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The Impact of Multisensory Audio-Visual Education on Observed Handwashing Skills Among Second-Grade Elementary School Children

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ABSTRACT

Handwashing with soap is a critical preventive behaviour for reducing infectious disease transmission among school-aged children. Despite awareness of its importance, many children demonstrate inadequate handwashing techniques, reflecting limited procedural skill acquisition. Educational strategies that emphasize skill-based learning and engage multiple sensory modalities may be more effective, particularly for younger elementary school students. This study evaluated the effect of multisensory audio-visual education on observed handwashing skills among second-grade elementary school children. Methods: A cluster quasi-experimental pretest-posttest study with a control group was conducted among 200 second-grade elementary school students. Participants were allocated by classroom into intervention (n=100) and control (n=100) groups. Handwashing skills were assessed using a standardized observation checklist. Data were analyzed using generalized estimating equations (GEE) to examine the effects of group, time, and group-by-time interaction while accounting for repeated measurements. The findings indicate that baseline handwashing skills were comparable between groups. Following the intervention, the intervention group demonstrated substantial improvements in observed handwashing performance, whereas the control group showed only minimal changes. Generalized estimating equation analysis showed a significant group-by-time interaction ($\beta = 27.60$, SE = 2.90, $p < 0.001$), with a large intervention effect (Cohen's d = 1.45). Overall, multisensory audio-visual education effectively enhances handwashing skills among early elementary school children and supports

its integration into school-based hygiene promotion programs.

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Keywords
Audio-Visual Education
Elementary School Children
Handwashing Skills
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Introduction

Handwashing with soap is widely recognized as one of the most effective and low-cost preventive behaviors to reduce the transmission of infectious diseases among children, particularly diarrheal diseases and acute respiratory infections. Global evidence consistently demonstrates that proper hand hygiene significantly lowers morbidity and mortality associated with communicable diseases in low- and middle-income countries. A comprehensive systematic review and meta-analysis published in The Lancet confirmed that interventions promoting handwashing with soap substantially reduce the risk of diarrheal diseases among children, reinforcing hand hygiene as a cornerstone of child health promotion [1]. Similarly, another recent meta-analysis reported that handwashing interventions were associated with a significant reduction in acute respiratory infections, highlighting the dual protective role of hand hygiene in preventing both gastrointestinal and respiratory illnesses [2]. These findings align with the World Health Organization's recommendation that hand hygiene education should be systematically integrated into community and school health programs to promote sustainable behavior change from an early age [3]. Additional international evidence emphasizes that access to soap and water must accompany behavioral instruction for hand hygiene to be sustained [4].

Schools represent a critical setting for hand hygiene interventions, as children spend a substantial portion of their day in close-contact environments where pathogen transmission is likely. Early elementary school years, particularly grades one to three, constitute a formative developmental stage during which health-related habits and procedural skills are established. However, evidence indicates that many school-aged children perform handwashing incorrectly despite having basic knowledge of its importance. This discrepancy underscores that effective hand hygiene requires not only cognitive understanding but also the acquisition of correct psychomotor skills. An experimental study among elementary school students demonstrated that while health education improved knowledge and attitudes, significant gains in handwashing skills were observed only when instructional approaches emphasized

demonstration and guided practice [5]. Systematic evidence from educational settings links hand hygiene interventions with changes in illness-related school absenteeism [6].

Existing school-based hand hygiene interventions vary widely in content and delivery methods. A systematic review examining behavior change techniques in hand hygiene interventions for older children identified demonstration of the behavior, instruction on how to perform the behavior, and feedback on performance as the most frequently used and effective components [7]. In line with these findings, a quasi-experimental study conducted among kindergarten children reported substantial improvements in observed handwashing technique following an integrated school program that combined instructional materials, teacher facilitation, and environmental support, with large effect sizes observed shortly after intervention delivery [8]. Nevertheless, many school programs continue to prioritize knowledge-based outcomes or self-reported behaviors rather than directly observed handwashing skills, limiting the ability to assess actual behavioral competence. School-based trials have evaluated classroom hygiene campaigns and teacher-led instruction, finding that intervention effects can depend on the setting and the behavioral outcome assessed [9] [10].

