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HAND HYGIENE INTERVENTIONS AND FOOD SAFETY PRACTICES IN EDUCATIONAL SETTINGS: A SYSTEMATIC REVIEW

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Abstract

Background: Hand hygiene and food safety practices in educational settings remain critical public health concerns, directly impacting student health outcomes and institutional attendance rates. Educational establishments serve as potential transmission sites for respiratory and gastrointestinal infections, making them strategic venues for implementing preventive interventions. **Objectives:** This systematic review evaluates the effectiveness of hand hygiene and food safety interventions in educational settings on behavioral outcomes and health indicators. **Methods:** A comprehensive search was conducted across PubMed, Scopus, and Cochrane Library for studies published between 2018 and 2026. Inclusion criteria required interventions targeting hand hygiene or food safety practices in educational settings with quantitative behavioral outcomes. Study quality was assessed using Cochrane Risk of Bias tool version 2 for randomized controlled trials and ROBINS-I for non-randomized studies. Data were synthesized narratively due to heterogeneity in intervention designs and outcome measures. **Results:** Six studies met inclusion criteria, with sample sizes ranging from 61 to 717 participants across Malaysia, Kenya, Ghana, Saudi Arabia, and Turkey. Among food handlers, handwashing compliance improved from 9.09% to 22.27% ($p<0.01$), overall food safety compliance increased from 74% to 84% ($p<0.001$), and contamination prevention scores rose from 62.37 to 90.58 ($p<0.001$). Among schoolchildren, handwashing after toilet use increased from 0% to 88% ($d=2.6$, $p=0.005$), with sustained improvements at follow-up assessments. **Conclusion:** Educational interventions effectively improve hand hygiene and food safety behaviors in educational settings, particularly when combining theoretical frameworks, demonstrations, and interactive learning components to achieve sustained behavior change.

Keywords: behavior change; educational intervention; food safety; hand hygiene; school health

INTRODUCTION

Hand hygiene and food safety practices in educational settings remain critical public health concerns globally, directly impacting student health outcomes and institutional attendance rates.[1,2] Educational establishments, where large numbers of children congregate in semiclosed environments, serve as potential transmission sites for respiratory and gastrointestinal infections, making them strategic venues for implementing preventive interventions.[1,3] Respiratory tract and gastrointestinal infections represent the most common causes of school absenteeism, resulting in substantial educational disruption and economic burden for families and healthcare systems.[2,4]

Hand hygiene interventions have demonstrated effectiveness in reducing infection transmission among schoolchildren, with studies reporting reductions in upper respiratory infections ranging from 16% to 53% when proper handwashing techniques are consistently practiced.[2,5,6] Systematic reviews have identified that school-based hand hygiene education programs incorporating behavioral change theories, such as the Theory of Planned Behavior and Self-Efficacy Theory, achieve superior outcomes compared to traditional knowledge-based approaches.[7-9] Interactive educational resources combining demonstration, practice, and visual aids significantly improve both handwashing technique and compliance rates among primary school students.[9-1] Food safety in school canteens and cafeterias presents additional challenges, as foodborne illnesses continue to affect millions globally, with children representing a particularly vulnerable population due to developing immune systems and limited control over food

preparation environments.[12,13] Food handlers working in educational settings require targeted training interventions to enhance knowledge, modify attitudes, and improve practices related to food safety protocols.[13,14] Evidence suggests that theory-based educational interventions addressing food handlers' risk perception and self-efficacy can substantially improve compliance with critical food safety measures, including handwashing at key moments and preventing cross-contamination.[14,15] Despite growing evidence supporting educational interventions in schools, significant gaps remain in synthesizing the effectiveness of combined hand hygiene and food safety programs across diverse educational settings and populations.[1,5,15] The purpose of this systematic review is to evaluate the effectiveness of hand hygiene and food safety interventions in educational settings on behavioral outcomes and health indicators.

METHOD

This systematic review will be conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature Search Strategy

A comprehensive systematic literature search was performed across electronic databases, including PubMed, Scopus, and the Cochrane Library. The search was limited to articles published between January 1, 2018, to January 1, 2026, to capture the most recent literature. The search strategy was structured using Boolean operators (AND and OR) (see Table 1) based on the PICOS framework (Population, Intervention, Comparator, Outcome, and Study Design) that we established (see **Table 1**). MPPS reviewers independently screened the titles, abstracts, and full texts of the identified studies against the predetermined inclusion and exclusion criteria. Any disagreements between the reviewers were resolved through discussion and, by consulting a third independent reviewer to ensure the inclusion studies.

