15]. There is variability in costs by country, and more by region, with the cost of a borehole varying from $17 to $38 per person in Africa alone [16, 17]. In comparison, in Asia the cost of a borehole varies from $21.34 to $27.90 and at $69.06 in Latin America [15, 16, 18]. The cost inconsistency is driven by the cost of materials and labor by region and the change in optimal water source by location [11, 15, 17, 18]. This indicates a need for specific costing by region and a decreased reliance by general scoping costing designs.

In comparison to hardware, the recurrent costs of a WASH program are more difficult to calculate, given their often-irregular schedule [15]. The majority of available information is regarding water service as this cost is more predictable as a monthly cost in a school setting. In comparing regions, Africa, specifically Kenya, boasts the greatest amount of data on recurrent costs [15]. The mean cost of per person per year of one unit of cleaning supplies, eg one brush, bucket or broom, varies from $0.03 to $0.08 [11, 19], indicating a much lower variability in this cost. In comparison the cost of emptying a pit latrine manually is variable within Sub Saharan Africa with the mean varying from $1.48 per person in a community in Tanzania to $0.10 per school in Kenya [11, 20]. Many of the existing cost assumptions relating to maintaining hardware, such as latrine door repair, are likely too low to support the expected increase of quality in school

WASH [15]. While estimated costs of recurrent services and repairs do exist, much of the data is highly variable and cannot be accurately applied for a school or other consumer to estimate their annual costs.

1.6 Barriers to Long Term Budgeting

A lack of funding to budget is frequently cited as one of the largest barriers to establishing a long term budgeting plan [21]. In the 2013 GLAAS report of 74 countries only 17 submitted data on their funding sources, with fewer providing information on their WASH budgeting plans [22]. Kenya had among the highest rates of reliance on external donor financing, at 41% of total government financing for WASH [22]. At the time of the initial survey in 2011 they had not provided an investment plan for the received funding. The survey estimates that 75% of the financing for sanitation and drinking water is focused on recurrent operations and maintenance [21]. There is a clear issue regarding management of existing funds, as the literature suggests that the external financing of WASH should be sufficient for most countries to meet the SDG goals and the countries reporting the largest issues in financing do not have a budgeting plan [23].

A general lack government and political will to support increased funding of WASH and increased budgeting oversight are key barriers in establishing a budgeting program [15, 24]. In many regions there is a lack of political pressure to ensure more resource accountability and encourage better management of existing resources. This results in poorly managed, and frequently underfunded, WASH programs, notably in schools where many ministries may be involved [15].

There is a general lack of understanding regarding establishing and keeping to budgets for program maintenance. These barriers showcase the large problem of a lack of care in maintaining what has already been built, in favor of meeting international targets rather that building and keeping good quality programs and infrastructure [24].

1.7 Necessity of Appropriate Construction and Regular Maintenance

Information on facilities maintenance is less available and the cost calculations are less robust due to variability by onsite usage levels, environmental factors, and regularity of minor repairs, among other factors [15, 25].

Should the community use a given water source more frequently than anticipated, there will be more wear and tear on the system that necessitates more frequent repairs. A study in South Africa found that overutilization of water sources, beyond their original design levels, ended with several of the "improved" sources breaking and users reverting to unsafe practices [26]. The environmental factors of a location need to be considered heavily before construction and have a large impact on repair costs going forward. A classic example is the arsenic levels we see in Bangladesh, where the constructed tube wells that served as a primary drinking source were found to be contaminated with the heavy metal. This resulted in high cost of care among the population related to arsenic poisoning and the necessitation of construction of a new piped water system in many heavily affected regions [27]. In areas with a high water table, traditional pit latrines pose a risk of polluting what may be a community's primary water source [28]. More frequent emptying of a pit latrine should be expected when increasing the number of users [20]. Where a community is utilizing pit latrines in a location with a high water table, they should be cognizant they may need to rely on a deep water source or another method of safe water collection. If they still plan on utilizing pit latrines and a shallow water source, the community can expect to spend additional funds on another step of water purification.

It is a common, though frequently erroneous, assumption that communities will maintain their own infrastructure once it is built by another party [29]. This necessitates either a comprehensive training of local staff assigned to maintenance on a semi/permanent basis or a regular availability of local trained maintenance people [25]. Performing regular maintenance is key to ensuring long term sustainability of infrastructure [25]. A poorly maintained pit latrine runs the risk of collapse and regular inspection and repair can mitigate the risk [20, 28, 30]. Regularly maintaining a piped water system helps to prevent leaks which may result in water loss or a negative pressure situation where pathogens can enter the water supply [31]. Additionally, annual maintenance of the water tank ensures the water tank is free of leaks and functioning normally [18]. Many programs, notably government grants, do not take into account long term funding for maintaining infrastructure once built [22]. This poses a large barrier for communities who may not plan to pay for said repairs themselves. Regular cleaning is paramount to usage fidelity and preemptive protection against dilapidation. An unclean latrine leads individuals to avoid the use of safe sanitation systems and users may revert to open defecation or defecating into plastic bags [30]. Cleaning of gutters in a rainwater harvesting system is important in ensuring water flows into the tank and does not overfill and spill off of the roof [18]. While these are specific examples, all aspects of a community's WASH program should be carefully cleaning and maintained regularly.

In a school setting, the community is the school and they must maintain their own WASH systems to ensure longevity. Pupils are frequently the ones responsible for regular cleaning of latrines and hygiene stations which necessitates the need for a set schedule of responsibilities [11]. Clean latrines with functional doors with locks help support girls staying in school during menstruation and protects against potential disease transmission [32, 33]. Ensuring handwashing stations are functional and have access to clean water help improve health outcomes in school children [34, 35]. While schools frequently have the benefit of receiving government funds to aid with WASH programs, often it is insufficient and supports disaster maintenance as opposed to regularly fixing issues as they arise [11]. This tremendously limits school staff's capacity to respond to general upkeep and contributes to the issue of WASH infrastructure falling into disrepair.

1.8 School WASH Benefits

The WHO estimates that nearly ten percent of the global disease burden can be mitigated by improving WASH [36]. Improving access to WASH is linked to a reduction in disease, improved nutrition, reduction in child mortality, and has been causally connected to a reduction in child stunting [3, 21, 36-43]. While there is limited data specifically on the health effects of improving WASH in schools, there is a plethora of literature noting the benefits of improved WASH programs and infrastructure within schools.

Strengthening WASH programs and infrastructure is known to decrease absenteeism and improve student enrollment [3, 34, 35, 43-50]. Girls have been the primary recipient of these benefits, with only marginal, if any, improvement among boys [44, 46-49]. Enhancing the quality of WASH in schools has been shown to increase the gender parity, where more girls are enrolling and staying in school [47, 48, 51]. Much of the improvement for girls is connected to an increased focus on menstrual hygiene management (MHM) in the education setting. As part of WASH programming, pupils are educated on MHM and girls have increased access to sanitary materials during menstruation [47, 49, 51]. Relative to the rest of WASH, a focus on MHM is a fairly new body of research, though already showing tremendously positive results in terms of student comfort and willingness to continue schooling [52]. There is ample research to demonstrate the efficacy of handwashing interventions among school children and the potential for the behavior to be sustained [46, 53, 54]. Increased access to handwashing with soap has been connected with a reduction in absenteeism due to disease [34]. Teaching children proper hygiene behaviors in school has been shown to have a carryover effect to the home, where parents may pick up more hygienic

WASH practices [55]. There is data to support that WASH interventions in schools are associated with a reduction in child diarrhea, though those results are frequently mixed [47]. Generally, results of WASH interventions are variable in their outcomes but overall provide a net benefit to the school in establishment of a program that promotes dignity and good hygiene.