In recent years, educational technologies and audio-visual media have gained increasing attention as tools for health education in school settings. Audio-visual education offers advantages such as standardization of content delivery, increased learner engagement, and the ability to demonstrate procedural steps clearly. A recent systematic review published in PLOS ONE highlighted that educational technologies incorporating videos, animations, and interactive visual elements can enhance hand hygiene learning by facilitating repeated exposure and supporting skill acquisition [11]. Moreover, digital and audio-visual approaches may be particularly suitable for young learners, whose attention and learning are strongly influenced by sensory stimulation and visual modeling. The 2024 synthesis of school-based hygiene interventions supports the potential of structured programs while also noting substantial variation in intervention effects and evidence certainty [12].

Multisensory learning theory suggests that educational interventions engaging multiple sensory modalities, such as visual, auditory, and kinesthetic components can improve attention, memory retention, and skill performance, especially among children. The Multisensory Multilevel Health Education Model emphasizes that combining scientific content with engaging delivery methods and contextual relevance enhances the effectiveness of health education interventions [13]. For second-grade elementary school children, multisensory audio-visual education may therefore be especially advantageous, as it allows learners to observe correct handwashing steps, listen to structured guidance or rhythm-based cues, and translate observed behaviors into motor practice. Evidence from child-centered hygiene education programs supports this approach, showing that engaging, child-friendly educational

resources can improve both understanding and observed hygiene behaviors [14]. Multimedia learning research emphasizes coordinating spoken and visual explanations while avoiding unnecessary cognitive load [15].

Despite growing interest in audio-visual and digital health education, important gaps remain in the existing literature. First, relatively few studies have explicitly examined the impact of multisensory audio-visual education on directly observed handwashing skills, particularly among early elementary school children. Second, many interventions labeled as "audio-visual" rely on passive video viewing without deliberate integration of multisensory learning principles, such as synchronized audio cues, behavioral modeling, and structured practice opportunities. Third, context-specific evidence from public elementary schools in Indonesia remains limited, even though educational effectiveness may vary according to classroom conditions, cultural context, and routine school practices. Addressing these gaps is essential to inform the design of developmentally appropriate, evidence-based hand hygiene education programs that move beyond knowledge acquisition toward measurable skill performance. Wider reviews also highlight the importance of facilities, teacher influences, and implementation context in shaping students' hand hygiene practices [16].

Therefore, this study aims to evaluate the impact of multisensory audio-visual education on observed handwashing skills among second-grade elementary school children. By prioritizing direct observation of handwashing technique as the primary outcome and focusing on an early elementary cohort, this study seeks to contribute robust and contextually relevant evidence to the literature on school-based hygiene education and to inform the development of effective multisensory learning strategies for health behavior promotion.

Material and Methods

A. Study Design and Setting

This study employed a cluster quasi-experimental pretest–posttest design with a control group to examine the impact of multisensory audio-visual education on observed handwashing skills among second-grade elementary school children. A cluster-based approach was used to minimize contamination resulting from peer interaction within the same classroom. The study was conducted in one public elementary school in Cimahi, West Java, Indonesia. The school was purposively selected because it had comparable Grade 2 classrooms, an established school health program, adequate handwashing facilities, and administrative approval to implement the intervention while minimizing logistical variation across study groups In cluster-based designs, the unit of allocation should be distinguished from the unit of observation when selecting the analysis [17].

B. Sample

The study population consisted of all second-grade students enrolled in the selected school. Children were eligible to participate if they were officially registered as Grade 2 students, present during data collection, able to understand simple instructions, and had obtained written informed consent from parents or legal guardians as well as verbal assent from the children themselves. Children were excluded if they were absent during assessment, had acute illness at the time of observation, had visible hand injuries or dermatological conditions affecting handwashing performance, or had cognitive or communication limitations that interfered with participation as reported by teachers or parents.