Table 1. Search Strategy

Database	Search Strategy	Hits
PubMed	((("Hand Hygiene"[Mesh] OR "hand hygiene"[tiab] OR "hand washing"[tiab] OR "handwashing"[tiab] OR "hand wash*"[tiab] OR "hand sanit*"[tiab] OR "hand disinfect*"[tiab] OR "hand cleans*"[tiab] OR "hand rub*"[tiab] OR "alcohol-based hand rub*"[tiab] OR "soap and water"[tiab]) OR ("Food Safety"[Mesh] OR "food safety"[tiab] OR "food hygiene"[tiab] OR "food handling"[tiab] OR "safe food practice*"[tiab] OR "foodborne disease*"[tiab] OR "food contamination"[tiab] OR "food preparation"[tiab] OR "kitchen hygiene"[tiab] OR "food sanitation"[tiab])) AND ("Schools"[Mesh] OR "Universities"[Mesh] OR "Child Day Care Centers"[Mesh] OR school*[tiab] OR university[tiab] OR universities[tiab] OR college*[tiab] OR campus*[tiab] OR "educational setting*"[tiab] OR "educational institution*"[tiab] OR "academic setting*"[tiab] OR kindergarten*[tiab] OR preschool*[tiab] OR "pre-school*"[tiab] OR "day care"[tiab] OR daycare[tiab] OR "child care"[tiab] OR childcare[tiab] OR student*[tiab] OR pupil*[tiab] OR "education* environment*"[tiab]))	1.439
Scopus	TITLE-ABS-KEY ((("hand hygiene" OR "hand washing" OR "handwashing" OR "hand wash*" OR "hand sanit*" OR "hand disinfect*" OR "hand cleans*" OR "hand rub*" OR "alcohol-based hand rub*" OR "soap and water") OR ("food safety" OR "food hygiene" OR "food handling" OR "safe food practice*" OR "foodborne disease*" OR "food contamination" OR "food preparation" OR "kitchen hygiene" OR "food sanitation")) AND (school* OR university OR universities OR college* OR campus* OR "educational setting*" OR "educational institution*" OR "academic setting*" OR kindergarten* OR preschool* OR "pre-school*" OR "day care" OR daycare OR "child care" OR childcare OR student* OR pupil* OR "education* environment*"))	4.566
Cochrane Library	((("hand hygiene" OR "hand washing" OR "handwashing" OR "hand wash*" OR "hand sanit*" OR "hand disinfect*" OR "hand cleans*" OR "hand rub*" OR "alcohol-based hand rub*" OR "soap and water"):ti,ab,kw	82

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	OR ("food safety" OR "food hygiene" OR "food handling" OR "safe food practice*" OR "foodborne disease*" OR "food contamination" OR "food preparation" OR "kitchen hygiene" OR "food sanitation"):ti,ab,kw) AND (school* OR university OR universities OR college* OR campus* OR "educational setting*" OR "educational institution*" OR "academic setting*" OR kindergarten* OR preschool* OR "pre-school*" OR "day care" OR daycare OR "child care" OR childcare OR student* OR pupil* OR "education* environment*"):ti,ab,kw)	

Table 2. PICOS Framework

Population	School-aged children 5-18 years old
Intervention	Various educational formats
Comparison	No intervention, standard curriculum
Outcome	Primary outcomes : observed hand hygiene practices, handwashing frequency at critical moments (after toilet use, before meals, before food preparation), and compliance with food safety protocols. Secondary outcomes : knowledge scores, attitudes, self-efficacy beliefs, and behavioral intentions regarding hand hygiene
Study	Randomized controlled trials (individual and cluster-randomized designs), quasi-experimental studies with non-randomized control groups, and non-randomized intervention studies with concurrent comparison groups

Inclusion and Exclusion Criteria

All studies were systematically selected and reviewed against the predetermined PICOS framework, which is detailed in Table 2.