1.9 Summation

Providing better WASH in schools is a necessity and many organizations and government entities are pushing for improvement. There are significant issues in implementation of plans for school WASH improvement, notably regarding lack of financing, planning, and general ignorance in establishing long term budgets. There are many misconceptions on hardware maintenance regularity and the corresponding costs, as well as how to effectively budget out the cost of consumable items through the school year. The nexus of this paper is to provide a clear itemization of costs Kenyan schools can expect to incur annually with the capacity for schools to effectively create their own budget from the data. In providing this data we hope to aid schools in planning out their expenses to avoid the "catastrophic maintenance" we so often see schools engaging in given their lack of funds. The data are designed to adhere to Kenyan national standards and leverage real costs schools incurred to ensure optimal accuracy in planning.

2. INTRODUCTION

The UN's Sustainable Development Goals (SDG) 4 and 6 set targets of quality education and water and sanitation for all [1]. As such, the WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation, and Hygiene (JMP) established indicators for countries to achieve at least a basic minimum service level at schools: drinking water that comes from an improved source, sanitation includes an improved facility that is sex segregated and usable, and handwashing facilities with accessible soap [3]. As of 2016, 69% of schools had an improved drinking water source, 66% had improved sanitation facilities, and 53% had handwashing facilities with access to soap [3]. These averages were considerably lower in Sub-Saharan Africa as nearly half of schools did not have improved drinking water sources, one in three did not have basic sanitation, and fewer than half had hygiene services with soap access [3].

It is estimated that 80% of countries state that the financing is insufficient to support the budged plans in the WASH sector and over three fourths of national school WASH plans are not fully funded or implemented [21]. There is less information available that specifically focuses on WASH in school settings [1, 11]. Out of the 74 countries profiled in the 2017 GLAAS report, only 14 reported details about their financing methods, and few of those countries had an implementation program for distributing the collected funds [23]. Only one-third of countries had financing plans that were fully defined and actively followed [21]. Frequently cited barriers to providing acceptable WASH programs in schools include inadequate financing and poor or no budgeting practices targeting program sustainability [5].

Within Kenya, there is no implementation for government funds received for sanitation or hygiene, they report having plans but not consistently having plans for drinking water [21].

Additionally, the country reports they only have between 50-75% of funding necessary to meet their 2030 SDG target [21].

A recent systematic review of published literature pertaining to WASH in schools founds there to be large gaps in data availability and variation by region. Out of the 48 articles within the review, 22 include WASH hardware and installation, 20 report recurrent costs, and 7 reference the cost of WASH software; only 12 articles were related to school specific WASH [15]. The researchers found there was a large different in costs based on country, with the cost of a traditional dug pit latrine varying from 2.44 USD per person in Ethiopia to 14.93 USD in Tanzania [15, 20, 56]. There is a wider variability when researchers compare costs by continent [15]. The review found there to be considerably less information on school than community WASH and the data is highly variable by country and region.

In 2006, the School Water, Sanitation and Hygiene plus Community Impact (SWASH+) project was established to help provide research and solutions for improving WASH in Kenyan schools [9, 10]. During the first phase of SWASH+, rigorous studies were done in 185 schools. The project results showed the positive impact of good WASH programs, such as increasing attendance, reduction in diarrheal disease and reduction in helminth infection. Based on the project recommendations, the Government of Kenya doubled the subsidy for WASH in public schools [9, 10]. The second phase of the SWASH+ program focused on providing sustainable services and identifying the lifetime costs of WASH programs and infrastructure.

The previous study on which this project is built is the "Life-Cycle Costs of School Water, Sanitation and Hygiene Access in Kenyan Primary Schools" with data from 89 rural Kenyan schools. The results established that schools spend an average of 1.83 USD per pupil per year on WASH programs. This is considerably lower than the estimated expenditure of 3.03 USD per pupil necessary to maintain basic WASH services or the 4.92 USD per pupil to install and maintain a school WASH program. The study also served to provide a base calculation the Government of Kenya used in their "Standards and Guidelines For Wash Infrastructure In Pre-Primary and Primary Schools In Kenya" document for users to estimate their costs of WASH programs and infrastructure in schools. This initial life cycle costing study established the framework on which this subsequent analysis is based.

Objective:

The primary goal of this study was to determine the WASH related costs Kenyan schools can expect to incur annually. The paper also compares available financing estimates provided by outside sources with actual annual expenses incurred by schools. The budget calculator created overcomes many barriers that schools face is establishing and maintaining a high-quality WASH program. The analysis was used to create a simple budget calculator for Kenyan schools to estimate their annual expenditures on WASH specific line items. With the advent of a cost calculation tool schools will have a customized budget they can use to plan out their expenses and will have guidance on what expenses are necessary to maintain their program. In providing this budget, schools can identify areas where their expenditures are sub-optimal and can lobby for additional resources or funding. By providing a clear estimation of what schools can expect to spend, they are able to manage their existing resources better and prioritize spending in areas that were previously neglected.

This analysis serves three purposes: provide head teachers statistically sound estimates of what their school can expect to spend per pupil per year, aid teachers in budgeting out WASH related expenses over the school year, and to serve as an advocacy tool to assist stakeholders in lobbying for increased financial resources to meet Kenyan national standards. The tool created solves many barriers schools face in maintaining a WASH program and establishes a budgeting framework schools can use to ensure they are appropriately allocating financial resources for long term program and infrastructure sustainability.

3. METHODS

3.1 Purpose

We conducted a study to determine the WASH related costs Kenyan schools can expect to incur annually, accounting for many factors and not assuming a one size fits all mentality. We utilized life cycle costing as a method to determines an items useful life as well as the accompanying methods to repair and maintain it. While life cycle costing has its roots in the U.S. military and is frequently used within the industrial sector, the IRC modified the Life Cycle Cost Approach (LCCA) to be applicable to WASH costing [57, 58]. The purpose of life cycle costing is to determine the full cost of a good, including estimating it future costs, such as those associated with repairs or maintenance. Life cycle costing allows the user to determine the real cost of a good by calculating the life span of the good and associated costs along its useful life [57]. The IRC created LCCA for communities to use in determining the full cost of facilities, including the additional expenses of repairs and maintenance [58]. The IRC calculated life cycle costs for WASH in schools in and established the six domains of WASHCost research: capital hardware and software, capital maintenance, capital start up cost, operating and maintenance, direct support, and indirect support [58, 59]. Within this research, we focus on three of the domains: capital hardware, capital maintenance, and operations and minor maintenance. We use this approach to ensure the expenses we report schools should be spending reflects the actual long-term costs.

Our primary questions are: What is the current spending on WASH in schools? and What should schools be spending to maintain at least basic WASH standards? We built a calculator that the head teacher or principle at a given school can use to estimate the WASH budget for the following year. We provide guidance to schools on budgeting their current finances.

