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ORIGINAL ARTICLE

Effectiveness of hand-hygiene interventions in reducing illness-related absence in educational settings in high income countries: systematic review and behavioural analysis

Emily Hoyle[1] · Henrietta Davies[1] · Jana Bourhill[1] · Nia Roberts[2] · Joseph J. Lee[3] · Charlotte Albury[3]

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Abstract

Aim Control of infection is important to prevent school absence. We aimed to review hand-hygiene interventions in high income countries aiming to reduce gastrointestinal and upper-respiratory tract infection-related absence in educational settings, and identify which intervention components are effective.

Subject and methods A systematic review and meta-analysis. Interventions were coded according to Behaviour Change Techniques Taxonomy. We searched MEDLINE, Embase, CINAHL, Cochrane Library, Education Resource Information Centre, Science and Social Sciences Citation Index and the British Education Index from 1 September 2014 to 25 May 2022, papers included in a 2014 review by Willmott et al., and hand-searching reference lists of included studies. We also searched for, and coded, relevant international guidelines on hand-hygiene.

Results We screened 1653 papers, including 11 papers from 9 studies. Meta-analysis showed that school-based interventions significantly reduced respiratory tract and gastrointestinal infection-related absence (relative rate ratio 0.754; 95% confidence interval 0.602 to 0.944). Evidence from subgroup analysis supports the use of more than seven behaviour change techniques, targeting both adults and children, and providing information on the risks of inadequate hand-hygiene as well as instruction. The effectiveness of individual behaviour change techniques could not be determined. We found no evidence to support the interventions currently recommended in a range of international guidelines.

Conclusion School-based hand-hygiene interventions are effective in reducing infection-related absence. There is some evidence that the number and type of behaviour change techniques used in interventions is important in increasing intervention success.

Keywords Systematic review · Infection prevention · Behavioural analysis · Hand hygiene · School absence

Introduction

Control of infection in children is important for preventing school absence, of which viruses that cause gastrointestinal (GI) and respiratory symptoms are a major cause (Lynch and Kajon 2016). Schoolchildren are at higher risk of catching and spreading respiratory tract (RT) (Kucharski et al. 2014) and GI infection (Doorduyn et al. 2012) due to their high number (Mikolajczyk et al. 2008) of social contacts. School absence is consistently associated with poorer educational outcomes (Carroll 2010) and results in long- (Ansari et al. 2020) and short-term (Thorrington et al. 2017) economic costs.

Multiple systematic reviews have demonstrated a significant reduction in acute respiratory infection following hand-hygiene interventions (Aiello et al. 2008; Warren-Gash et al. 2013; Jefferson et al. 2020), and a 2008 systematic review showed a significant reduction in incidence of gastrointestinal (GI) infection (Aiello et al. 2008). Other reviews have shown effectiveness of hand-hygiene interventions in reducing the incidence of diarrhoea (Ejemot et al. 2008; Freeman et al. 2014). Hand-hygiene is defined by the World Health

✉ Emily Hoyle
emily.hoyle@bnc.ox.ac.uk

[1] University of Oxford Medical School, University of Oxford, John Radcliffe Hospital, Headley Way, Headington, Oxford, UK

[2] Bodleian Health Care Libraries, University of Oxford, Oxford, UK

[3] Nuffield Department of Primary Care Health Sciences, Medical Sciences Division, University of Oxford, Oxford, UK

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Organization as "a general term referring to any action of hand cleansing"(WHO 2009).

Some evidence indicates these interventions may translate into a reduction in related school absences. A 2016 systematic review from Willmott et al. (2016) assessed the effectiveness of hand-hygiene interventions in reducing illness absence among children in educational settings in high- and low-income countries. This review found evidence that interventions may reduce RT infection among younger children, but equivocal evidence on both reduction of GI infection, and associations with school related absence. It is now timely to update this work, to find out the current evidence on the effectiveness of handwashing in educational settings.

As well as understanding if hand-hygiene interventions are effective in reducing illness and absenteeism in educational settings, it is crucial to better understand *which components* of hand-hygiene interventions can be most effective. Trials use a diverse range of intervention components, and there is inconsistency in how these are described and reported. This makes effective implementation and replication of study results challenging, and means there is a dearth of evidence regarding which are most effective.