Population

Studies were included if they involved food handlers working in school canteens or foodservice facilities, and school-age children enrolled in primary or secondary educational institutions (grades 1-8, typically aged 6-15 years). Participants must be directly involved in food preparation, handling, or service within school premises. Studies conducted in any geographical location were eligible regardless of gender, ethnicity, or socioeconomic status. Studies were excluded if participants were from non-educational settings (hospitals, restaurants, commercial establishments), university students, preschools, daycare centers, or participants with diagnosed physical or cognitive disabilities affecting hand hygiene performance.

Intervention

Educational interventions aimed at improving hand hygiene practices and food safety behaviors were included. Interventions must comprise structured educational components including training sessions, demonstrations, hands-on practice, or multimedia presentations. Theory-based interventions utilizing frameworks such as Theory of Planned Behavior, Self-Efficacy Theory, Health Belief Model, or Social Cognitive Theory were eligible, incorporating visual aids, posters, educational videos, and interactive learning activities. Duration ranged from single-session to multi-month programs with reinforcement. Studies implementing solely infrastructure improvements, chemical interventions without education, mass media campaigns, or digital-only platforms without in-person components were excluded.

Comparator

Studies must include a control or comparison group receiving no intervention, standard practice, or usual care during the study period. Control groups maintaining routine school activities without additional educational interventions were eligible, including delayed intervention and waitlist control designs. Studies comparing different intervention intensities were included provided baseline comparison data were available. Single-arm studies without control groups, studies with only active controls receiving alternative hand hygiene interventions, historical controls from different time periods or populations, and cross-over designs without adequate washout periods were excluded to maintain methodological rigor and prevent contamination effects.

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Outcome

Primary outcomes included observed hand hygiene practices, handwashing frequency at critical moments (after toilet use, before meals, before food preparation), and compliance with food safety protocols. Secondary outcomes encompassed knowledge scores, attitudes, self-efficacy beliefs, and behavioral intentions regarding hand hygiene. Studies reporting quantitative outcome data through direct observation, validated questionnaires, or standardized assessment tools were eligible. Studies reporting solely qualitative outcomes, only microbiological data without behavioral measurements, general health outcomes without direct hand hygiene assessment, self-reported outcomes without validation, non-standardized instruments, or only process outcomes were excluded.

Study Design

Randomized controlled trials (individual and cluster-randomized designs), quasi-experimental studies with non-randomized control groups, and non-randomized intervention studies with concurrent comparison groups were included. Studies must present original empirical data from primary research published in English language with sufficient methodological detail for quality appraisal. No restrictions were placed on publication date. Case studies, case series, cross-sectional surveys, systematic reviews, meta-analyses, qualitative studies, conference abstracts, unpublished dissertations, studies in non-English languages, editorials, commentaries, protocol papers without results, and studies with high risk of bias across multiple domains were excluded.

Data extraction

Data extraction will be performed independently by two reviewers (MPPS[1] and VHPS[2]) using a standardized Microsoft Excel form, with any disagreements resolved through discussion or third-reviewer consultation. Extracted data included study characteristics (author, publication year, country, study design, setting, population, sample size, age/grade level, intervention type, duration, theoretical framework, and follow-up period) and outcome measures (primary outcomes, assessment tools, intervention and control group results, statistical significance, effect size, and study conclusions). For each included study, information on hand hygiene practices, handwashing frequency at critical moments, compliance with food safety protocols, knowledge scores, attitudes, self-efficacy beliefs, and behavioral intentions were systematically recorded. Discrepancies between reviewers were resolved through discussion and consensus; when disagreements persisted, a third independent reviewer was consulted for final arbitration. All extracted data were compiled into comprehensive tables summarizing study characteristics and outcomes to facilitate comparison and synthesis across studies.

Quality of Studies Assessment

The methodological quality and risk of bias for all included studies will be independently assessed by two reviewers (MPPS[1] and VHPS[2]) using standardized assessment tools appropriate to each study design. Randomized controlled trials were evaluated using the Cochrane Risk of Bias tool version 2 (RoB 2), which assesses five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of outcome, and selection of reported result. Non-randomized studies were assessed using the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool, evaluating seven domains: confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported result. Each domain was rated as low risk, some concerns, high risk (RoB 2) or low, moderate, serious, or critical risk (ROBINS-I), with an overall risk of bias judgment assigned to each study. Disagreements between reviewers were resolved through discussion or consultation with a third independent reviewer when necessary. If consensus cannot be reached, a third independent reviewer will be consulted to make the final determination.