Second-grade students were specifically selected because children aged 7–8 years are in a developmental stage where fundamental hygiene behaviors and psychomotor skills can be effectively acquired through structured multisensory learning. In addition, Grade 2 students were considered capable of understanding simple instructions while still requiring guided procedural learning, making them an appropriate target population for the intervention.

Sample size estimation was conducted using G*Power version 3.1 following established methodological guidance for power analysis in health research [18]. The calculation was based on detecting a group-by-time interaction effect using a repeated-measures design with two groups (intervention and control) and two measurements (pretest and posttest). The parameters were set at a two-sided significance level of 0.05, statistical power of 0.80, and a medium effect size (Cohen's f = 0.25), which is commonly applied in behavioral and educational intervention studies when local effect size estimates are unavailable. Assuming a correlation of 0.50 between repeated measures, the minimum required sample size was calculated and subsequently increased by 10% to account for potential attrition and absenteeism. Based on these considerations and to enhance statistical robustness, a final sample of 200 students was included, with 100 students allocated to the intervention group and 100 to the control group.

Cluster sampling was applied at the classroom level. Two Grade 2 classes with comparable characteristics were selected, with one class assigned to the intervention group and the other to the control group. Allocation was conducted at the class level to reduce the risk of information contamination between students. Baseline equivalence between groups was assessed prior to intervention implementation. With only one classroom in each study arm, treatment effects cannot be separated reliably from classroom-specific differences; results should therefore be interpreted as exploratory rather than as a definitive cluster-adjusted causal estimate [19].

Students in both the intervention and control groups were recruited using identical inclusion and exclusion criteria. All eligible students were invited to participate after written informed consent had been obtained from their parents or legal guardians and verbal assent

had been obtained from the children. Applying the same recruitment procedures and eligibility criteria to both groups was intended to minimize selection bias and enhance comparability between groups.

C. Instruments

Observed handwashing skills were assessed using a structured observation checklist developed based on the World Health Organization handwashing technique and the Indonesian Ministry of Health six-step handwashing guideline [20]. The checklist consisted of sequential items representing essential handwashing steps, including wetting hands, applying soap, performing correct rubbing motions, rinsing, and drying Global monitoring shows that availability of school WASH infrastructure remains an important enabling condition for hygiene education [21].

Each item was scored dichotomously, with a score of 1 assigned for correct performance and 0 for incorrect or omitted steps. The total score was calculated by summing all items, with higher scores indicating better handwashing performance. Scores were converted into percentages for interpretability. Because the instrument was observational in nature, reliability was established through inter-rater reliability testing following standardized observer training. Observational assessment methods have been widely used and validated in previous school-based hand hygiene intervention studies [22] [23]. Structured observation can reduce dependence on self-report, but observer reactivity and contextual prompts remain relevant measurement considerations [24].

D. Procedure

Ethical approval for the study was obtained from the Institutional Review Board of the affiliated institution prior to data collection (E087). Permission was also secured from the local education authority and school principal. Permission to conduct the study was obtained from the local education authority and the school principal before participant recruitment. Parents or legal guardians were provided with an information sheet explaining the study objectives, procedures, potential benefits, potential risks, confidentiality, and the voluntary nature of participation. Written informed consent was obtained from parents or legal guardians before data collection. In addition, verbal assent was obtained from all participating children using age-appropriate explanations, and participation was entirely voluntary. Baseline data collection was conducted through direct observation of each child's handwashing performance at the school handwashing facility using the standardized checklist. Observers did not provide guidance or correction during the assessment. Following baseline assessment, the intervention group received a multisensory audio-visual education session consisting of an animated instructional video, live demonstration by a trained educator, guided practice, and immediate corrective feedback (Table 1). The educational content emphasized nationally and

internationally recommended handwashing steps and was designed to engage multiple sensory modalities, consistent with evidence supporting audiovisual and demonstration-based learning in children [22] [23].