3.2 Data

We collected annual reported WASH expenditures from 189 urban and rural schools and cost data for WASH items from 32 local shops across six counties in Kenya. Data from rural schools were collected from three counties in Kenya and included the annual WASH specific expenditures of 89 rural, primary schools in 2014 [11]. Thirty schools were randomly selected from each county and data were collected via paper forms by trained enumerators with extensive experience in the Kenyan school WASH sector. In 2017, similar data were collected from 100 public and private primary schools and secondary schools in four urban counties of Kenya. Data were collected from schools during the second phase via mobile data collection using the same enumerators from the 2014 study. School officials were asked the costs of maintaining their WASH program, both in what do they purchase and what is the annual expense. Respondents were additionally asked to report their water sources, latrine number, type and status, student body population, and estimated cost of repairs to existing infrastructure. Along with the formal interview, observational data on the schools WASH infrastructure was collected. This data was further used to assess the quality of existent infrastructure and estimate the cost of repairs to return to at least "basic" WASH status. Information collected from schools separated costs by actual or estimated expenditures. Collected data from both surveys was aggregate, sorted, and cleaned in SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

Along with actual reported expenditures, costs of goods from local shops and hardware stores, in both urban and rural counties, were collected and NGO and government interviews were done to assess additional costs the schools did not directly incur. Local shop data were collected in a Word (Microsoft, Redmond, WA, USA) document and entered into an Excel file.

3.3 Analysis

Our initial step in analysis was sorted the costs into explicit budget categories. Collected cost variables were assigned to one of the three cost domains established by the IRC WASHCost studies: operations and maintenance, capital maintenance, or capital infrastructure [58]. We did not include costs of WASH specific education programs, trainings, or cost of capital as schools did not report this expense. While we have data regarding capital infrastructure construction costs, the Government of Kenya provided clear cost and construction information in their "Standards and Guidelines" document [12]. The budget tool itself references these direct costs; however, the user must directly select them as they are not automatically considered in the budget estimation. We further separated operations and maintenance into the two categories of consumables and services. The final budget estimations are separated into three output categories: consumables, services, and capital maintenance. Consumables are defined as goods that need to be regularly purchased in order to maintain at least basic WASH standards, such as cleaning materials or water treatment. Services is the category of operations and maintenance comprising annual recurrent payments, such as related salaries and water purchase. Capital maintenance comprises anything that maintains the structural integrity and general structural quality of a schools WASH infrastructure, including latrine door repair or replacement, water tap replacement, or pipe repairs. Post categorization, we identified 28 line items of interest that are relevant in budgeting a school WASH program. We calculated the costs "per capita", using the schools total annual cost divided by the number of pupils enrolled in the school.

We then assigned schools to different categories to proceed with analysis. Most schools in the dataset utilized multiple sources of water and multiple types of latrines. Schools were assigned a "primary" water source based on self-reported data. The "primary" latrine type was determined by the number of each unlocked, usable latrine with a functioning door each school has available to students. Schools were assigned a primary type where greater than 50% of their usable latrines were alike. The school location, student age group, latrine type, and water source were used as the primary strata during analysis.

In total the calculator can estimate annual school WASH expenditures with the following variables (Table 2):

Table 2: Major Variables for Data Stratification

Stratification Variables			
School Location	**Student Age Group**	**Water Source**	**Latrine Type**
Urban	Primary	City Piped Water	VIP/Pit
Rural	Secondary	Borehole	Pour-Flush
		Rainwater Harvesting	Traditional Flush
		Vendor Purchased	

We applied the variables to the data and attempted to model estimated costs based on school characteristics. In providing the budget estimates, we only consider variables significant predictors of cost if it changes the estimated annual value by 10% or greater. Where the variable was shown to have a significant practical effect on the results, the variable is reported as conditional in cost estimation. While the student population, percent of females, and current number of latrines are requested within the input page of the calculator, all are used as value multipliers instead of use in analysis or stratification.

3.4 Statistical Calculations

In cases where greater than 30 schools reported costs for a line item, the variable was stratified by school location, student age group, water source, and latrine type. The data were only stratified when five or more schools fit into each category. Given the non-parametric nature of cost data, the expenditures were bootstrapped through SAS 9.3 (SAS Institute Inc., Cary, NC, USA) to normalize the data and provide a more accurate measure of the true mean of the values [60]. This methodology protects medium sized, highly skewed cost data from providing potentially inaccurate information about costs. Additionally, bootstrapping allows for resampling within the data to provide more robust estimations cost for data with a small sample size.,

Data were bootstrapped when the sample size was 9 or greater else the mean and sample size were only reported. A size of 9 was chosen as the minimum for a bootstrap since we found several variables with sample size less than 9 generating data that was not as reliable as the straight cost means. The means and confidence intervals were calculated from the resampled values and compared across the variables of interest. These values are reported in the results and are used by the budget calculator to provide robust estimates of school annual costs.

3.5 Line Item Assumptions

In 12 of the 28 line items there was either insufficient data to make robust statistical estimates of real costs or it is known schools chronically underfund an item and actual costs will be an underestimate of necessary expenditures. For these cases we provide the assumption and rationale behind them.

3.5.1 Operations and Maintenance: Consumables

Within the category of consumables, we make assumptions regarding consumption level and cost as school wide purchase level was generally below necessary consumption levels or Kenyan standards. We use outside estimates for three of the consumables line items: Sanitary pads, sanitary pad disposal bins, and toilet paper. These items warranted outside estimations as the given cost data supported the problem of chronic underfunding.

Previous research established the assumption of 3 sanitary pads per girl for 25% of girls in a given primary school [11]. Based on Kenyan established standards, we increased that assumption to 5 pads per girl in primary and 10 pads per girl annually in secondary school. This is based on a

9-month term schedule, where secondary school girls have access to at least once per menses per month to meet the "for emergency use" criteria within Kenyan "Standards and Guidelines" document [12]. Given the younger age of primary school girls we estimate 5 sanitary pads per girl per year. We did not collect data from rural secondary schools on this line item but applied the same principle of 10 sanitary pads per girl in secondary school to the 4 KES cost in rural regions. For sanitary pad disposal bins, we assume a cost of 650 KES (6.50 USD) per bin given it is the mean of available shop data; there was limited information to stratify costs by location. We recommend one per bin for secondary school girl's latrines, and at least 1 per 2 latrines for primary school girls latrines given the price of purchase. The assumption of 9 rolls of toilet paper per student per school year (one per month) is based on the assumption of the previous Life Cycle Cost paper, where they calculated half a roll per student per year [11]. We increased that estimate to ensure the adequate supply of anal cleansing materials specified in the Government of Kenya standards document [12]. As in the previous assumptions, we used the mean price from local shops to estimate the cost per roll of toilet paper.

3.5.2 Operations and Maintenance: Services

Within services only sewage line unblocking required an outside estimate to ensure schools were spending enough to maintain their existing sanitation infrastructure. We assume that every school year approximately 1 per 2 latrines at a secondary school level and 1 per 4 latrines at a primary school level will require sewage line unblocking, with an average cost of 3000 KES (30 USD) per blockage. Schools will only experience this expense if they have pour flush or traditional cistern flush toilets. The rate is higher to compensates for the high level of unmaintained infrastructure that will need to be repaired to achieve basic WASH status. The cost per blockage is based in the existing costing data and the frequency of repairs needed is based on the observational data collected during the initial interviews. Caretaker and security guard analysis warranted breakdown explanations as the school population size heavily influenced costs. Additionally, rural schools did not report any expenses for a security guard. We analyzed the caretaker and security guard data to determine possible conditions where the cost per pupil changes by more than 10% and there are at least 5 schools in each category. Schools with a caretaker can be sorted into three categories of pupil size: 1-300, 301-600, and 601+ pupils in the student body, with a decreasing per pupil cost as the school size increases. For security guards, the primary schools in urban regions can be broken into three categories: 1-500 students, 501-1000, and 1001+ pupils in the student body. While inconsistent across category, the student body size groupings estimates demonstrate where the greatest cost changes occur.