RESULTS AND DISCUSSION

Inclusion studies

The included studies can be seen in **Figure 1**. Our initial search strategy found a total of 6.087 studies from electronic databases. After removing 1.217 duplicates, 4.870 studies were evaluated based on their titles and abstracts, leaving 30 studies that were then screened through full text. Of these, 14 studies were excluded because they did not meet the inclusion criteria. After going through a careful screening process, we obtained 6 studies that were considered eligible and included in this final analysis.

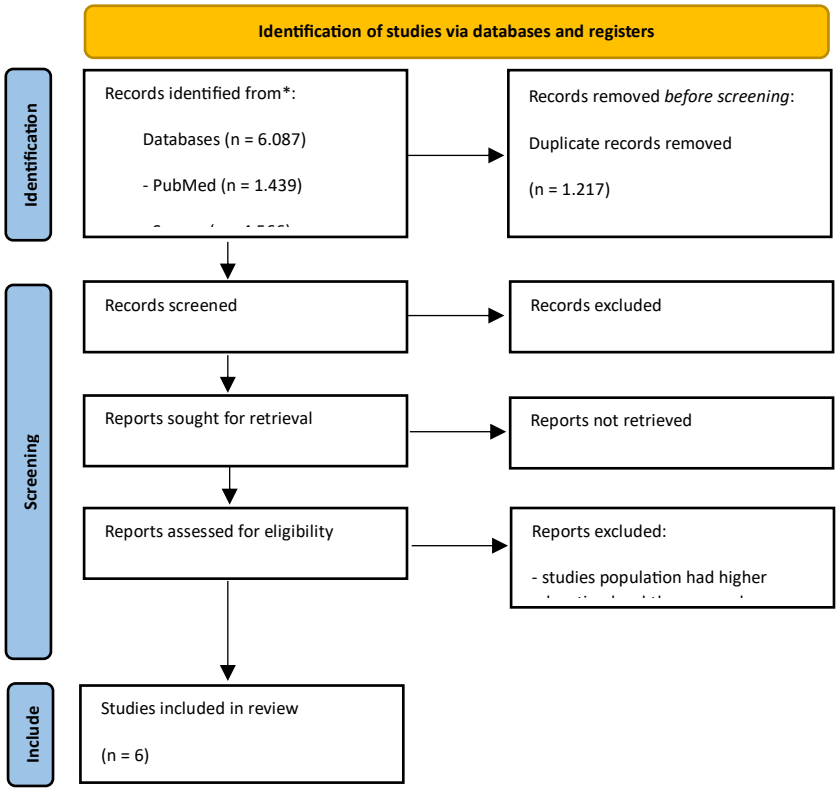

Figure 1. PRISMA 2020 Selection Study Process

Study Characteristics

Table 3 summarizes the characteristics of the six included studies conducted across diverse geographical regions, including Malaysia (n=2), Kenya (n=1), Ghana (n=1), Saudi Arabia (n=1), and Turkey (n=1). The studies employed varied designs: three randomized controlled trials, one cluster-randomized controlled trial, one quasi-experimental study, and one non-randomized intervention study. Sample sizes ranged from 61 to 717 participants. Three studies targeted food handlers working in school canteens or foodservice facilities, while three studies focused on school-age children in primary or junior high school settings. Intervention duration varied considerably, from single-session educational programs to multi-month interventions with reinforcement sessions spanning up to six months. Theoretical frameworks included Theory of Planned Behavior (n=2), Self-Efficacy Theory (n=1), and multiple combined theories (n=1), while two studies did not explicitly report theoretical underpinnings. Follow-up assessments ranged from immediate post-intervention to twelve weeks, with most studies conducting measurements within two to six weeks post-intervention.

