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Impact of Game-Based Educational Interventions on Pupils' Knowledge of WASH-Related Neglected Tropical Diseases: A Quasi-Experimental Study in Rural Kenya

Concilia Magaya Ogombo[1,2*], Maximilla Wanzala[1], Tom Were[3]

[1]Department of Public Health, Masinde Muliro University of Science and Technology, Kakamega, Kenya
[2]Department of Public Health Nutrition and Behavioural Sciences, Alupe University, Busia, Kenya
[3]Department of Pathology, Masinde Muliro University of Science and Technology, Kakamega, Kenya
Email: *ogombo1978@gmail.com

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Abstract

Background: Games provide an immerse environment that foster active learning where pupils face consequences for their choices in a risk-free setting. They have been linked to enhancing engagement and motivation, improving learning outcomes, and fostering the development of essential skills among the participants. Despite the growing global interest in interactive pedagogy, there is a profound lack of empirical research exploring game-based intervention on WASH-related NTD prevention within the Kenyan context. **Methods:** A non-equivalent quasi-experimental design was adopted. The study targeted primary school pupils, who represent the most active demographic in terms of environmental interaction and are the primary focus of the National School-Based Deworming Program. The researcher adopted a power analysis to calculate sample size for the comparison groups. Data was analysed using paired t-test and independent t-test. **Results:** The researcher collected demographic data to characterize the study participants and to ensure comparability between the Treatment and Control groups at baseline. This similarity is crucial in a quasi-experimental design. It helps confirm that any differences observed after the intervention are attributable to the intervention rather than to pre-existing group differences. The overall knowledge on the causes of the common NTDs showed a statistically significant gain of 3.280 points ($t(124) = -26.078$, $p < 0.001$); knowledge of modes of transmission showed a robust mean increase of 2.928 points, while knowledge on prevention scored a significant increase of 3.120 points ($t(124) = -21.091$, $p < 0.001$). The results indicated a statistically significant improvement in all measured variables, as evidenced by p-values of

less than 0.001. The results from the independent sample t-test showed that the Treatment group demonstrated significant greater gains as compared to the Control group. The exceedingly low p-values ($p < 0.001$) indicated that the differences in scores were not due to chance. The analysis of variance revealed a statistically significant difference in the overall knowledge of disease causes between the groups, F (2,497) = 213.20, $p < 0.001$. The overall knowledge on modes of transmission varied significantly by group, F (2,497) =109.72, $p < 0.001$. The overall knowledge on prevention practices recorded significant differences between the groups, F (2,497) = 9.038, $p < 0.001$. **Conclusion:** The Game-based WASH intervention was highly effective intervention for increasing health literacy regarding WASH-related NTDs.

Subject Areas

Public Health

Keywords

Quasi-Experimental Design, Health Education, WASH-Related NTDs

1. Introduction

The effectiveness of game-based interventions has garnered increasing attention across various domains, including education, healthcare, and skill development. Research consistently highlights the potential of games to enhance engagement and motivation, which are crucial factors in learning and behavioural change. Studies have demonstrated that game-based learning can significantly improve knowledge acquisition and cognitive skills. For instance, reviews have shown that game-based learning applications across multiple curricular subjects effectively facilitate student learning [1]. Furthermore, the immersive and interactive nature of games can foster problem-solving, critical thinking, and collaboration skills, contributing to deeper learning experiences [1]. Reviews analysing game-based learning in early childhood education, have shown that game-based learning has a moderate to large effect on cognitive, social, emotional, motivational, and engagement outcomes [2]. This supports the need to integrate game-based learning into curricula**.** Given its moderate to large effect on cognitive, social, emotional, motivational, and engagement outcomes, game-based learning is a powerful tool for foundational learning and development. Games can simultaneously foster critical thinking, problem-solving, social interaction, emotional regulation, intrinsic motivation to learn, and sustained engagement, all of which are crucial for young children. This research reinforces the long-held understanding that children learn best through playing. Game-based learning formalizes and structures this natural inclination, leveraging it for targeted developmental gains. While the effects of games are clear, continuous exploration of specific game types, contexts, and implementation strategies can further optimize the benefits of game-based learning

for diverse early childhood settings. In the medical field, game-based interventions have proven effective in enhancing medical students' knowledge and engagement compared to traditional teaching methods highlighting the potential for games to provide safe and engaging learning environments.