3.5.3 Capital Maintenance

Capital maintenance as a category had the highest number of line items necessitating costing assumptions to overcome the limited data and regular underfunding. Within this category of maintenance, we make assumptions for six costs: latrine door replacement, latrine door hardware replacement, water pipe repair, flush toilet repair, latrine compartment superstructure repair, and latrine slab repair.

Schools had varying quantities of latrines available to students, many of which are not classified as improved WASH since they have broken doors or no locks and hinges. We estimate that approximately half of all latrine will need to have the locks or hinges replaced annually, with a mean prince obtained from local shops of 300 KES (3.00 USD) per item. We utilized the standard estimates established by the early life cycle costing study of one half of latrine locks and latches being replaced annually, with an adjustment to reflect the mean cost of materials from local shops and hardware stores [11]. We used an estimate of one fourth of doors needing to be replaced annually as more frequent repairs of locks may protect the lifespan of the door itself [25]. The government of Kenya standards have a WASH student to latrine ratio of 25:1 [12], we used this ratio when calculating the cost per pupil of latrine maintenance annually. Water pipe repair is consistent among rural schools, but variable depending on water source within urban schools. For this reason, we established straight estimates of one repair per year at costs dependent on the water source. For flush toilet repair, we made a straight assumption of 1 repair per 8 toilets at 1000 KES (10.00 USD) each. This is based on schools reported number and cost of annual flush toilet repairs as well as the existing data on quality of working toilets. We assume this value at a high frequency to overcome the existing poor infrastructure at many schools and to ensure appropriate availability of school funding. Much as we saw with other capital maintenance items, the latrine superstructure was shown to be in disrepair in many schools, indicating chronic underfunding. Few schools reported this expense, but we took that reported value, adjusted for the number and quality of their existent latrines, and established an estimate of 1 repair per 10 latrines at 4500 KES (45.00 USD). Latrine slab repair is typically a cost that only occurs during pit emptying practices. We provide an estimate of each repair costing 8000 KES (80 USD).

3.6 Ethics

Data collection was not classified as human subject research and were not subject to ethics approval by Emory University's Institutional Review Board. Both the rural and urban arms of life cycle cost study had written approval from the Government of Kenya and had obtained permission from principles and/or head teachers to be interviewed about the schools WASH infrastructure and expenses.

4. RESULTS

We conducted 189 surveys in total, 89 in rural schools and 80 in urban primary and 20 surveys in urban secondary schools. Preliminary data review revealed that in 15 out of 28 line items urban schools expenses differ from costs in rural areas. We saw the same results within the collected shop data, indicating that school location is an important criterion in costing. The existing literature supports that secondary schools tend to have greater expenses, and greater government funding than primary schools [13]. Our data found student age, i.e. primary or secondary school, to be a major factor in the costs of WASH goods and service. Existent costing literature from the recent WASH costing systematic review identified the type of water source as a major determinant of cost [15]. Further, this review demonstrated there is tremendous variability in cost based on a community's given latrine type. These four variables are the principle points of analysis. We found school size to be a major cost determinant in two WASH line items: caretaker and security guard and is only used as a variable of interest for those items.

4.1 Consumables

Our study focused on 9 line-items with varying percentages of schools reporting expenditures: brooms, brushes and mops (56%); detergent (60%); buckets (44%); disinfectant (44%); handwashing soap (13%); sanitary pads (25%); sanitary pad disposal bins (5%); toilet paper (4%); and water treatment (8%) (Figure 1).

Figure 1: Number of Schools Reporting Consumables Expenditures by Variable

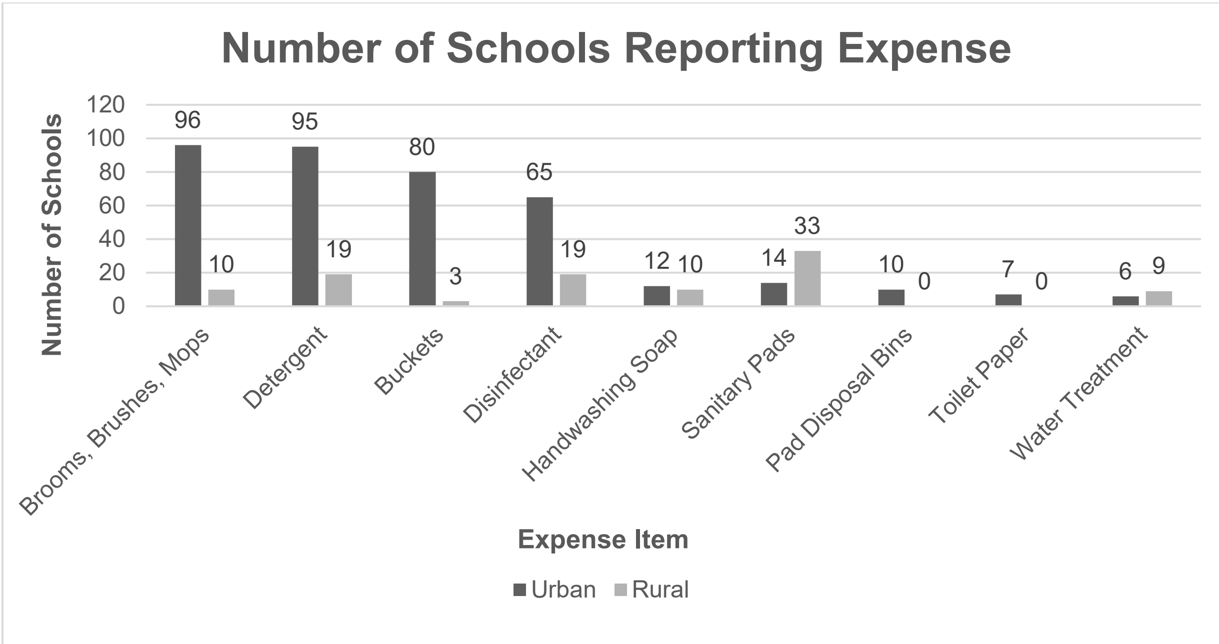


Table 3 shows the full breakdown of results for consumables. This category of goods had the highest rates of schools reporting expenditures.

Table 3: Consumables Operations and Maintenance Life Cycle Costing Breakdown

	Cost Parameter					
	Conditionality		**Value [1]**	**Units [2]**	**Means of Verification**	**Reporting**
Life Cycle Cost Category: O&M Consumables						
Brooms, brushes, mops	Location + Age	Rural Primary	5.7	per pupil	CI = (5.6230, 5.8346) **	N = 10
		Urban Primary	4.1	per pupil	CI = (4.0618, 4.1799) **	N = 75
		Urban Secondary	4.9	per pupil	CI = (4.8645, 5.0104) **	N = 20
Detergent	Location + Water Source	Rural	12.7	per pupil	CI = (12.4737, 12.8975) **	N = 19
		Urban Piped Water	54.7	per pupil	CI = (53.8319, 55.6088) **	N = 57
		Urban Not Piped Water	37.5	per pupil	CI = (36.6512, 38.3508) **	N = 38
Buckets	Location + Age	Rural	1.6	per pupil	Mean of cost data Mean=1.5771	N = 3
		Urban Primary	3.6	per pupil	CI = (3.5407, 3.6091) **	N = 60
		Urban Secondary	4.6	per pupil	CI = (4.6379, 4.7493) **	N = 20
Disinfectant	Location + Age	Rural	16.2	per pupil	CI = (15.7819, 16.6225) **	N = 19
		Urban Primary	20.8	per pupil	CI = (20.5797, 21.0388) **	N = 49
		Urban Secondary	57.5	per pupil	CI = (56.0675, 58.8739) **	N = 16
	Location	Rural	10.0	per pupil	CI = (9.8114, 10.2366) **	N = 10