Coding interventions according to the Behaviour Change Technique Taxonomy version 1 (BCTTv1) (Michie et al. 2013) is one method of improving reporting and replication, and also identifying and characterising the 'active ingredients' of an intervention. BCTs are defined as "an observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour" (Michie et al. 2013). Individual techniques can be grouped into 'domains' where they share similar underlying mechanisms of action.

Exactly how to improve hand-hygiene to reduce infection in educational settings is an urgent public health problem, yet no studies have applied behaviour change analysis to assess which BCTs have been used in study interventions motivating hand-hygiene behaviours, and which of these may be effective in reducing GI and RT infection-related absence. In this paper we address this gap. We aim to identify if specific BCTs used in existing hand-hygiene interventions in high income countries reduce GI and RT infection-related absence in educational settings and, if so, which BCTs may be the active ingredients in these interventions. To meet this aim we will address the following objectives, to assess:

1- Which BCTs have been used in existing interventions, in order to understand the form of previous study interventions and, therefore, which techniques have can be evaluated.
2- The effectiveness of the BCTs used in reducing common infection-related school absence, in order to quantify the overall effect of school-based hand-hygiene interventions.
3- If interventions aimed at children alone, or children and adults, are likely to be more effective.
4- If there is an association between the total number of BCTs used and intervention effectiveness.
5- If targeting 'risk perception' and 'instruction' is more effective than 'instruction' alone. Objectives 3 to 5 aim to further characterise the most effective interventions, in order to guide future intervention design.
6- Which, and how many, BCTs are used in trial interventions, compared with those recommended by international guidelines. This will allow evaluation of the evidence base for current recommendations.
7- Direct measures of behaviour change, including changes in the frequency of handwashing and intervention acceptability, with the aim to appreciate the potential for sustaining intervention results.

Methods

PROSPERO protocol pre-registration, CRD42020218144.

Eligibility criteria

We included: randomised controlled trials where the intervention included a hand-hygiene component; peer-reviewed studies, conducted in educational settings in high income countries-according to the World Bank classification at the time of the study-; interventions including children aged 3-11 years old; and which reported a measure of absence due to symptoms of RT and/or GI infection. For studies of other age ranges, we only included results pertaining to our age criteria.

Willmott defined educational settings as "institutions incorporating formal educational activities including day care facilities and nurseries"(Willmott et al. 2016).

Hand-hygiene interventions were defined as "any initiative for children and/or staff working with them undertaken to prevent the spread of infectious illness"(Willmott et al. 2016). Comparators could include placebos or active comparators. We did not restrict on length of follow up or language.

Search strategy

We developed the search terms and strategy in consultation with both an information specialist (NR) and our patient and public involvement group formed of teachers.

We searched MEDLINE, Embase, CINAHL, Cochrane Library, Education Resource Information Centre, Science and Social Sciences Citation Index and the British Education Index from 1 September 2014 to present. Searches were carried out on 16th November 2020. The search update was

completed on 25th May 2022 (full search strategy, available in supplementary information (SI)).

We also screened papers included in, or citing, the 2014 review by Willmott et al. (2016).

We deduplicated using EndNote before screening using Rayyan (Ouzzani et al. 2016).

Two reviewers (EH and CA) independently screened all titles and abstracts. Conflicts were resolved with discussion. Three reviewers (EH and CA & HD) followed the same process for full text screening.

Data extraction and quality assessment

The lead author (EH) extracted data from studies included in Willmott's review (Willmott et al. 2016) and checked against Willmott's extraction. All newly identified studies were extracted from independently by both EH and HD, and results compared. Information extracted included study details, description of the intervention and control, length of follow up, outcomes and analysis. The risk of bias in all studies was independently assessed by both EH and HD, in accordance with Cochrane guidance (Higgins et al. 2020).

Any disagreements throughout the process were resolved through discussion or involvement of a third reviewer (JJL).

We planned to assess publication bias via funnel plot asymmetry and Egger's test, if there were sufficient studies.

Behaviour change techniques coding

All included papers were independently coded by EH and either CA, HD, or JB according to BCTTv1 (Michie et al. 2013). Any discrepancies were resolved through discussion. A codebook was created and populated throughout the process supporting consistency across coders. We consulted teachers on defining 'credible source'.