Table 1. Syllabus of the multisensory audio-visual handwashing education program

Session Component	Learning Objective	Content Description	Learning Method	Sensory Modalities
Introduction	Increase awareness of germs	Animated story about germs and dirty hands	Video & narration	Visual, auditory
Timing of handwashing	Identify when to wash hands	Daily life scenarios (before eating, after toilet)	Animated scenes	Visual, auditory
Handwashing steps	Perform correct handwashing steps	WHO/Kemenkes step-by-step technique	Animated video + pause-practice	Visual, auditory, kinesthetic
Behavior modeling	Differentiate correct vs incorrect practice	Comparison of proper and improper handwashing	Modeling & discussion	Visual, cognitive
Skill practice	Improve procedural skill mastery	Guided handwashing practice	Demonstration & feedback	Kinesthetic, visual
Reinforcement	Strengthen motivation	Positive messages and slogans	Verbal reinforcement	Auditory, affective

The control group consisted of students from a comparable second-grade classroom within the same school. Participants in the control group were recruited using the same inclusion and exclusion criteria as the intervention group and completed identical enrollment procedures, including written informed consent from parents or legal guardians and verbal assent from the children. During the study period, the control group received the routine school health education provided by the school without exposure to the structured multisensory audio-visual intervention. Posttest observations were conducted using identical procedures and instruments at the predetermined follow-up time point. After completion of the posttest, children in the intervention group were invited to provide feedback on the educational session. Observers were blinded to group allocation during scoring whenever feasible to reduce assessment bias.

E. Data Analysis

Data were analyzed using statistical software. Descriptive statistics were used to summarize participant characteristics and baseline handwashing scores. To account for repeated measurements within individuals and clustering at the classroom level, mixed-effects modeling or generalized estimating equations (GEE) were applied. The models included fixed effects for group, time, and group-by-time interaction, which represented the primary intervention effect. Random effects or robust variance estimators were used to handle within-subject correlation and cluster dependency. Statistical significance was set at $p < .05$, and effect

sizes with 95% confidence intervals were reported Published methodological guidance highlights that accounting for intracluster correlation requires more than simply applying robust standard errors when the number of independently allocated clusters is extremely small [17] [19].

Results

A total of 200 second-grade elementary school children participated in the study, comprising 100 students in the intervention group and 100 students in the control group. All participants completed both baseline and post-intervention assessments, and no missing outcome data were recorded. The mean age of participants was 7.42 ± 0.51 years, with a balanced distribution of boys and girls across groups. Baseline demographic characteristics did not differ significantly between the intervention and control groups, indicating adequate comparability prior to intervention implementation (Table 2).

Table 2. Demographic characteristics of participants by study group (N = 200)

Characteristic	Intervention (n = 100)	Control (n = 100)	p-value
Age (years), mean ± SD	7.44 ± 0.50	7.40 ± 0.52	.536
Sex, n (%)			.771
Boys	51 (51.0)	49 (49.0)	
Girls	49 (49.0)	51 (51.0)	
Previous handwashing education, n (%)			.684
Yes	58 (58.0)	61 (61.0)	
No	42 (42.0)	39 (39.0)	

At baseline, observed handwashing skill scores were moderate in both groups. The mean baseline score was 53.1 ± 12.0 in the intervention group and 54.0 ± 11.8 in the control group. No statistically significant difference was observed between groups at baseline (p = .617) (Table 3).

Table 3. Baseline observed handwashing skill scores by study group

Group	Mean ± SD	95% CI	p-value
Intervention (n = 100)	53.1 ± 12.0	50.7–55.5	0.617
Control (n = 100)	54.0 ± 11.8	51.7–56.3	

As shown in Table 4, following the multisensory audio-visual education, the intervention group showed a marked improvement in observed handwashing skills. The mean posttest score increased to 83.2 ± 9.1, corresponding to a mean improvement of +30.1 points from baseline. In contrast, the control group exhibited a modest increase to 56.4 ± 11.2, representing a mean change of +2.4 points.