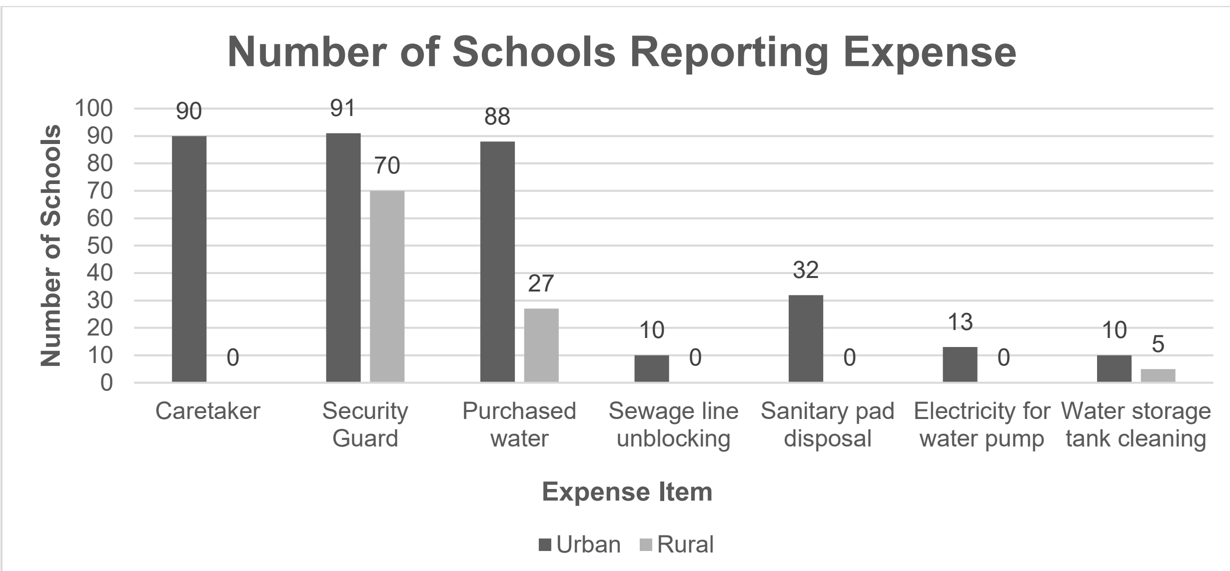
Soap for handwashing		Urban	10.7	per pupil	CI = (10.4949, 10.8479) **	N = 12
Sanitary pads	Location + Age	Rural Primary	20.0	per girl	5 per girl at 4 KES per pad Government of Kenya Guidelines and mean shop cost data	
		Rural Secondary	40.0	per girl	10 per girl at 4 KES per pad Government of Kenya Guidelines and mean shop cost data	
		Urban Primary	50.0	per girl	5 per girl at 10 KES per pad Government of Kenya Guidelines and mean shop cost data	
		Urban Secondary	100.0	per girl	10 per girl at 10 KES per pad Government of Kenya Guidelines and mean shop cost data	
Sanitary pad disposal bins	Age	Primary	13.0	per girl	One bin per 2 girls' latrine annually at the 650 KES - shop cost; Assume 1 latrine per 25 girls as per gov't standards	
		Secondary	26.0	per girl	One bin per girls' latrine annually at the 650 KES shop cost; Assume 1 latrine per 25 girls as per gov't standards	
Toilet paper	Location	Rural	144.0	per pupil	9 rolls per student per year, 16 KES per roll, shop costs	
		Urban	180.0	per pupil	9 rolls per student per year, 20 KES per roll, shop costs	
Water Treatment	None		2.0	per pupil	CI = (1.9309, 2.0147) **	N = 15

[1] Values in KES (100 KES = 1 USD) on a per school year basis
[2] Annual expense unless otherwise stated
** Indicates bootstrapping to control for wide variability within non parametric costing data [60].

4.2 Services

There are 7 reported line items with varying percentages of schools reporting expenditures: caretaker wages (48%), security guard wages (85%), purchased water (61%), sewage line unblocking (5%), sanitary pad disposal (17%), electricity for the water pump (7%), and water storage tank cleaning (8%). There were notable differences in schools reporting line items, including rural schools only hiring security guards and no caretakers (Figure 3).

Figure 2: Number of Schools Reporting Service Expenditures by Variable



As with Consumables, some line items have little reported data and assumptions are used in calculation to meet "basic" standards and water availability. Urban schools' expenditures on caretakers were highly variable and dependent on student age body size. Out of 20 secondary schools 17 hired at least one caretaker and the mean remained consistent across school size. In the 73 primary schools with caretaker expenditures, there was considerable variability based on student population size. Schools with smaller student body size spent more per pupil on average. Secondary schools also reported higher expenditures on caretakers in comparison to primary schools.

Within urban schools there was minimal difference in secondary schools' expenditures of security where the population was below 1000. Three schools had a student body greater than 1000 and spent much less than the other 17 (1221 KES v. 614.5 KES/pupil). All expenditures were bootstrapped within their subset excluding the 3 secondary schools where the number of schools and the mean expense is reported.

The most complex expense with the greatest conditionals is water purchase, where there is variability by location, student age, water source, and latrine type. Within purchased water there are 9 combinations with varying numbers of schools in each category: Rural and Primary (N=27); Vendor purchased water (N=4), Urban, Primary, and Borehole water (N=6); Urban, Primary, Piped water, and Pit/VIP (N=23); Urban, Primary, Piped, Flush or Pour/Flush latrine (N=32); Urban, Primary, and Rainwater harvesting (N=7); Urban, Secondary, and Piped water (N=12); Urban, Secondary, and Rainwater harvesting (N=2); and Urban, Secondary, and Borehole water (N=6). In all categories where less than 10 schools reported, the sample size and mean are reported, else the data are bootstrapped, and the means and confidence intervals reported (Table 4).

Sanitary pad disposal was not reported by rural schools, this may be due to only primary schools having been surveyed for this specific line item. Unsurprisingly there was large difference between the mean expenditures in primary and secondary schools (26 v 85 KES), though only 9 out of 20 total secondary schools reported spending in this category. The 23 primary schools' values were bootstrapped, and the means and confidence intervals are reported (Table 4), the mean and sample size of secondary schools were reported as well, but there was too little data for a reliable bootstrap.

Only 13 schools reported spending money on electricity for a water pump; the survey respondent estimated how much of the electricity bill was directly associated to the water pump.

Few schools report water storage tank cleaning as an expense (N=15), with both rural and urban schools contributing. With the limited sample we calculated the mean and did not stratify on any other conditions.