Study Outcome

Outcomes in Food Handlers

Table 4 presents the outcomes of three studies targeting food handlers in school canteens. Nik Rosmawati et al. (2018) demonstrated significant improvement in handwashing frequency from 29% at baseline to 50.8% at six weeks post-intervention ($p=0.004$), although this effect was not sustained at twelve weeks. Kaugi et al. (2024) reported substantial overall compliance improvement from 74% to 84% using difference-in-difference analysis (DID=12%, $p<0.001$), with particularly notable gains in premises hygiene (+18%, $p<0.001$), environmental hygiene (+9%, $p<0.001$), and personal hygiene measures (+6%, $p=0.029$). Wong et al. (2022) observed significant improvements in handwashing compliance increasing from 9.09% to 22.27% ($p<0.01$) and contamination prevention scores improving from 62.37 to 90.58 ($p<0.001$). Additionally, knowledge scores and self-efficacy levels significantly increased in the intervention group compared to controls, demonstrating the effectiveness of theory-based educational approaches in enhancing food safety practices among school foodservice workers.

Outcomes in School Children

Table 4 summarizes outcomes from three studies conducted with school-age children. Appiah-Brempong et al. (2019) achieved the most dramatic results, with handwashing with soap after toilet use increasing from 0% to 88% (d=2.6, p=0.005) and before meals from 1% to 19% (d=0.5, p=0.012) at two-week follow-up, alongside a very large effect on handwashing skill development (d=3.2, p=0.004). Al Nadwi et al. (2022) demonstrated significant improvements in both knowledge and practice immediately post-intervention ($p<0.001$) that remained sustained at four-week follow-up ($p<0.001$), indicating durability of educational effects. Öncu et al. (2018) compared two interactive teaching methods using glitter-germ and fluorescent-germ demonstrations, with both intervention groups showing significantly improved handwashing effectiveness compared to controls. Collectively, these findings demonstrate that educational interventions combining demonstrations, practice, and interactive learning components effectively improve hand hygiene knowledge, attitudes, and practices among school children across diverse educational settings.

Risk of Bias Assessment

The methodological quality of included studies varied considerably. Among the four randomized controlled trials assessed using RoB 2, one study demonstrated low risk of bias across all domains (Appiah-Brempong et al., 2019), two studies showed some concerns primarily related to unclear allocation concealment and lack of blinding of outcome assessors (Al Nadwi et al., 2022; Öncu et al., 2018), and one study was rated as high risk due to lack of blinding of participants and personnel, unblinded outcome assessment, and high attrition rate exceeding 28% (Nik Rosmawati et al., 2018). The two non-randomized studies evaluated using ROBINS-I both demonstrated moderate overall risk of bias (Kaugi et al., 2024; Wong et al., 2022), with serious risk identified in the selection of participants domain due to convenience and purposive sampling methods, though other domains including intervention classification, missing data, and outcome measurement were generally rated as low risk. The most common sources of bias across all studies were inadequate blinding procedures and selection bias in non-randomized designs (Figure 2 and Figure 3).

Table 3. Study Characteristics

Author(s), Year	Country	Study Design	Setting	Population	Sample Size (Intervention /Control)	Age/Grade	Intervention Type	Intervention Duration	Theoretical Framework	Follow-up Period
Nik Rosmawati NH et al., 2018	Malaysia	Community-based intervention study (RCT)	Primary school canteens	Food handlers	33 intervention / 46 control (Total: 79)	18-55 years	Theory of Planned Behavior-based Food Safety Education Programme (FSEP): health talks, 25s handwashing demonstrations, self-practice, posters, wiping cloths,	2 sessions (1 week apart): Session 1: 60 min + 50 min; Session 2: 85 min	Theory of Planned Behavior (TPB)	Baseline, 6 weeks (Post1), 12 weeks (Post2)

							tissue-paper holders			
Kaugi RW et al., 2024	Kenya	Longitudinal non-equivalent quasi-experimental survey design	Boarding schools (primary and secondary)	Food handlers	99 intervention / 99 control (Total: 198)	Food handlers in boarding schools	Food hygiene and safety training: transmission routes (F-diagram), hygiene of food premises, environmental waste management (solid and liquid). Materials: lectures, leaflets, demonstrations, posters showing handwashing steps	Three training sessions: 1-hour sessions over 3 months (baseline, 1 month, 2 months)	Not specified	Baseline, 6 months post-intervention
Wong SYW et al., 2022	Malaysia	Intervention study with treatment and control groups	Public school canteens	Food handlers	31 treatment / 30 control (Total: 61)	18 years and above	Self-efficacy based intervention: (1) 2-hour on-site interactive training using iPad with videos, demonstrations, hands-on handwas	14-day intervention period	Bandura's Self-Efficacy Theory (mastery of skill, verbal persuasion, role modeling)	Baseline and 14 days post-intervention