Hand-hygiene guidelines

Eligible guidelines must come from a government or national health body, and be specifically related to children's hand-hygiene in educational settings. We searched for guidelines from the UK, USA, Australia, Canada, and New Zealand. If multiple eligible guidelines were found for one country, all were included. EH and CA coded included guidelines using the process above.

Statistical analyses

We used Stata for statistical analyses (StataCorp, Tx).

Objective 1: We used simple counts to map BCT use in interventions.

Objective 2: Due to the reduced influence of factors such as parents' ability to find childcare, we used the number of GI and RT infection absence episodes, rather than days, as the measure of absence.

We used random effects meta-analysis to pool results and estimated statistical heterogeneity using I^2.

We planned to estimate the effect of BCTs with meta-regression if there were sufficient studies, or otherwise use subgroup analysis.

Objectives 3-5: Studies were divided into subgroups according to whether BCTs were targeted at adults and children or children alone; if they had more or less than the median number of BCTs targeted at the intervention group alone (seven); and whether they utilised techniques targeting 'risk perception' and 'instruction' or 'risk perception' alone respectively.

We used random-effects meta-analysis to compare subgroups. Details of equations used, (SI).

Objective 6: We used the process above to BCT code. Recommended BCTs were described and compared to those used in study interventions.

Objective 7: Any metrics of handwashing quality, duration and frequency or measures of intervention acceptability were collected.

Results

We screened 1653 papers for eligibility, and 11 papers from 9 studies met the inclusion criteria (Fig. 1). Summary of included studies, Table 1.

Characteristics of included studies

All the included studies were cluster randomised controlled trials. Two studies clustered by class (White et al. 2001) or 'teams' of classes (Sandora et al. 2008). All other studies clustered by school (Ladegaard and Stage 1999; Nandrup-Bus 2009; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016; Alzaher et al. 2018).

All studies included children across multiple ages or school years. The age range of four studies extended beyond the age range (White et al. 2001; Nandrup-Bus 2009; Azor-Martínez et al. 2014, 2016; Alzaher et al. 2018).

Eight of the studies were carried out in schools (White et al. 2001; Sandora et al. 2008; Nandrup-Bus 2009; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016; Alzaher et al. 2018) and one took place in a day care centre (Ladegaard and Stage 1999).

Four of the studies were set in Europe (Ladegaard and Stage 1999; Nandrup-Bus 2009; Prazuck et al. 2010; Azor-Martínez et al. 2014, 2016), three took place in the USA (White et al. 2001; Sandora et al. 2008; Stebbins et al. 2011), one in New Zealand (Priest et al. 2015) and one in Saudi Arabia (Alzaher et al. 2018).