Table 4: Service Operations and Maintenance Life Cycle Costing Breakdown

	Cost Parameter					
	Conditionality		**Value [1]**	**Units [2]**	**Means of Verification**	**Reporting**
Life Cycle Cost Category: O&M Services						
Caretaker	Location + Age + Student Population	Urban Primary 1-300 Pupils	551.0	per pupil	CI = (543.7, 557.8) **	N = 22
		Urban Primary 301-600	258.0	per pupil	CI = (104.8, 410.7) **	N = 17
		Urban Primary 601+	117.0	per pupil	CI = (85.1554, 149.2) **	N = 34
		Urban Secondary	251.0	per pupil	CI = (186.4, 316.2) **	N = 17
Security Guard	Location + Age + Student Population	Rural	124.0	per pupil	CI = (123.5, 124.8) **	N = 70
		Urban Primary 1-500	785.0	per pupil	CI = (776.4, 792.5) **	N = 31
		Urban Primary 501-1000	318.0	per pupil	CI = (315.2, 320.8) **	N= 22
		Urban Primary 1001+	130.0	per pupil	CI = (129.1, 131.5) **	N = 17
		Urban Secondary 1-1000	1221.0	per pupil	CI = (1202.7, 1239.3) **	N = 18
		Urban Secondary 1000+	615.0	per pupil	Mean of cost data Mean = 615	N = 3
Purchased water	Location + Age + Water source + Latrine Type	Rural Primary	46.5	per pupil	CI = (45.8974, 47.0313) **	N = 27
		Vender Purchased	525.6	per pupil	Means of cost data Mean = 525.5785	N = 4
		Urban, Primary, Borehole	380.0	per pupil	Means of cost data Mean = 379.875	N = 6
		Urban Primary, Piped, Pit/VIP	180.4	per pupil	CI = (177.2, 183.5) **	N = 23

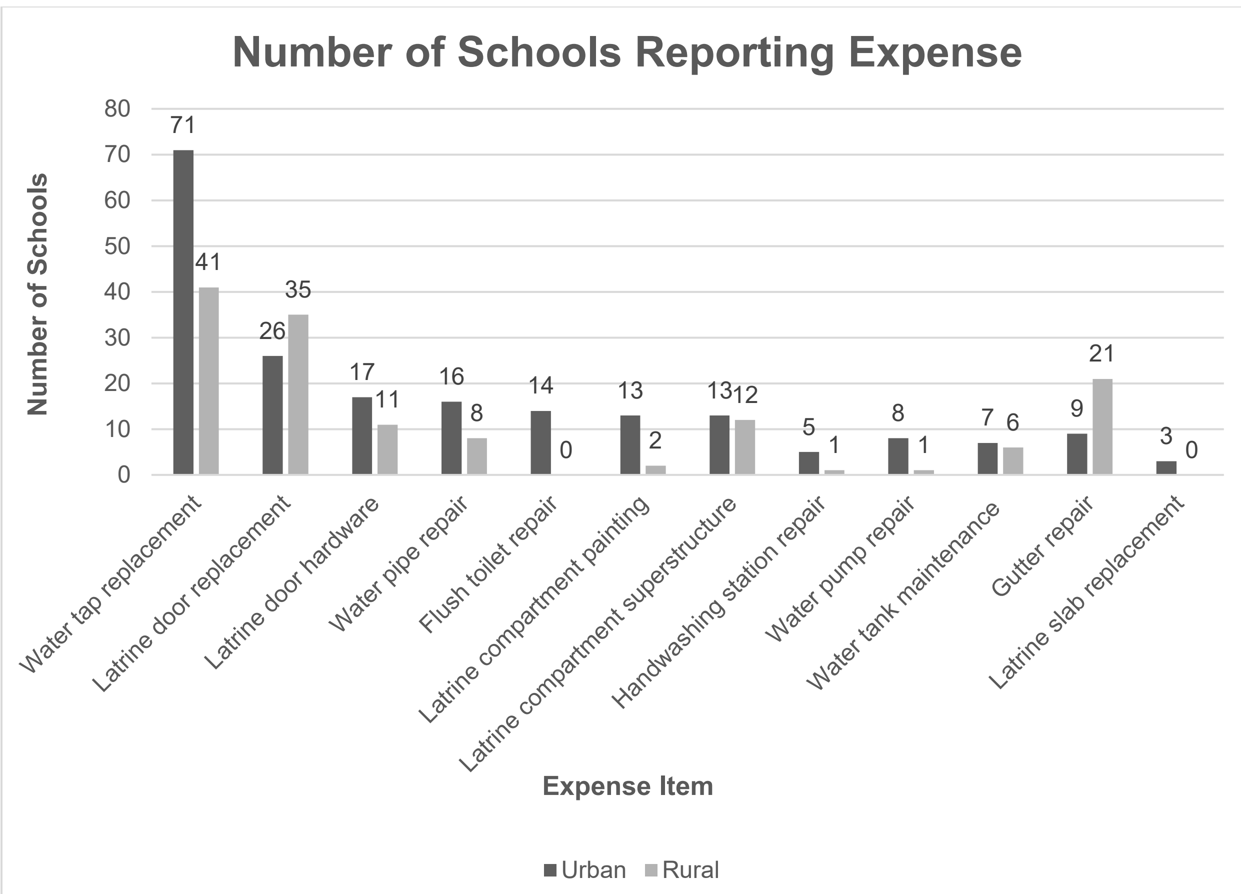
		Urban Primary, Piped, Flush/ Pour Flush	241.3	per pupil	CI = (239.4, 243.2) **	N = 32
		Urban Primary, Rainwater	118.0	per pupil	Means of cost data Mean = 117.926	N = 7
		Urban Secondary, Piped	690.1	per pupil	CI = (681.2, 699.0) **	N = 12
		Urban Secondary, Rainwater	361.0	per pupil	Means of cost data Mean = 360.689	N = 2
		Urban Secondary, Borehole	145.0	per pupil	Means of cost data Mean = 144.703	N = 6
Sewage line unblocking	Age + Latrine Type	Primary, Traditional/ Pour Flush	30.0	per pupil	1/4 latrines break at 3000 KES per blockage; Government of Kenya standards of 25 pupils per latrine	
		Secondary, Traditional/ Pour Flush	60.0	per pupil	1/2 latrines break at 3000 KES per blockage; Government of Kenya standards of 25 pupils per latrine	
Sanitary pad disposal	Age	Primary	26.0	per pupil	CI = (25.8486, 26.2171) **	N = 23
		Secondary	85.0	per pupil	CI = (82.4681, 87.5840) **	N = 9
Electricity for water pump	Water Source	Borehole	115.0	per pupil	CI = (113.6, 116.0) **	N = 13
Water storage tank cleaning	None		9.8	per pupil	CI = (9.7010, 9.9846) **	N = 15

[1] Values in KES (100 KES = 1 USD) on a per school year basis
[2] Annual expense unless otherwise stated
** Indicates bootstrapping to control for wide variability within non parametric costing data [60]

4.3 Capital Maintenance

There are 12 capital maintenance line items collected in this study with differing percentages of schools reporting each: water tap replacement (59%), latrine door replacement (32%), latrine door hardware (15%), water pipe repair (13%), flush toilet repair (7%), latrine compartment painting (8%), latrine compartment superstructure repair (13%), handwashing station repair (3%), water pump repair (5%), water tank maintenance (7%), gutter repair (16%), and latrine slab repair (2%) (Figure 3).

Figure 3: Number of Schools Reporting Capital Maintenance Expenditures by Variable



Despite many schools reporting expenditures on capital maintenance and infrastructure repairs, most still report unusable latrines, broken infrastructure, or dilapidated WASH buildings.

For this reason, we rely more heavily on assumption than actual expenditures as schools likely are not spending enough to maintain basic standards.