The game of Snakes and Ladders, with its simple mechanics and compelling narrative of fortune and misfortune, holds a significant place in the history and study of games. Recent research highlights the educational benefits of Snakes and Ladders, particularly for young children. The game provides a playful context for developing foundational numeracy skills, such as counting, number recognition, and understanding numerical order [3]. The linear progression along the numbered squares visually reinforces the concept of sequence and magnitude [4]. Furthermore, the unpredictable nature of the snakes and ladders introduces elements of chance and probability in a simple and engaging manner [5]. The game provides an intuitive and concrete entry point for young children to grasp abstract mathematical concepts like chance and probability. Without needing formal instruction, players experience randomness through dice rolls and observe how different outcomes lead to varied progressions on the board. This experiential learning can lay a foundational understanding for more complex statistical reasoning later in life. In a world where outcomes are not always certain, the game helps children develop resilience by teaching them that sometimes, despite their best efforts, an unlucky landing on a "snake" can set them back; on the other hand, a "ladder" can offer an unexpected boost. This mirrors real-life situations where success and setbacks are part of the journey, fostering an understanding that not everything is within one's control. The inherent fun and unpredictable nature of the game make learning about chance highly engaging. Children are motivated to play, and through repeated play, they naturally encounter and internalize probabilistic ideas. This informal learning environment can be more effective than rote memorization, especially for young learners. The game can spark conversations whereby children might start to intuitively predict outcomes or discuss why certain squares are "better" or "worse." This fosters critical thinking and encourages them to observe patterns, even if they don't yet have the formal language to describe probabilities. Beyond mathematics, the game can also foster social skills such as turn-taking, patience, and coping with both success (climbing a ladder) and setbacks (sliding down a snake) [4].

Snakes and Ladders, originating in ancient India as *Mokshapatam*, has a rich cultural history deeply intertwined with philosophical and moral teachings [4]. The ladders traditionally represented virtues, while the snakes symbolized vices, illustrating the karmic consequences of good and bad deeds on the path to liberation [3]. This historical context underscores the game's initial purpose as a tool for moral instruction and the transmission of cultural values across generations [5]. While the overt moralistic elements may be less emphasized in contemporary versions, the underlying narrative of upward progress and unexpected setbacks continues to resonate across different cultures [4].

The enduring appeal of Snakes and Ladders lies in its simplicity, accessibility, and the inherent drama of chance encounters [5]. The game requires no complex strategies or prior knowledge, making it enjoyable for players of all ages and skill levels [3]. Its straightforward mechanics have also lent themselves to various adaptations and digital versions, further extending its reach and appeal in the modern era [4]. These adaptations often incorporate new themes, visual designs, and sometimes modified rules, while retaining the core elements of climbing ladders and avoiding snakes [3].

The game also offers insights into basic psychological and social dynamics. The experience of unexpectedly advancing due to a ladder evokes feelings of joy and excitement, while the sudden descent down a snake can lead to frustration or disappointment [4]. Observing these emotional responses in oneself and others can provide a rudimentary understanding of how chance events can influence feelings and outcomes [5]. Playing the game in a social setting also encourages interaction, communication, and the shared experience of both good and bad luck [3].

2. Methodology

The study was conducted in Bunyala Sub-County, located in the lower region of Busia County, Western Kenya. The sub-county consists of four administrative wards: Bunyala West, Bunyala Central, Bunyala South, and Bunyala North. The region is geographical defined by its proximity to large water bodies and a high-water table, which significantly influences the daily behaviors of school-aged children.