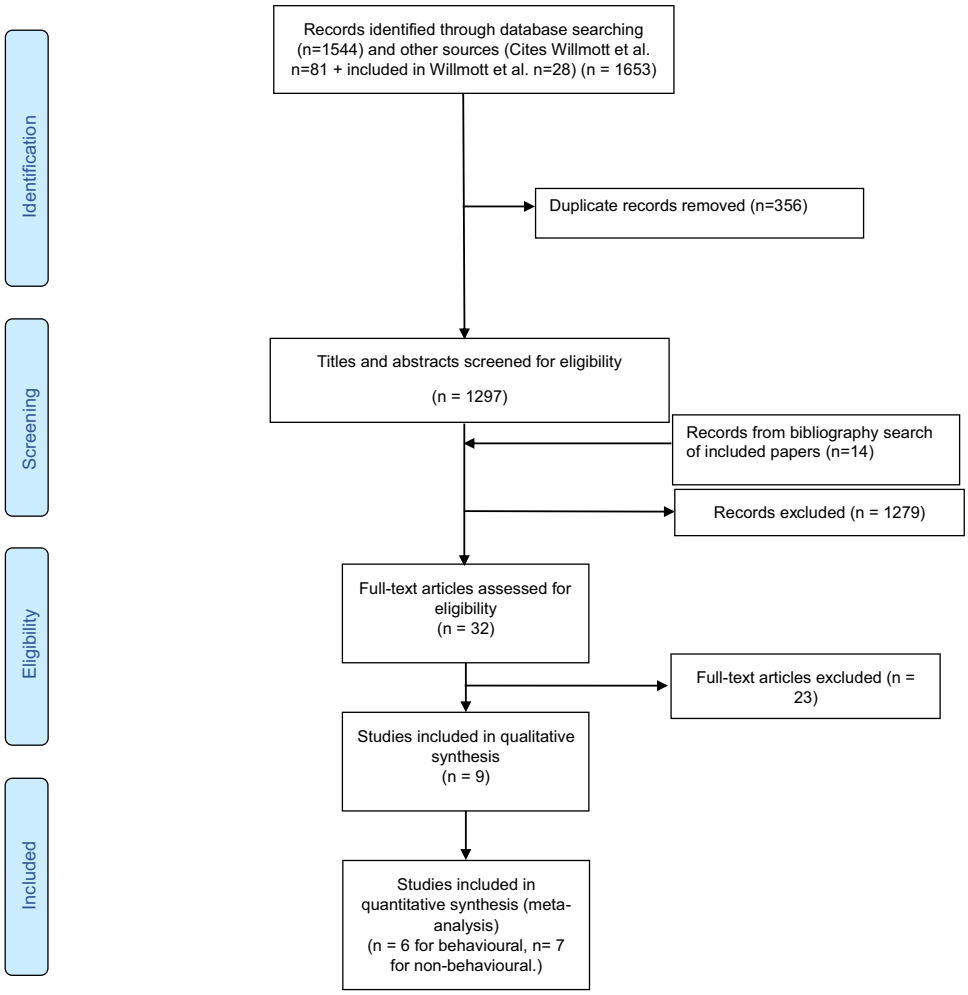

Fig. 1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram outlining the study selection process

Intervention

In four of the studies, intervention components were targeted at children only (Sandora et al. 2008; Nandrup-Bus 2009; Priest et al. 2015; Alzaher et al. 2018) whilst five targeted parents and/or teachers as well as children (Ladegaard and Stage 1999; White et al. 2001; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014, 2016). The majority of interventions involved the provision of hand sanitiser (White et al. 2001; Sandora et al. 2008; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016), often in addition to hygiene education. 3 studies used soap and water only (Ladegaard and Stage 1999; Nandrup-Bus 2009; Alzaher et al. 2018), whilst 1 used hand sanitiser only (Sandora et al. 2008). 5 took approaches involving both soap and water, and hand sanitiser (White et al. 2001; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016), each involving education with designated occasions for hand sanitiser use.

Control

Most control groups (Ladegaard and Stage 1999; Sandora et al. 2008; Nandrup-Bus 2009; Stebbins et al. 2011; Azor-Martínez et al. 2014, 2016; Alzaher et al. 2018) were told to follow normal handwashing procedure, although this was poorly reported. In two studies (Prazuck et al. 2010; Priest et al. 2015), the control group received part of the education package provided to the intervention group. One study (White et al. 2001) used a placebo hand sanitiser solution for the control group with all other elements remaining the same across both groups.

Outcomes

Some studies reported both GI and RT illness related absence episodes and/or school days lost (White et al. 2001; Sandora et al. 2008; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016); others reported on

Table 1 Summary of included studies

Study	Year	Participants	Age	Setting	Location	Intervention	Control	Cluster	Number of clusters
Alzaher	2018	School children (n= 496)	6-12 years	Primary schools (n= 4)	Riyadh, Saudi Arabia	Hand hygiene and infection education.	Normal hand-washing procedure.	School	4 clusters 2 intervention 2 control
Azor-Martinez	2009-2010	School children (n= 1341)	4-12 years	Primary schools (n= 5)	Almeria, Spain	Hand hygiene and infection education, hand sanitiser provided.	Normal hand-washing procedure.	School and classroom	4 schools and 29 classes. 2 schools + 14 classes in intervention. 2 schools + 15 classes in control.
Ladegaard and Stage	Unknown	Children (n= 399)	3-6 years	Day care centres (n= 8)	Odense municipality, Denmark	Hand hygiene and infection education.	Normal hand-washing procedure.	Day care centre	8 clusters 4 intervention 4 control
Nandrup-Bus	2006-2007	School children (n= 652)	5-15 years	Elementary schools (n= 2)	North Zealand, Denmark	Hand hygiene education, scheduled hand washing.	Normal hand-washing procedure.	School	2 clusters 1 intervention 1 control
Prazuck	2007-2008	School children (n= 478)	6-10 years	Primary schools (n= 2)	Olivet, France	Hand washing instruction, hand sanitiser provided.	Information given on how to wash hands properly with soap and water.	School	2 clusters 1 intervention 1 control
Priest	2009	School children (n=2443)	5-11 years	Primary schools (n=68)	South Island, New Zealand	Hand hygiene and infection education, hand sanitiser provided.	Same hand hygiene and infection education as intervention schools apart from no instruction on hand sanitiser use.	School	68 clusters 34 intervention 34 control
Sandora	2006	School children (n= 285)	Grades 3-5 (age not reported)	Elementary school (n= 1)	Ohio, USA	Hand hygiene instruction, hand sanitiser provided.	Normal hand hygiene procedures.	Teams' of classes, based on rotation through shared facilities	6 teams 3 intervention 3 control
Stebbins	2007-2008	School children (n= 3360)	Kindergarten-5th grade (age not reported)	Elementary schools (n=10)	Pennsylvania, USA	Hand hygiene and infection education, hand sanitiser provided.	Normal hand-washing procedure.	School	10 clusters 5 intervention 5 control