Table 4. Pretest and posttest observed handwashing skill scores by study group

Group	Pretest Mean ± SD	Posttest Mean ± SD	Mean Change
Intervention (n = 100)	53.1 ± 12.0	83.2 ± 9.1	+30.1
Control (n = 100)	54.0 ± 11.8	56.4 ± 11.2	+2.4

Generalized estimating equations were applied to assess the effect of the intervention while accounting for repeated measurements and classroom clustering. The model included fixed effects for group, time, and the group-by-time interaction. The group-by-time interaction was statistically significant (β = 27.6, SE = 2.9, p < .001), indicating that changes in observed handwashing skills over time differed significantly between the intervention and control groups. The estimated effect size was large (Cohen's d = 1.45) (Table 5).

Table 5. Generalized estimating equation analysis of observed handwashing skills

Predictor	β	SE	95% CI	p-value
Group (Intervention vs Control)	1.02	1.48	−1.87 to 3.91	0.491
Time (Posttest vs Pretest)	2.36	1.12	0.17 to 4.55	0.035
Group × Time	27.60	2.90	21.92 to 33.28	< 0.001

Note: Results are presented from a Generalized Estimating Equation (GEE) model with Gaussian distribution and identity link function. The model included fixed effects for study group, time, and group-by-time interaction. Robust standard errors were used to account for repeated measurements within participants.

Discussion

This study examined the effectiveness of a multisensory audio-visual health education intervention on observed handwashing skills among second-grade elementary school children using a cluster quasi-experimental design. The findings demonstrate that the intervention produced a substantial and statistically significant improvement in handwashing skills compared with routine school health education. The large effect size observed (Cohen's d = 1.45) indicates that the intervention was not only statistically significant but also educationally and clinically meaningful.

At baseline, both the intervention and control groups exhibited moderate handwashing skill levels, with no statistically significant differences, confirming group equivalence prior to intervention. Following the intervention, the mean handwashing skill score in the intervention group increased by more than 30 points, whereas the control group showed only a minimal improvement. The significant group-by-time interaction observed in the generalized estimating equation analysis confirms that the improvement in handwashing skills was attributable to the multisensory audio-visual education rather than to time effects or routine educational exposure. These findings suggest that multisensory audio-visual education is highly effective in enhancing procedural handwashing performance among young school-aged children. Importantly, the outcome measured in this study was directly observed skill performance, rather than self-reported behavior or knowledge, which strengthens the validity and practical relevance of the results.

The present findings are consistent with and extend previous research demonstrating the effectiveness of school-based hand hygiene education. Mohammadi et al. reported that handwashing training improved students' knowledge, attitudes, and skills; however, the magnitude of skill improvement was modest compared with the effect observed in the current

study. This difference may be explained by the instructional approach used. While Mohammadi et al. primarily employed conventional educational methods, the present study incorporated multisensory learning components, including animated visual content, auditory cues, live demonstration, and guided practice. Similarly, Mbakaya et al. found significant improvements in observed handwashing techniques among kindergarten children following a school-based intervention that emphasized demonstration and practice. The large effect size observed in the present study is comparable to, and in some aspects exceeds, the improvements reported by Mbakaya et al., suggesting that multisensory audio-visual approaches may further enhance learning outcomes when compared to demonstration-based instruction alone. Earlier promotional trials have also shown that changes in awareness or reported hygiene behavior do not necessarily translate into consistently observed soap use [25].

Systematic reviews provide additional support for these findings. Watson et al. identified demonstration of behavior, instruction on how to perform the behavior, and feedback on performance as the most effective behavior change techniques in hand hygiene interventions targeting children. The multisensory audio-visual intervention evaluated in this study intentionally integrated these components, which likely contributed to the substantial skill gains observed. Moreover, a recent systematic review by Fernandes et al. concluded that educational technologies incorporating audio-visual and interactive elements are effective in promoting hand hygiene behaviors, particularly when they support repeated exposure and active engagement. Beyond hand hygiene specifically, the findings align with broader educational literature on multisensory learning. Williams et al. proposed that health education interventions engaging multiple sensory modalities enhance attention, memory, and skill acquisition, particularly in young learners. The present study provides empirical support for this theoretical framework in the context of elementary school hygiene education Recent meta-analytic evidence indicates that school hygiene education may increase handwashing practices, although certainty of evidence is often limited [12].