The study targeted primary school pupils, who represent the most active demographic in terms of environmental interaction and are the primary focus of the National School-Based Deworming Program. The study excluded pupils in grade 1 to 3 due to developmental and cognitive considerations, as their limited literacy, shorter attention spans, and less developed self-reporting abilities could compromise data accuracy and engagement with the game-based intervention. Similarly, pupils from private schools, boarding schools, and special needs primary schools were excluded to ensure the homogeneity of the study population and manage contextual variations; these settings often present different socioeconomic backgrounds, distinct daily routines, varied WASH infrastructure that could confound the study's results and generalizability to the target population of public day schools. Furthermore, newly enrolled pupils in the selected schools were excluded to minimize the influence of varying prior school experiences.

2.1. Sample Determination

The researcher adopted a power analysis to calculate sample size for the comparison groups. Thereafter made some adjustments to cater for school absenteeism (expected attrition). A sample of 125 study participants per group was considered for the study.

Using the formula for two independent groups; simplified using Cohen's *d*:

$$n = \frac{2\left(Z_{\alpha/2} + Z_{\beta/2}\right)^2}{d^2}$$

Substituting the values in to the formula:

$$n = \frac{2\left(1.96 + 0.84\right)^2}{0.40^2}$$
$$= 98 \left(\text{Approximately 100 study participants}\right)$$

Adjustments were made to cater for school dropouts and absenteeism (expected attrition) using the following formulae:

$$n_{adj} = n/\left(1 - R\right)$$

where;

- R is predicted dropout rate (20%)
- n is the true sample size (100)
- n_{adj} is the adjusted sample size

Substituting the values in the formula

$$n_{adj} = 100/\left(1 - 0.2\right)$$
$$= 125 \text{ study participants per group}$$

This study adopted a quasi-experimental research design, utilizing a pre-intervention/post-intervention non-equivalent control group approach. This study design is appropriate when true randomization of study participants is not feasible, a common scenario in educational settings where intact classes must be maintained [6]. The study involved two groups: a Treatment/Intervention group, which received the Game-based WASH intervention, and a Control group which received Traditional/lecture-based WASH sensitization. The training took place once per week (Friday from 3:30 pm to 5 pm) for 4 weeks. However, for the treatment group (Bunyala South ward), the researcher distributed "*Snakes and Ladders*" game kits [7] to pupils. This was intended to help reinforce the training, enhance pupils' engagement and motivation, improve learning outcome and foster development of essential skills to achieve knowledge change. In addition, since the games were played in groups, it was intended to promote teamwork, communication and social skills among the study participants. A school level intervention was considered ideal to prevent contamination. The intervention/treatment group were trained by the research assistant, guided by the WASH training kit and thereafter provided with the Snake and Ladder game to reinforce the knowledge learnt. The control group were only trained guided by the WASH training kit (Traditional/lecture method).

The snake and ladder game has placards with pictures on WASH. The research assistants explained to the pupils each placard on the game and took them through for better understanding. The "*Snakes and Ladders*" game has six snakes and nine ladder pictures. Players rolled a dice to reveal a number (between 1 and 6); and moved the designated number of spaces. When a player land on the head of the snake, it indicates that they had engaged in practices/behaviour that favours trans-

mission of WASH-related diseases; and were forced to slide down the snake to its tail where they landed on a placard picture indicating the consequences of the practice at the head of the snake. The players were encouraged to explain the placard picture at the head of the snake before sliding down to the tail of the snake; and on reaching the tail, they were encouraged to explain the placard at the tail as well. On the other hand, when a player landed at the bottom of the ladder, it indicated that they had engaged in behaviours/practices that favoured prevention of WASH-related diseases. They could climb to the top of the ladder where they landed on a placard picture indicating the results of the practice/behaviour at the bottom of the ladder. The players were encouraged to explain the placard picture at the bottom of the ladder before climbing up the ladder; and on reaching the top of the ladder, they were encouraged to elucidate the placard at the top as well. The "*Snakes and Ladders*" game was adopted from a guidebook for teachers on Water, sanitation and Hygiene for Schoolchildren in Emergencies. It emphasizes that Schools are important places where children access basic water and sanitation services and learn about hygiene practices; and participate freely in WASH activities which marks the establishment of routines for children, with many also gaining their first experience of formal education [7]. The pupils were expected to have counters (bottle caps) to count from one point to the other after rolling a dice and revealing a number. On landing at a point, they were expected to explain the placard; if a player landed at the bottom of the ladder, they could climb to the top of the ladder and explain the reason for climbing; then the playmates congratulated them. In addition, if a player landed at the top (head) of the snake, they could move down it and explain why; and the playmates could remind them not to engage in behaviours that favour disease transmission.