Table 1 (continued)

Study	Year	Participants	Age	Setting	Location	Intervention	Control	Cluster	Number of clusters
White	1999	School children (n= 769)	5-12 years	Elementary schools (n= 3)	California, USA	Hand hygiene and infection education, hand sanitiser provided.	Same hand hygiene and infection education as intervention group but placebo hand sanitiser solution.	Class	32 clusters 16 intervention 16 control

RT illness (Stebbins et al. 2011; Alzaher et al. 2018) or GI illness-related (Prazuck et al. 2010) absence alone.

Two studies (Sandora et al. 2008; Prazuck et al. 2010) did not report infection-related absence episodes, only infection-related absence days, therefore their data could not be included in the quantitative analysis. Outcomes of these studies (SI).

Risk of bias

Many studies demonstrated common design issues. The nature of the intervention meant that blinding of participants and study personnel was an almost universal issue, with 8/9 studies being high risk, potentially causing performance bias. The reliance on parental reporting of absence/illness type could have contributed to: detection and social desirability bias and poor response rates leading to loss of data, with 3/9 studies being high or unclear risk for incomplete data (SI). Some studies attempted to overcome the subjective nature of symptom reporting by verifying cases of infection through laboratory testing or GP consultation, but 7/9 studies were still found to have a high risk of bias for blinding of outcome assessment. Full justification for risk of bias assessments, (SI). As there were fewer than 10 studies, we could not test for publication bias.

Hand-hygiene guidelines

One set of eligible guidelines was found for the UK (NICE 2017), Canada (Government of Canada 2021) and Australia (Australian Government Department of Health 2021). Two sets were found for the USA (Centres for Disease Control and Prevention 2021; CDC Healthy Schools 2021) and no eligible guidelines were found for New Zealand.

Objective 1 - BCTs used in existing studies

A total of 18 BCTs out of 93 possible techniques (19.35%) were identified across the included studies (Fig. 2). The number of BCTs used in each intervention ranged from 6-11, (median, 8.5). A wider variety of BCTs were targeted at children compared to adults (17 vs 8); only one study (Ladegaard and Stage 1999) aimed more techniques at adults than children.

The most commonly used BCT was ‘instruction on how to perform the behaviour’, used in all study interventions whilst ‘action planning’ (White et al. 2001; Sandora et al. 2008; Nandrup-Bus 2009; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015;