Table 5: Capital Maintenance Life Cycle Costing Breakdown

	Cost Parameter					
	Conditionality		**Value [1]**	**Units [2]**	**Means of Verification**	**Reporting**
Life cycle cost category: Capital Maintenance						
Water tap replacement	Location	Primary	3.9	per pupil	CI = (3.8532, 3.9445) **	N = 98
		Secondary	9.4	per pupil	CI = (9.2641, 9.5251) **	N = 14
Latrine door replacement	Location	Rural	5.0	per pupil	1/4 of doors replaced annually at 500 KES per door; Assume Government of Kenya standard of 1 latrine per 25 pupils	
		Urban	18.0	per pupil	1/4 of doors replaced annually at 1800 KES per door; Assume Government of Kenya standard of 1 latrine per 25 pupils	
Latrine door hardware	None		6.0	per pupil	1/2 of all hinges, locks and latches on latrine doors replaced annually at 300 KES per door; Assume Government of Kenya standard of 1 latrine per 25 pupils	
Water pipe repair	Location + Water Source	Rural	10.6	per pupil	Mean of cost data Mean = 10.62872	N = 8
		Urban Piped	4000	per year	One repair per school per year; cost 4000 KES	
		Urban Borehole	400	per year	One repair per school per year; cost 400 KES	
Flush toilet repair	Latrine Type	Traditional Flush	5.0	per pupil	1 repair per 8 toilets at 1000 KES each; Assume Government of Kenya standard of 1 latrine per 25 pupils	
Latrine compartment painting	None		35.0	per pupil	CI = (34.0411, 35.1412) **	N=13

Latrine compartment superstructure	None		18.0	per pupil	1 repair per 10 latrines at 4500 KES; Assume Government of Kenya standard of 1 latrine per 25 pupils	
Handwashing station repair	None		22.0	per pupil	Mean of cost data Mean = 21.72016	N=5
Water pump repair	Water Source	Borehole	122.7	per pupil	CI = (118.5, 126.8) **	N = 9
Water tank maintenance	Water Source	Rainwater	16.2	per pupil	CI = (15.9986, 16.4919) **	N = 13
Gutter repair	Location	Rural	30.6	per pupil	CI = (29.7784, 31.4436) **	N = 21
		Urban	44.9	per pupil	CI = (43.8911, 45.8272) **	N = 9
Latrine slab repair	Latrine Type	Pit/VIP	8000	per pit exhausted	1 repair per pit emptied at 8000 KES	

[1] Values in KES (100 KES = 1 USD) on a per school year basis
[2] Annual expense unless otherwise stated
** Indicates bootstrapping to control for wide variability within non parametric costing data [60]

5. DISCUSSION

Our principle aim was to conduct and report on cost analysis of WASH programs in schools in a transparent and system method. To accomplish this, we needed answers to our two primary questions: What is the current spending on WASH in schools? and What should schools be spending to maintain at least basic WASH standards?

We found the current spending on WASH programs in schools to be irregular and influenced by what goods are donated by local NGOs or outside organizations. The irregularity in spending and school specific needs indicates there is not a reliable estimate of how much schools currently spend on average per pupil on WASH. We see a chronic underfunding of key elements of WASH programs: in toilet paper, sanitary pads, door hardware replacement, among others, that indicates schools are not spending enough to maintain a basic program. The necessary spending on WASH in schools is variable and driven primarily by four factors: school location, student age, water source, and latrine type. The combination of these factors means that there are 48 school WASH combinations with varying expenses by category. A rural primary school of 400 pupils, with half being female, using VIP latrines and rainwater harvesting can expect to spend 562.3 KES per pupil per year to maintain basic WASH services. On the other end of the spectrum, an urban, secondary school with 400 pupils, half of which are female, traditional flush toilets and a piped water supply can expect to spend the most per pupil annually, at 2852.6 KES per pupil per year. Most schools can expect to find an estimate between 1000-2000 KES per pupil annually, depending on their current WASH infrastructure and supplies.

The calculations and corresponding cost assumptions are supported both by the existent literature and the school cost data themselves. There are high levels of variability in spending in schools relative to location, age, water source and latrine type; in some cases, the size of the student body had a large effect on expenditures.

5.1 Consumables

In looking at the costs for consumables, we found the primary drivers of cost were average student age and school location. These parameters are known contributors to cost variation within schools, both anecdotally and within the literature [11, 13, 59]. Within the variable of brooms, buckets, and mops, we found the cost per pupil to differ across student age and school location by greater than 10% in rural primary, urban primary, and urban secondary schools (5.7 v. 4.1 v. 4.9 KES) respectively. They also contained non overlapping confidence intervals ((5.6230, 5.8346) v. (4.0618, 4.1799) v. (4.8645, 5.0104) KES), indicating the variables are statistically supported (Table 3). The 10% marker was selected to ensure there was practical, as well as statistical significance, in establishing the cost parameters. In water treatment we found no specific variables driving cost, and thus used the bootstrapped mean and confidence interval. We see the dual impact of location and age on expenses for three other variables in this category as well: buckets, disinfectant, and sanitary pads. We saw location to be the only parameter of significance in handwashing soap and toilet paper. The former is due to the limited data points available where we could not use age as a valid parameter, indicating many schools do not report purchasing hand soap. Soap is the only consumable variable that violates the 10% marker, where the expense in rural schools is estimated at 10 KES with confidence interval (9.8114, 10.2366) and urban schools at 10.7 KES with a confidence interval of (10.4949, 10.8479). We included location as an important variable here as it was statistically significant, with non-overlapping confidence intervals, and the rounded value meets the 10% rule. Only in detergent did water supply became a significant factor in establishing an annual cost estimate. We saw this in urban schools where the expected difference between an urban school with piped water and one without was greater than 45% (54.7 KES v 37.5 KES). We do not see this in rural schools (12.7 KES), given the more limited data we collected in rural schools. We do see water supply acting as an important parameter within services and capital maintenance but is only significant for detergent within consumables.

Three line items in the consumables category required cost assumptions to be made, this is due to the limited data available and evidence supporting that an insufficient volume is purchased by schools. We provide frequency and cost estimations for sanitary pads, sanitary pad disposal bins, and toilet paper purchase. The absence of expenditures on sanitary pads and the associated disposal bins was unsurprising, given previous literature on the subject [47]. We interpreted the "for emergency use" recommendation within the Kenyan "Standards and Guidelines" documents to provide at least one sanitary pad per girl per month in secondary school and one pad for every other girl in primary school [12]. This equates to 5 pads per girl per year in primary and 10 pads per girl per year in secondary school. In rural areas we found an approximate cost of 4 KES per sanitary pad and 10 KES per pad in urban regions. Much like sanitary pads, few schools reported purchasing bins for sanitary pad disposal. This low number indicated that many schools may not have designated bins and pupils may be disposing of sanitary materials in the latrine. Improper disposal in traditional flush or pour flush latrine may lead to blockages which can contribute to the higher maintenance costs we see in the data. This could be a likely contributor to the high rate of broken or unusable latrines in secondary schools, however the collected data is not robust enough to make this assumption. These costs could be mitigated by the addition of appropriate sanitary pad disposal bins in girls' latrines. In following the "Standards and Guidelines" we recommend the purchase of at least one bin per two girls' latrines in primary school and one bin per girls latrine in secondary school. Costing data suggests each bin costs approximately 650 KES from a local shop. Assuming schools meet the 1:25 student to latrine ratio, this equates to 13 KES per girl in primary and 26 KES per girl in secondary school. Toilet paper was the last variable within consumables category that required an assumption for cost calculation. We doubled the estimate from the previous Life Cycle Costing paper from ½ of a roll of toilet paper to one roll per pupil per year [11]. This was increased as several urban schools reported expenditures above previous recommendations, but still did not have a sufficient supply.