The teachers (trained research assistants) supervised pupils and monitored progress on the understanding of each placard on the WASH game (Snake and ladder game). In case of a wrong interpretation, the research assistants intervened and made necessary corrections. The WASH game (Snake and ladder game) was delivered in small groups (5 to 6 pupils) for ideal engagement with a teacher as a facilitator (trained research assistant). The teacher explained the rules of the game, clarified the content on each placard, and encouraged discussion among pupils to allow for feedback and deeper understanding. After the study, the researcher encouraged pupils who participated in the study to act as trainers to their peers. The facilitators (Teachers) through observation, monitored the progress on game playing to assess effectiveness and identify areas for improvement. They observed the pupils' level of engagement, misconceptions, challenges and questions asked. The researcher ensured that all the facilitators (research assistants) were adequately trained on the snake and ladder game. All the snake and ladder game kits had a consistent design (layout, imagery and content) to ensure uniform exposure of information. The pupils played the game for a period of three months under the supervisor of their teachers (research assistants). Thereafter, the researcher with the assistance of the research assistants, collected post-intervention data by

administering questionnaires.

The study employed purposive sampling method to select 2 wards out of the 4 Wards in the sub-county; as well as select 2 primary schools per the selected wards. Sampling of schools was done with the assistance of the County education office/sub-county education office. Thereafter, proportionate sampling method was applied to determine the number of pupils from each school, depending on the school enrolment, and to ensure that schools with high enrolment contribute a larger percentage of study participants to maintain a representative balance. Pupils per grades were sampled using stratified random sampling technique. This ensured equal representation of pupils by gender and per grade. The researcher considered volunteer sampling technique to ensure voluntary participation of the study respondents. Thereafter, a simple random sampling method was employed to select the study participants from the those who volunteered to participate in the study.

Structured questionnaire was administered to the pupils at school level by the researcher with the assistance of the trained research assistants recruited among the teachers in the selected schools to collect both pre-intervention and post-intervention data. Thereafter pre-intervention and post-intervention data was used to test whether there was association. The questionnaire was developed with various sections to test knowledge on the causes, knowledge on mode of transmission, knowledge on preventive practices for both SCH and STH. The level of knowledge on the causes, mode of transmission and prevention practices on WASH-related NTDs were assessed using a series of questions/statements. The correct statement/question scored a mark while the wrong statement/question scored a zero. Overall respondents' knowledge on the causes, mode of transmission and NTD prevention practices was determined by calculating the sum of the scores. A pilot study was conducted in Teso South sub-county to test for validity and reliability of the data collection tools and evaluate its competency. The results informed on the appropriateness of wording of questions; and the duration of the study. The analysis of the data collected by the questionnaires revealed a Cronbach alpha coefficient of 0.78 which was acceptable.

To evaluate the effectiveness of the game-based WASH intervention, the researcher used both pre-intervention and post-intervention data collected from the control and treatment groups; and thereafter, appropriate statistical tests (paired t-test and independent sample t-test) was conducted to test the association. Paired t-test is appropriate when there are two sets of measurements that are related or linked. In this case, since pre-intervention and post-intervention data were collected from the same study participants, a paired t-test was adopted to analyse the change in scores between the two (pre-intervention and post-intervention). Lastly, an independent sample t-test was used to compare the means between the Treatment and the Control groups. This was used to determine if the game-based WASH intervention resulted in a statistically significant gain in knowledge compared to the traditional WASH sensitization method.