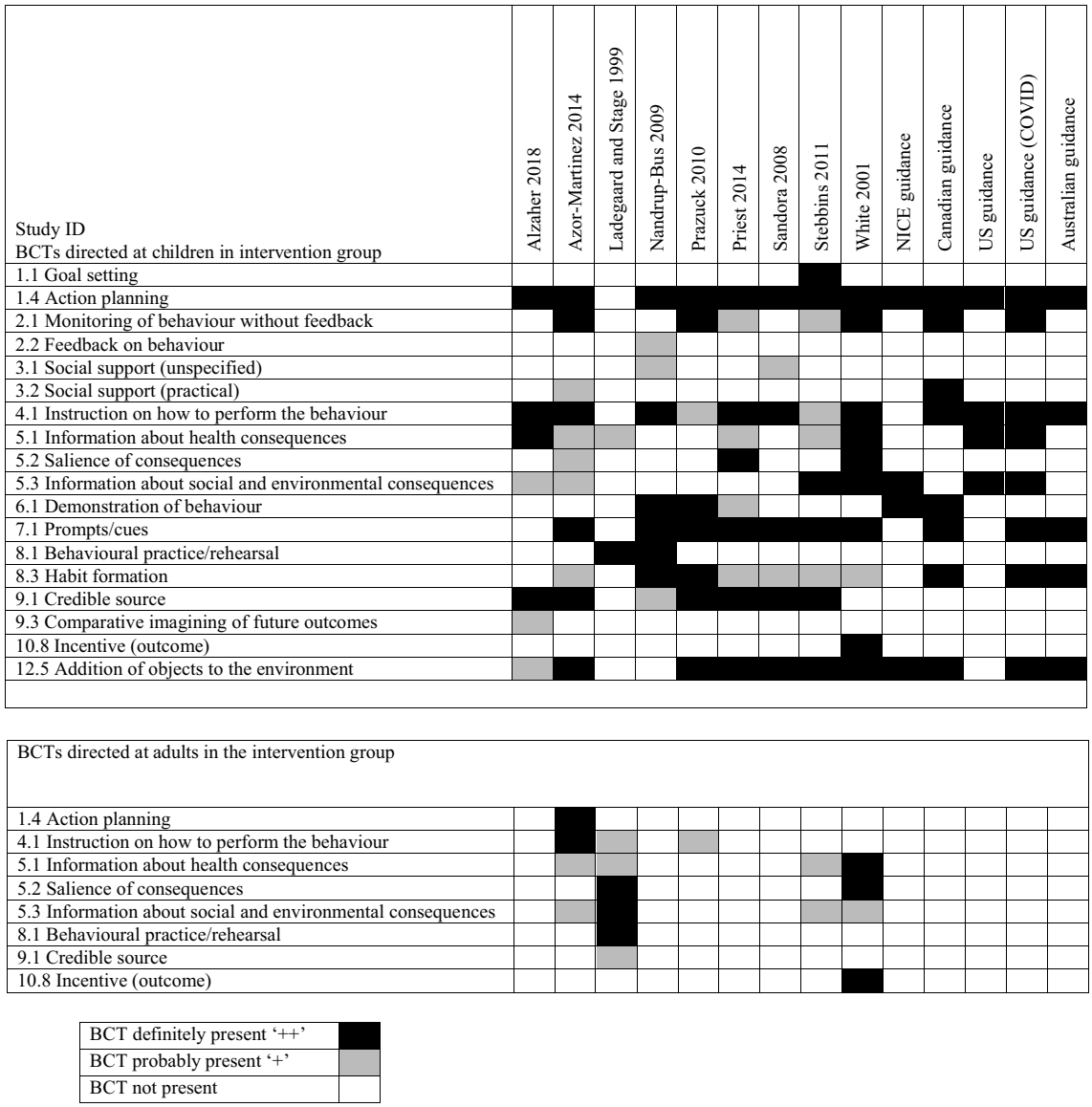

Fig. 2 Summary of BCTs used in each study or recommended by each guideline

Azor-Martinez et al. 2016; Alzaher et al. 2018) and 'credible source' (Ladegaard and Stage 1999; Sandora et al. 2008; Nandrup-Bus 2009; Prazuck et al. 2010; Stebbins et al. 2011; Azor-Martínez et al. 2014; Priest et al. 2015; Azor-Martinez et al. 2016; Alzaher et al. 2018) were included in eight interventions. Examples of commonly used BCTs, (SI).

Objective 2 – BCT effectiveness

Meta-analysis of the number of infection-related absence episodes (Fig. 3) revealed a significant reduction in absence in the intervention groups (pooled estimate of relative rate ratio 0.754, 95% confidence interval (0.602, 0.944), I^2= 91.86%, p= 0.014).

As we included fewer than 10 papers, we were unable to perform meta regression, so used subgroup analyses to explore heterogeneity.

Objectives 3-5 - subgroup analyses

Data from White et al. (2001) were not included in quantitative behavioural analysis as both arms were exposed to the same BCTs, the only difference being whether the hand sanitiser was placebo or not.