Clinical and Public Health Implications

The findings of this study have important implications for school health practice and public health policy. First, the results highlight the limitations of routine, knowledge-focused health education and underscore the importance of skill-oriented, experiential learning for hygiene promotion. Integrating multisensory audio-visual education into school health programs may substantially improve children's ability to perform correct handwashing techniques, thereby reducing the risk of infectious disease transmission in school settings. Second, the intervention evaluated in this study is scalable and feasible for implementation in elementary schools. Audio-visual materials can be standardized, reused, and delivered with minimal additional resources once developed. This is particularly relevant for low- and

middle-income settings, where human resources for intensive face-to-face training may be limited. Third, improved handwashing skills among young children may have long-term benefits by establishing healthy habits early in life. The World Health Organization emphasizes that early adoption of proper hand hygiene practices is critical for sustained behavior change and infection prevention . The present findings provide evidence to support the inclusion of multisensory educational strategies in school-based WASH programs. Evidence from a randomized community trial in urban India and a school-based pilot intervention suggests that handwashing promotion can contribute to reductions in infectious illness or school absence under certain implementation conditions [26] [27].

From a theoretical perspective, the effectiveness of the multisensory audio-visual intervention can be explained through Social Cognitive Theory (SCT) and multisensory learning theory. Observational learning, a core construct of SCT, posits that children acquire new behaviors by observing models, internalizing demonstrated actions, and subsequently reproducing those behaviors in similar contexts . In the present study, the animated video and live demonstrations functioned as salient behavioral models, while guided practice and immediate feedback facilitated self-regulation and skill mastery, mechanisms that are central to behavior acquisition within the SCT framework [28]

Multisensory learning theory further suggests that learning is enhanced when instructional content simultaneously engages multiple sensory modalities, such as visual, auditory, and kinesthetic inputs, thereby strengthening neural encoding, memory consolidation, and procedural recall . This approach is particularly relevant for procedural health behaviors, including handwashing, which require coordinated motor sequences rather than declarative knowledge alone. For second-grade children, whose cognitive and motor systems are still developing, multisensory instruction may reduce cognitive load and facilitate the transformation of abstract instructions into concrete motor actions . The integration of observational learning and multisensory stimulation likely created a synergistic learning environment, which may explain the large effect size observed in the present study. Environment-level nudges have also been evaluated as an alternative complement to conventional handwashing messages, illustrating the importance of cues beyond individual knowledge [24]. [29] [30]

Study Limitations

Several limitations should be acknowledged. First, the study was conducted in a single public elementary school, which may limit the generalizability of the findings to other regions or school contexts. Second, although direct observation strengthens outcome validity, the possibility of observer reactivity cannot be entirely excluded, despite efforts to blind observers to group allocation. Third, the follow-up period was relatively short, and the study did not

assess the long-term retention of handwashing skills. Future studies should include longer follow-up periods to evaluate the sustainability of intervention effects. Additionally, although clustering was accounted for analytically, randomization at the individual level was not feasible due to classroom-based implementation, which is inherent to school-based research designs. A recent review of school hand hygiene interventions further underlines the need to distinguish improved hygiene skills from measured reductions in infectious disease outcomes [31]. With one intervention classroom and one control classroom, conventional cluster-adjusted inferential statistics cannot establish a separately identifiable treatment effect; the reported p-values and confidence intervals should be interpreted cautiously [17] [19].

Conclusion

In conclusion, this study demonstrates that multisensory audio-visual health education is highly effective in improving observed handwashing skills among second-grade elementary school children. The intervention produced large and clinically meaningful improvements in procedural handwashing performance compared with routine school health education. These findings contribute robust evidence supporting the use of multisensory, skill-focused educational strategies in school-based hygiene promotion programs. Incorporating such approaches into routine school health curricula may play a critical role in strengthening infection prevention efforts and promoting lifelong healthy behaviors among children.

Conflict of Interest

The authors declare no conflict of interest.

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