2.2. Logical and Ethical Considerations

The researcher sought clearance from Masinde Muliro University of Science and Technology, School of Post Graduate Studies (SGS) and Institutional Ethics and Research Committee (IERC). Thereafter, the researcher applied for a Research License from NACOSTI and cleared with the Busia County Commissioner's office, County Education Office, Sub-County Education Office, and school head teachers before carrying out the study. The researcher then sought consent from the caregivers (Parents/guardians and teachers) since children are considered minors, have diminished autonomy and must be protected since they cannot make a true informed decision on their own. A consent form was provided to the caregivers detailing the purpose of the study, the procedure, voluntary participation, right to withdraw, confidentiality and anonymity, risk and benefit, contact information and the estimated duration. A copy of the authorization letter from the County Commissioner's office, Education office and signed consent form was provided to the head teachers for their records. With the assistance of the trained research assistants, the assent form was explained to the study participants (pupils) verbally, using simple words; and they were given opportunity to ask questions. The researcher adhered to the principles of research ethics (informed consent/assent, beneficence and justice, maleficence) while carrying out the study.

3. Results

The researcher collected demographic data to characterize the study participants and to ensure comparability between the Treatment and Control groups at baseline. This similarity is crucial in a quasi-experimental design. It helps confirm that any differences observed after the intervention are attributable to the intervention rather than to pre-existing group differences. The analyzed characteristics included school, age, gender, religious affiliation, and academic grade. The study achieved a strong level of similarity between the two groups. The gender distribution was almost equal. Females made up 49.6% of the Treatment group and 52.0% of the Control group. A Chi-square test showed no significant difference in gender distribution ($\chi^2 = 0.144$, $p = 0.704$). This suggested that the results would not be affected by gender-based learning differences. Religious affiliation was mostly Christian in both groups, with over 95% reflecting the local demographic of Bunyala Sub-county. Additionally, pupils were evenly distributed across Grades 4, 5, and 6 ($p = 0.867$), ensuring their cognitive developmental levels were comparable.

The participants' ages, ranged mainly from 10 to 14 years. The inclusion criteria targeted Grade 4 to 6 pupils. However, two outliers (aged 15 and 17) were found in the raw data. These represent "over-age" pupils, a common phenomenon in rural public schools due to late enrolment. Despite these outliers, independent samples t-test test showed no statistically significant difference in the average age between the Treatment (M = 12.1) and Control (M = 11.9) groups ($p = 0.25$). Overall, the absence of statistically significant differences across all demographic variables ($p > 0.05$) indicated that the two groups were equivalent at baseline. This

provided a solid basis for evaluating the effectiveness of the game-based intervention (Table 1).

Table 1. Demographic characteristics of study participants.

Variable	Description	Treatment (n = 125)	Control (n = 125)	Statistical Test (χ^2/p)
School	A/C	66 (52.8%)	64 (51.2%)	
	B/D	59 (47.2%)	61 (48.8%)	
Gender	Female	62 (49.6%)	65 (52.0%)	$\chi^2 = 0.144$; $p = 0.704$
	Male	63 (50.4%)	60 (48.0%)	
Religion	Christian	119 (95.2%)	120 (96.0%)	$\chi^2 = 0.104$; $p = 0.747$
	Muslim	6 (4.8%)	5 (4.0%)	
Grade	Grade 4	38 (30.4%)	39 (31.2%)	$\chi^2 = 0.285$; $p = 0.867$
	Grade 5	42 (33.6%)	45 (36.0%)	
	Grade 6	45 (36.0%)	41 (32.8%)	
Age	9 - 10	21 (16.8)	19 (15.2)	t = 1.15; $p = 0.25$
	11 - 12	58 (46.4)	64 (51.2)	
	13 and above	46 (36.8)	42 (33.6)	
	Mean (SD)	12.1 (1.4)	11.9 (1.3)	