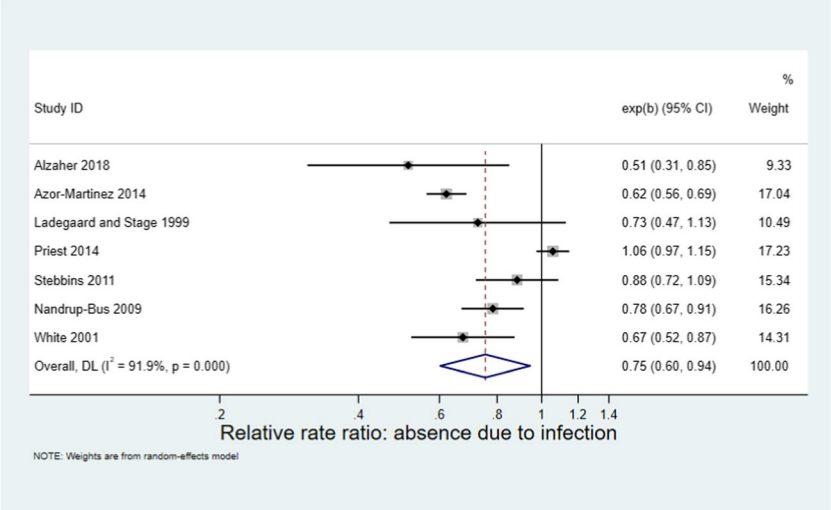

Fig. 3 Forest plot showing results from random effects meta-analysis, comparing intervention and control groups across all included studies

Table 2 Results of subgroup analyses, significant results highlighted in bold

Subgroup analysis	Subgroup	Estimated effect size	95% confidence interval	P value for individual subgroup	P value from parametric test of subgroup differences	P value from non-parametric test of subgroup differences	I^2 (%)
Number of BCTs	≤7 BCTs used	0.773	0.494, 1.209	0.259	0.8838	0.8273	80.2
	>7 BCTs used	**0.745**	0.600, 0.923	**0.007**			83.8
Target of BCTs	Just children	0.815	0.600, 1.108	0.193	0.5904	0.8273	88.7
	Children and adults	**0.729**	0.557, 0.953	**0.021**			78.4
Mechanism of BCT	Just instruction	0.917	0.683, 1.231	0.563	0.1680	0.2667	91.1
	Instruction and risk perception	**0.692**	0.547, 0.877	**0.002**			70.7

Objective 3 – target of interventions

The first subgroup analysis compared interventions that targeted adults and children versus children alone. Meta-analysis (Table 2) showed that reduction in GI and RT illness absence episodes was only significant in the subgroup of studies targeting BCTs at adults as well.

Objective 4- number of BCTs

Studies were divided according to the median number, 7, of BCTs targeted only at the intervention group. There was a significant absence reduction in the subgroup using >7 BCTs (Table 2).

Objective 5– 'risk perception' and 'instruction'

Reduction in absence was significant in the subgroup targeting both 'risk perception' and 'instruction' but not 'instruction' alone (Table 2).

Forest plots illustrating results of all subgroup analyses, (SI).

However, for all subgroups, both parametric and non-parametric contrast tests showed that there was no significant difference between the pooled effect estimates of the two subgroups. Unexplained heterogeneity within subgroups remained high, although it was reduced compared to combined meta-analysis. Together this means that the confidence in the benefit of using more BCTs, targeting them at both adults and children and targeting 'risk perception' and 'instruction' is limited.

Objective 6- guidelines

Ten different BCTs were used across the national guidelines for the UK (NICE 2017), Australia (Australian Government Department of Health 2021), Canada (Government of Canada 2021) and USA (Centres for Disease Control and Prevention 2021; CDC Healthy Schools 2021). The median number of BCTs was five (range, 4-8). All guidelines recommended fewer BCTs than used in study interventions.

In line with the study interventions, frequently recommended BCTs included 'action planning' (5 guidelines)

(NICE 2017; Government of Canada 2021; Australian Government Department of Health 2021; Centres for Disease Control and Prevention 2021; CDC Healthy Schools 2021); 'instruction on how to perform the behaviour' (Government of Canada 2021; Australian Government Department of Health 2021; Centres for Disease Control and Prevention 2021; CDC Healthy Schools 2021), and 'addition of objects to the environment' (NICE 2017; Government of Canada 2021; Australian Government Department of Health 2021; Centres for Disease Control and Prevention 2021) (both in four guidelines). Despite eight out of nine of the study interventions using a 'credible source', no guideline recommended the use it. The Australian and Canadian guidelines did not recommend addressing 'risk perception'.