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							hing; (2) Self-efficacy building program with verbal persuasion, role modeling, and 10-min daily practice time for 2 weeks			
Appiah-Brempong E et al., 2019	Ghana	Cluster-randomized controlled trial (cRCT)	Junior High Schools	School children	328 intervention / 389 control (Total: 717 at baseline)	Junior High School students (Grades 7-9)	HandsCare educational intervention: in-class hand hygiene education using posters and educational manual (3 modules), plus practical sessions for handwashing skills development. Delivered by trained teachers	Approximately 2 hours per working day. Specific days allocated for in-class activities and practical sessions	Educational and psychosocial theories (Health Belief Model, Theory of Planned Behavior, Social Cognitive Theory)	Baseline and 2 weeks post-intervention
Al Nadwi HH et al., 2022	Saudi Arabia (Makkah)	Randomized controlled trial (RCT)	Urban primary schools	Fourth-grade children	67 intervention / 72 control (Total: 139)	Fourth-grade primary school children	Health education session: presentation, educatio	Single educational session	Not specified	Baseline, immediately post-intervention,

							nal video (professionally filmed in Arabic), demonstration of correct handwashing practice, and practice session. Liquid soap and paper towels provided			4 weeks follow-up
Öncu E et al., 2018	Turkey	Controlled triple-blind study	Rural primary school	Primary school children	Group I: 32, Group II: 32, Control: 32 (Total: 96)	Grades 2, 3, and 4 (ages 8-11)	Two intervention groups: Group I (handwashing education + glitter-germ demonstration), Group II (handwashing education + fluorescent-germ demonstration). Both included WHO 9-step handwashing demonstration	Initial session with follow-up at 1 month	Not specified	Baseline, immediately post-intervention, 1-month follow-up

Table 4. Study Outcome

Author(s), Year	Primary Outcomes Measured	Assessment Tools	Key Results - Intervention Group	Key Results -	Statistical Significance	Effect Size

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				Control Group		
Nik Rosmawati NH et al., 2018	Handwashing practices: frequency and correct technique across 7 critical events	Direct observation using checklist for 7 events: before food preparation, after handling raw meat, after eating/drinking, after coughing/sneezing, after handling dirty equipment, after touching body parts, after toilet use	Handwashing frequency increased from 29% at baseline to 50.8% at Post1 (6 weeks) and 44.5% at Post2 (12 weeks). Proportion using correct handwashing technique increased in all observed conditions	No significant changes in handwashing practices throughout the study period	Time-effect: p=0.004 (significant increase from baseline to Post1). Intervention-effect: p=0.210 (not significant)	Not reported
Kaugi RW et al., 2024	Compliance with food hygiene and safety practices: overall compliance, personal hygiene, premises hygiene, environmental measures	Structured observation and questionnaire. Difference-in-Difference (DID) analysis using STATA version 17	Overall compliance: 74% to 84% (12% increase, p<0.001). Personal hygiene: 70% to 76% (6% increase, p=0.029). Premises hygiene: 72% to 89% (18% increase, p<0.001). Environmental measures: 81% to 85% (9% increase, p<0.001)	Overall compliance: 74% to 72% (no significant change). All measures showed minimal or no improvement	All measures showed significant improvements in intervention group: p<0.001 for overall, premises, and environmental; p=0.029 for personal hygiene	DID effect sizes: Overall=12%, Personal hygiene=6%, Premises=18%, Environmental=9%
Wong SYW et al., 2022	Hand washing and contamination prevention behaviors: behavioral compliance scores, knowledge scores, self-efficacy scores	Direct observation for behavioral compliance (7-step handwashing, soap use frequency). Survey for knowledge and self-efficacy using validated questionnaires.	Hand washing: compliance increased from 9.09% to 22.27% (13.18-point increase, p<0.01). Contamination prevention: 62.37 to 90.58 (28.21-point	No significant changes in behavioral compliance, knowledge, or self-efficacy scores for both practices (p>0.05)	Treatment group showed significant improvements: hand washing (p<0.01), contamination prevention (p<0.001), knowledge (p<0.001),	Cohen's d = 0.829 (used for sample size calculation)