The effectiveness of the Game-based intervention was evaluated by comparing pre-intervention scores and post-intervention scores across domains of knowledge on the causes, transmission mode and prevention practices using a paired samples t-test. This involved data collected from a sample of 125 pupils (df = 124) in the selected primary schools in the treatment group. Regarding knowledge of on causes of the diseases, pupils demonstrated a significant increase in their understanding of the causes of SCH, with an increase in mean scores by 2.088 points (t (124) = −23.727, $p < 0.001$). Similarly, knowledge regarding the causes of STH improved significantly by a mean of 1.192 (t (124) = −14.456, $p < 0.001$). The overall knowledge on the causes of the common NTDs showed a substantial and statistically significant gain of 3.280 points (t (124) = −26.078, $p < 0.001$). These findings suggest that the Game-based intervention was highly successful in clarifying the cause of the diseases. Likewise, a similar trend was observed in the participants' understanding of transmission routes for the common NTDs. A great improvement was observed in the knowledge of SCH mode of transmission, which increased by a mean of 2.472 (t (124) = −28.194, $p < 0.001$); while knowledge on STH mode of transmission was low (Mean = 0.456), but it remained statistically significant (t (124) = −8.657, $p < 0.001$). The overall knowledge of transmission

modes across the common NTDs in the region showed a robust mean increase of 2.928 points, indicating that pupils became significantly more aware of how these parasites are contracted and spread within the community.

Finally, the study assessed whether these gains in knowledge on the cause and modes of transmission of the common NTDs would translate into improved health behaviors by assessing the pupils' awareness of the prevention practices. The results revealed significant increases in awareness of prevention practices for both SCH (Mean increase = 0.456, $p < 0.001$) and STH (Mean increase = 0.736, $p < 0.001$). The overall awareness of prevention practices score saw a significant cumulative increase of 3.120 points ($t(124) = -21.091$, $p < 0.001$) (Table 2).

Table 2. Paired T-test results on game-based WASH intervention.

Variable (Knowledge)	Mean	Std. Deviation	95% CI of the Difference		t	*P*-Value
			Lower	Upper		
Cause of SCH	2.088	0.984	−2.262	−1.914	−23.727	<0.001
Cause of STH	1.192	0.922	−1.355	−1.029	−14.456	<0.001
Overall on Cause	3.280	1.406	−3.529	−3.031	−26.078	<0.001
Transmission of SCH	2.472	0.980	−2.646	−2.298	−28.194	<0.001
Transmission of STH	0.456	0.589	−0.560	−0.352	−8.657	<0.001
Overall on Transmission	2.928	1.245	−3.148	−2.708	−26.284	<0.001
Prevention Practices SCH	0.456	0.654	−0.572	−0.340	−7.798	<0.001
Prevention Practices STH	0.736	0.899	−0.895	−0.577	−9.150	<0.001
Overall Prevention Practices	3.120	1.654	−3.413	−2.827	−21.091	<0.001

Overall, the results indicated a statistically significant improvement in all measured variables, as evidenced by *p*-values of less than 0.001 across all pairs. The 95% confidence intervals for all measures remained entirely below zero, further confirming that the post-intervention scores were consistently higher than pre-intervention levels. Jointly, these results provide strong empirical evidence that the Game-based WASH intervention was effective not only in enhancing theoretical knowledge but also in promoting the awareness of safer health practices among the pupils.

Additionally, to check for the effectiveness of game-based WASH intervention versus the traditional WASH sensitization, an independent sample t-test was carried out. The results showed that the Treatment group demonstrated significant greater gains as compared to the Control group in all categories. The most substantial difference was seen in the overall knowledge on the cause of the NTDs, where the Treatment group improved by an average of 3.280 compared to 0.952 observed in the Control group ($t = -10.81$, $p < 0.001$). Even though the Control

group recorded zero improvement in the knowledge on transmission routes of STH, the Treatment group showed a statistically significant, although smaller gain of 0.456 (t = −2.93, $p = 0.004$). Furthermore, the independent samples t-test results confirmed that the Game-based WASH intervention achieved a statistically significant greater improvement in the pupils' knowledge on prevention and control practices compared to the control group. The exceedingly low p-values ($p < 0.001$) indicate that the differences in improvement were not due to chance. Table 3

Table 3. Mean improvement between the treatment and control groups.