5.2 Services

Services comprise the smallest WASH category with only 7 relevant budget items. However, due to the nature of the services, there is a high level of cost variability notably regarding water. Arguably the most complex costing variable, purchased water has highest number of variable combinations with budget estimations ranging from 46.5 KES per pupil at rural primary schools to 690.1 KES per pupil for an urban secondary school with a piped water supply. The variable combinations result in several of the potential combinations having a small sample size, limiting the capacity of the bootstrapping method to provide robust statistical power. Even with limited statistical power, it is important to differentiate the costs as there is considerable variability in expenditures based on the schools existing WASH program that need to be considered during budgeting. Traditional flush toilets consume the greatest amount of water per flush and generally require the most maintenance to remain at "improved" status. Schools with VIP or pit latrines use less water for sanitation and have a correspondingly lower water expense per pupil on average. Schools using predominantly piped water exhibited higher spending per pupil on water, as a municipal water bill will be higher than the "free" cost of collecting water from a river or other surface water. Many schools reported rainwater harvesting as their primary water source, however this source may be difficult to maintain in the dry season and will likely need to be supplemented by another supply, potentially causing wide variability in costs throughout the year. Boreholes have fluctuating costs per pupil when compared to location and student population age, this is likely due to many being in disrepair and requiring more annual upkeep than a traditional piped system. They have the added expense of electricity, bringing up the annual cost per pupil.

While there is support in the literature for the impact of location, student age, water source, and latrine type on WASH expenses, there is limited information on the impact of school size. School size had a marginal effect on the calculated expense per pupil, with larger schools better able to distribute WASH costs. This was only notable in determining the mean cost of a caretaker and a security guard, where smaller schools reported spending much more per pupil than larger schools. Caretakers were only present in the expenses of urban schools; it is likely that the security guards of rural schools are responsible for both positions. The established breakpoints of 300 and 600 pupils in urban primary schools were chosen to maximize the number of schools in each size category (N=22, N=17, and N=34 respectively), control for the extremes of high and low student populations, are the points at which the confidence intervals overlap the least ((543.7, 557.8) v (104.8, 410.7) v (85.1554, 149.2) KES per pupil), and the means are the most distinct (551 v 258 v 117 KES per pupil. Urban secondary schools did not have enough variability to justify any breakdown by size. The same principle for student population breakdown was applied to security guard expense, however the points of significance were found to be at 500 and 1000 pupils. The cost was considerably higher for security guards as well.

The only assumption necessary for the services category was for sewage line unblocking, where there is variation by latrine type. We see this reflected in the literature, as different types of latrines incur different expenses. Our primary assumption is on the frequency of breakage: one fourth of primary and one half of secondary latrines will need repair. This line item is considered a service as it is considered a rolling expense that schools can regularly expect to incur, as opposed to thee one-time fixes that we see within capital maintenance.

5.3 Capital Maintenance

Repairs on infrastructure and general maintenance were highly variable, with few schools reporting expense in maintaining all aspects of their WASH systems. The limited reported repairs combined with the dilapidated infrastructure reported in the observation data indicated that schools are routinely performing less maintenance than they should be. We assume that schools performing the maintenance needed restorative maintenance and repair, beyond a necessary annual upkeep cost. Few schools reported repainting the latrine compartment (N=13), repairing the handwashing station (N=5), or repairing the gutters (N=20). We assume these are activities schools should annually be engaging in to ensure a “basic” school WASH program. Schools should expect to incur these expenses annually, or semi-annually, and should be included as part of the WASH budget. For items like latrine compartment superstructure repair we had more limited data and based the repair calculations off of the frequency of broken latrines in schools and the estimated cost of repairs to return them to improved and usable status. As compared to the other two categories, capital maintenance sees the most assumptions of costs and expenditures. This is due to the general poor quality of existing infrastructure and the routine neglect of maintenance.

6. STRENGTHS AND LIMITATIONS

This paper presents findings that are statistically strong given they come from actual school reported WASH related annual expenses and have been resampled via the statistical technique of bootstrapping to ensure sound estimates of mean costs. This statistically robust methodology serves as one of the primary strengths of the paper. We avoided utilizing a one size fits all methodology to help control for the wide variability in expenses based on the identified variables: school location, school age group, water source, latrine type, and for some variables the student body population. This enables us to prevent use of direct means that are not representative of the entire sample. The results are designed to aid school head teachers where they can identify their school specific characteristics and view the estimations that are appropriate for them. This methodology is comparably unique to WASH costing data in the past where values are not disaggregated by impactful variables [15]. Additionally, at points where estimations are necessary, given the lack of available data or its insufficient quality/quantity, we leveraged existing standards from the Government of Kenya's "Standards & Guidelines For Wash Infrastructure In Pre-Primary & Primary Schools In Kenya [12]." This allowed us to directly cost out what schools should be spending to meet set government guidelines, as opposed to arbitrary markers. It additionally allows users to know how the estimations of expenses fall in line with national policies.

While there are many strengths of the statistical and other methods used in our financing estimations, there are many limitations as well. The data were collected via interviews with head teachers or principles of participating schools on what their WASH associated costs were in the past year. This may cause recall bias where the interviewee misremembers what the costs were or does not have access to the exact costs and guesses. Specifically, for boreholes interviewees are asked to estimate the cost of electricity in operation. They then must estimate how much of their current bill goes towards that expense, opening the potential for error. Aside from potential interview bias, the rural cost data was collected in 2014 and the urban in 2018, the 4 year gap could potentially bias results and, assuming inflation, would make costs in rural schools artificially lower than in urban schools that were collected at the later date. Another limitation in this paper could be that the data is used for secondary analysis. This could have resulted in some relevant data not being collected at the time, notably in the rural schools where there is limited information on some relevant variables. Additionally, among the rural schools, there is only data available for primary and not secondary schools. This biases estimation of secondary school costs as there is no data to inform associated costs in a rural context. Despite the clear limitations, the statistically robust nature of the paper overcomes the obstacles.

7. PUBLIC HEALTH AND POLICY IMPLICATIONS

There are many implications in both health and for policy planning as a result of this research. Kenyan schools are underfunded and lack the capacity to effectively budget out their annual WASH expenditures. This results in poorly maintained infrastructure, a lack of sufficient consumable goods, and poor quality of existing services. This paper is designed to combat those issues by providing clearly defined estimations of annual expenditures that schools can use for annual WASH budgeting. From a policy perspective, this allows government officials to see how much it will cost to run a school WASH program that meets national guidelines. This information will allow officials to more accurately fund the FPE and FSE to reflect actual expenditures, as opposed to estimations. On a wider scale, this additional funding can improve the existent WASH services and infrastructures at schools though increases dedicated to repairs and maintenance.

Additionally, this will have an impact on Kenyan school's health and health programs as well. Within MHM programs, it would provide more funding for sanitary materials for girls and in other hygiene programs will provide more funding for items like soap or improved handwashing stations. We can expect the increased quality of WASH services coupled with more consumable materials, notably for girls, can decrease absenteeism and improve overall school health.

8. RECOMMENDATIONS

Based on the results of this research, we have several recommendations for future school planning and government action. Going forward there needs to be increased funding in both the FPE and FSE to allow schools more grant money to property financing and budget for their WASH programs. Increased funding opportunities allows for schools to invest in their own infrastructure and programs, as well as dedicate more money to consumable material that may frequently be inadequate. Head teachers whose schools do not have adequate financing to meet the budget estimations should use the estimated costs to lobby the local BoM for increased funding. The boon of the paper is that head teachers will have exact costs and will not have to engage in guess work regarding how much additional funding they will need. Maintenance and general repairs appear to be neglected in many WASH programs and increased dedicated funding can help mitigate the associated costs and encourage more frequent repair activity. Along with directly increasing funding, schools need to create a set schedule of budgeted activity so they can better manage their existing resources. In providing both more resources and guidance on establishing a budget to facilitation distribution of the new financing, schools will be better able to maintain their existing programs and infrastructure, as well as expand to meet set Kenyan national standards of WASH in schools.

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