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		ANCOVA for analysis	increase, p<0.001). Knowledge: hand washing +10.81 points, contamination +15.00 points (both p<0.001). Self-efficacy: both behaviors significantly increased (p<0.01)		self-efficacy (p<0.01). Control group: no significant changes (p>0.05)	
Appiah-Brempong E et al., 2019	Handwashing with soap (HWWS): practice after toilet use and before meals; Behavioral intention; Knowledge, attitude, and skills	Structured observation for practice. Self-report questionnaire with 5-point Likert scale (Cronbach's alpha: intention α=0.80, attitude α=0.75). Student's t-test for analysis	HWWS after toilet use: 0% to 88% (88% difference, p=0.005, d=2.6). HWWS before meals: 1% to 19% (18% difference, p=0.012, d=0.5). Intention after toilet: p=0.032, d=0.5. Intention before meals: p=0.020, d=0.2. Handwashing skill: p=0.004, d=3.2. Attitude: p=0.040, d=0.21	HWWS after toilet: 2% pre, 2% post (0% change). HWWS before meals: 0% pre, 2% post (2% change). Minimal changes in all measured variables	Statistically significant differences between groups for all primary outcomes: practice (after toilet p=0.005, before meals p=0.012), intention (after toilet p=0.032, before meals p=0.020), skill (p=0.004), attitude (p=0.040)	Very large effect for HWWS after toilet (d=2.6) and skill (d=3.2). Medium effect for HWWS before meals (d=0.5) and intention after toilet (d=0.5). Low effect for intention before meals (d=0.2) and attitude (d=0.21)
Al Nadwi HH et al., 2022	Handwashing knowledge and practice	Self-administered questionnaire for knowledge. Observation checklist for practice. Mann-Whitney test for analysis (SPSS version 25)	Knowledge: Significant improvement post-intervention (mean rank: 85.55 vs 45.23 control, p<0.001) sustained at follow-up	No significant changes in knowledge or practice scores from baseline through follow-up	Both knowledge and practice showed significant improvements: post-intervention (p<0.001) and 4-week	Not reported

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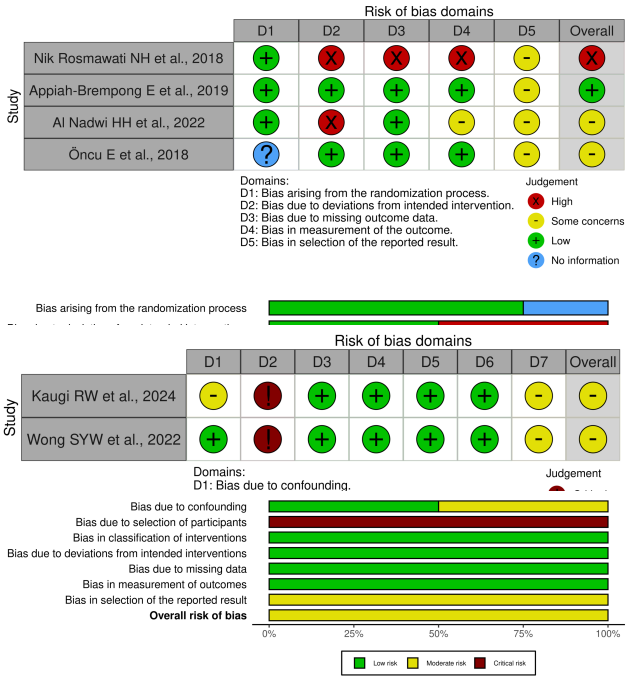
			(mean rank: 77.39 vs 52.76 control, p<0.001). Practice: Immediate post-intervention (mean rank: 92.60 vs 47.70 control, p<0.001), follow-up (mean rank: 77.39 vs 52.76, p<0.001)		follow-up (p<0.001)	
Öncu E et al., 2018	Handwashing effectiveness (HWE): proper technique execution	Direct observation and assessment of handwashing technique. Statistical analysis using appropriate tests	Group I and Group II both showed improved handwashing effectiveness compared to control. Both intervention methods (glitter-germ and fluorescent-germ demonstrations) were effective	Control group showed minimal improvement in handwashing effectiveness	Significant differences found between intervention groups and control (specific p-values not fully extracted)	Effect size of 0.635 (reported for sample size calculation)