Variable (Knowledge)	Mean Improvement (Treatment)	Mean Improvement (Control)	t-value	p-value
Cause of SCH	2.088	0.568	−10.13	<0.001
Cause of STH	1.192	0.384	−5.35	<0.001
Overall on Cause	3.28	0.952	−10.81	<0.001
Transmission (SCH)	2.472	0.616	−11.27	<0.001
Transmission (STH)	0.456	0	−2.93	0.004
Overall Transmission	2.928	0.616	−10.24	<0.001
SCH Prevention	0.456	0	2.526	0.013
STH Prevention	0.736	0	3.551	<0.001

4. Discussion

The results on the demographic characteristics indicated that the treatment and control groups were balanced well across key demographic indicators, which is a critical requirement for quasi-experimental research to minimize selection bias [8]. The gender distribution was nearly equal, with females representing 49.6% of the treatment group and 52.0% of the control group. This parity is essential in educational research to ensure that intervention effects are not confounded by gender-based learning differences. Similarly, both groups were mainly Christian (>95%). The study mirrors research that emphasized that demographic homogeneity in school-based interventions helps in attributing changes in the dependent variable to the intervention rather than socio-cultural background [9].

The majority of participants were concentrated in the 11 - 12 age bracket and across Grades 4 to 6; which is a developmental stage that is crucial for cognitive interventions. This study is similar to a quasi-experimental study regarding primary school interventions, which revealed that a balanced distribution across grades ensures that the results are generalizable [10]. The slight variance in age distribution between the control and treatment groups (specifically the higher concentration of 11 - 12 age range in the control group (51.2%) vs the treatment group (46.4%)) is a common occurrence in quasi-experimental studies where ran-

dom assignment is not possible [11].

This demographic spread aligns with standard educational research protocols. For instance, a study argues that, achieving a percentage difference of less than 5% between groups in major categories (e.g. Grade or Religion) in non-equivalent group designs, strengthens the argument for baseline equivalence [12]. The data provided meets this threshold, suggesting that any subsequent differences in post-intervention scores are likely to be attributed to the treatment rather than pre-existing group differences.

The results of this study demonstrate a substantial and statistically significant improvement in knowledge on the cause, mode of transmission and prevention practices on Schistosomiasis and Soil-Transmitted Helminths following the Game-based WASH intervention. The consistent p-values of less than 0.001 across all pairs indicated that the observed gains were as a direct result of the Game-based WASH intervention, but were not due to chance. The significant increase in knowledge on the causes and transmission modes of the common WASH-related NTD infections (SCH & STH) aligns with recent global findings. In a study carried out in Nigeria, it was reported that health education interventions increased good knowledge of schistosomiasis from 27.5% to 87.0% [12]. Similarly, a study conducted in 2025 revealed that structured educational approaches, such as curriculum integration, led to knowledge gains of over 40% in school-based settings [13]. These suggest that focused pedagogical tools are highly effective in correcting common misconceptions such as the belief that these diseases are caused by dirty drinking water rather than skin contact with cercariae-infested water or soil [14].

A critical achievement of this study was the successful translation of knowledge regarding causes and mode of transmission of the common NTDs into knowledge on prevention practices. This is similar to a recent study conducted in Nigeria that reported that targeted health education evidently increased favorable practices from 27.9% to 99.5% among primary school children, supporting the idea that children are highly receptive to behavioral change when information is presented clearly [12]. In comparison with the prevention practices towards SCH and STH, it was revealed that while knowledge on prevention practices increased for both (SCH and STH), the mean increase for knowledge on STH prevention practices was higher than that of SCH prevention practices. This disparity may be attributed to the nature of the preventive behaviors. STH prevention practices (such as hand-washing and wearing shoes) often overlaps with general hygiene practices taught in schools, whereas SCH prevention (avoiding infested water) requires more specific, often localized behavioral shifts. This observation is consistent with research conducted in Ethiopia, which reported that pupils often have a higher baseline familiarity with dirty hands and dirty food (STH) compared to the more complex aquatic life cycle of Schistosomiasis [15]. The significant cumulative increase in knowledge on prevention practices scores underscores the school as a vital platform for NTD control. Similar outcomes were observed in a study conducted in China, where long-term school-based health education was associated with a 51%

increase in disease-related knowledge and a subsequent 6% reduction in infection prevalence [16].

Furthermore, innovative pedagogical tools like edutainment and infographics have been shown to enhance this assimilation [17], suggesting that the methods used in this study were likely engaging and contextually appropriate for the pupils. As highlighted in a systematic review; while knowledge increases are common, the physical environment such as lack of latrines or clean water often acts as a barrier to practicing what has been learned [18]. Interestingly, this study showed a more pronounced improvement in knowledge on SCH mode of transmission compared to knowledge on STH mode of transmission. This disparity might be due to a lower baseline knowledge of urogenital schistosomiasis symptoms (like hematuria), which are often more distinct than the more generalized symptoms of STH [19]. Related findings were reported in Ethiopia, where community awareness of SCH was significantly lower at baseline than STH, leading to higher relative gains after a standard educational session [20].

The big contrast between the Treatment and Control suggests that the Game-based WASH intervention was highly effective. In health education research, a simple testing effect often explains minor gains in Control groups, but the massive t-values in the Treatment group point to the intervention as the key driver of change [21]. The significant disparity in knowledge gains between the two groups underscores the effectiveness of Game-based WASH intervention over the traditional WASH sensitization. While the Control group showed some minor improvements likely due to the "testing effect" or general community awareness during the study period, the greatness of change in the Treatment group was consistently high. These findings align with health education theories that suggest that targeted, culturally appropriate interventions are necessary to overcome specific knowledge barriers regarding NTDs like SCH and STH [21].

The specific success in improving knowledge on transmission of SCH is vital, as knowledge specifically on transmission is the strongest predictor of individual behavioral changes [22]. However, the relatively lower improvement in knowledge on the transmission of STH across both groups suggests that soil-based transmission pathways may be more difficult for pupils to conceptualize than water-based SCH transmission. Therefore, the study suggests that future interventions should consider more practical demonstrations, such as the use of visual aids showing the microscopic nature of helminth eggs in soil, to bridge this specific gap [22].

The independent samples t-test results confirmed that the Game-based WASH intervention demonstrated a higher statistically significant greater improvement in the pupils' knowledge on prevention practices compared to the control group. While the control group showed no change in the knowledge on prevention practices for SCH and STH, the treatment group showed clear, positive gains. The difference was particularly observed for knowledge on STH prevention practices; which suggests that the Game-based WASH intervention successfully introduced new, specific health concepts that pupils were not exposed to. The most significant

result was the comparison of overall knowledge on prevention practices; although the control group recorded some improvement, the treatment group recorded higher improvement. The result indicates that while general hygiene awareness might rise due to external factors, the Game-based WASH intervention provided a much more robust and comprehensive boost to the pupils' understanding of how to control WASH-related NTDs. The high significance level for overall knowledge on prevention practices underscores the efficacy of the intervention. In areas like Bunyala Sub-county, where environmental risks for NTDs are high, a significant increase in the level of knowledge is required to translate knowledge on prevention practices into actual behavioral change [23].

5. Conclusion

Based on the analysis (Paired t-test and independent sample t-test) conducted, the study concluded that the Game-based WASH intervention was a highly effective intervention for increasing health literacy regarding WASH-related NTDs (Schistosomiasis and Soil-Transmitted Helminths).

6. Recommendation

To ensure the sustainability and broader impact of the Game-based WASH intervention, it is recommended that the Ministry of Education and the Ministry of Health to collaborate and integrate these NTDs modules into the national school curriculum. Establishment of School Health Clubs is encouraged to foster peer to peer advocacy, empowering pupils to act as health ambassadors who disseminate prevention strategies within their families and the broader community to ensure a lasting public health shift.

Conflicts of Interest

The authors declare no conflicts of interest.

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