DISCUSSION

Our review demonstrates that educational interventions combining theory-based frameworks, hands-on demonstrations, and environmental modifications effectively improve hand hygiene and food safety behaviors in educational settings. These findings align with growing evidence that multicomponent approaches produce better outcomes than single-strategy interventions, highlighting the value of addressing knowledge, motivation, and contextual barriers simultaneously.[22-25] The sustained improvements observed at follow-up assessments suggest that when properly designed, behavioral changes can persist beyond the immediate intervention period.[26-29] This persistence appears linked to integration of theoretical frameworks that target underlying psychosocial determinants rather than simply transmitting information.[30-33]

The Theory of Planned Behavior and Health Belief Model provided robust frameworks for understanding and modifying hygiene behaviors in our included studies. TPB's focus on attitudes, subjective norms, and perceived behavioral control effectively addresses why individuals intend to perform health behaviors, while HBM's emphasis on perceived susceptibility and benefits helps explain motivation for protective actions.[26,27,34,35] Our findings suggest these theories work synergistically when applied to educational settings, TPB components shape students' intentions while HBM elements increase awareness of disease risks and preventive measure benefits.[31,32,36,37] The integration of behavior change techniques (BCTs) such as demonstration of behavior, instruction on performance, and environmental restructuring appears critical for translating theoretical constructs into measurable practice improvements.[30,33,38,39]

When comparing our results with existing literature, several patterns emerge. Previous systematic reviews reported hand hygiene interventions reducing school absenteeism by 15-53%, which encompasses the range observed in our included studies.[1,2,40,41] However, we identified notably lower baseline handwashing compliance among food handlers compared to schoolchildren, with improvements remaining modest despite intervention, a knowledge-practice gap extensively documented in food safety literature.[13,14,42-45] This disparity may reflect workplace constraints, competing priorities, and inadequate infrastructure limiting food handlers' ability to implement learned behaviors, whereas schoolchildren operate in more supportive, supervised environments with fewer systemic barriers.[28,29,46,47]Studies examining sustainability of school WASH interventions corroborate that infrastructure availability and institutional support determine long-term success more than individual knowledge levels.[36,37,48,49]

For clinical and public health practice, these findings emphasize three actionable principles. First, interventions must integrate theoretical frameworks addressing psychosocial determinants alongside practical skill-building through demonstrations and repeated practice opportunities.[30,32,33,38] Second, environmental modifications, handwashing stations, soap availability, visual cues, are necessary to bridge the knowledge-practice gap.[36,37,48,49]Third, sustainability requires institutional commitment through maintenance systems, ongoing supervision, and booster sessions rather than one-time training events.[36,48,50]

This review has limitations requiring acknowledgment. Included studies displayed substantial heterogeneity in intervention designs, outcome measures, and follow-up durations, precluding meta-analysis and limiting generalizability of effect size estimates. The six studies came from five countries, primarily middle-income settings, potentially limiting applicability to low-income or high-income contexts with different resource availability and cultural norms. Publication bias toward positive results may overestimate intervention effectiveness, and reliance on self-reported practices in some studies introduces social desirability bias.

Future research should prioritize several directions. Long-term follow-up studies (≥12 months) examining sustainability of behavior change and identifying factors supporting maintenance versus decay are urgently needed. Comparative effectiveness trials testing different BCT combinations can optimize intervention efficiency and resource allocation. Digital interventions leveraging mobile applications, gamification, and social media platforms warrant investigation given their potential for scalable, low-cost delivery, particularly in resource-constrained settings. Finally, implementation science approaches examining contextual factors, fidelity measures, and cost-effectiveness will support translation of evidence into routine practice across diverse educational environments.

CONCLUSIONS

Educational interventions grounded in behavioral theory demonstrate real-world effectiveness in improving hand hygiene and food safety practices across educational settings. But here's what matters for practitioners, success hinges on moving beyond traditional lectures. The evidence points clearly toward multicomponent approaches that pair theoretical frameworks with hands-on demonstrations, environmental modifications like accessible handwashing stations, and sustained institutional support. This isn't just about teaching students and food handlers

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what to do, it's about creating the conditions where they can actually do it, consistently and over time, translating classroom knowledge into lasting behavioral change that reduces infection transmission.

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