None of the study interventions included all of BCTs recommended by NICE. Therefore, it was not possible to assess the effectiveness of this particular combination.

Objective 7- handwashing metrics

Only three studies (White et al. 2001; Nandrup-Bus 2009; Stebbins et al. 2010) reported on the frequency of handwashing or hand sanitiser use, showing moderate uptake. One survey found that promoting hand washing 2-4 times per day, use of hand sanitiser and teaching about practices to prevent flu were highly acceptable to teachers (Stebbins et al. 2009).

Discussion

Main finding of this study

We systematically reviewed 11 papers from 9 studies and coded interventions using the BCTTv1 taxonomy (Michie et al. 2013). We found that a school-based hand-hygiene intervention can significantly reduce incidences of GI and RT illness related school absence. Subgroup analyses reduced heterogeneity, but pooled effect sizes were not significantly different. It was not possible to assess the effectiveness of the individual BCTs. We found no evidence to support either the number of BCTs or the specific combination recommended by guidelines.

There is some evidence to support using more BCTs, targeting them at both adults and children and targeting both 'risk perception' and 'instruction'.

What is already known on this topic

This systematic review and behaviour change techniques analysis builds on Willmott et al.'s existing review. It is the only systematic review assessing the impact of school-based hand-hygiene interventions on illness-related absenteeism. We limited our searches to high income countries and identified three additional studies not included by Willmott et al. Based on individual study results Willmott et al. (2016), and a second review by Meadows et al. (Meadows and Saux 2004), indicated that school-based hand-hygiene intervention in all settings may reduce infection-related absence. Both reviews were unable to carry out a pooled meta-analysis, and neither sought to identify the 'active ingredients' of interventions.

Several reviews have carried out behavioural analyses of hand-hygiene interventions in a range of populations (Huis et al. 2012; Staniford and Schmidtke 2020; Sands et al. 2020). Staniford et al. (Staniford and Schmidtke 2020) carried out a systematic review and behavioural analysis of the effect of interventions on behaviour performance, e.g. frequency of handwashing, rather than associated infection. They also used Michie's BCTTv1 (Michie et al. 2013) and the most frequently used domain was 'shaping knowledge'. This is in keeping with our finding that 'instruction on how to perform behaviour', which falls under the 'shaping knowledge' domain, was the most frequently employed technique. They also found that studies targeting ≥4 BCT domains were more likely to have a positive outcome than those targeting <4 (Staniford and Schmidtke 2020). This is in keeping with both our findings and the broad trend observed by Huis et al. who found that the relative difference in effect size between intervention and control groups increased with the number of behavioural determinants addressed (Huis et al. 2012).

Wang et al. (2017)'s systematic review is the only review to characterise and compare intervention types. They described the content of hand-hygiene interventions in educational settings, identifying soap and hand sanitiser-based interventions were effective in reducing GI infection-related absence. Their broad categorisation did not capture all aspects of the interventions, and they highlighted a need to investigate further the motivators of hand-hygiene practices, which we captured in our BCT analysis.

In relation to intervention characteristics, existing evidence from other areas (Enright et al. 2020) shows adults are often drivers of behaviour change in children and can facilitate important behavioural changes. Additionally, existing work shows that a multifaceted approach, targeting both education and action, is more effective, and that risk perception may promote handwashing behaviours (Miller et al. 2011).

What this study adds

Our meta-analysis indicated that school-based hand-hygiene interventions lead to a significant decrease in RT and GI illness-related absence, and so should be implemented, despite high heterogeneity. The optimal behavioural contents of this intervention remains unclear. Therefore, although guidelines recommend specific BCTs there is no evidence those recommended are most effective.

We found some evidence that using more BCTs, utilising both 'risk perception' and 'instruction' in intervention design, and targeting both children and adults is more effective. Although the evidence is weak, given the current absence of further studies and the limited harms in implementation, we would recommend incorporating these aspects into intervention design.

Action planning was used in almost all studies, meaning we were unable to isolate this BCT to identify its effectiveness. However, making a specific plan about when a behaviour should be performed has been identified as effective in many similar studies (Sands et al. 2020). Given equivocal evidence, limited harms in implementation, we would recommend the use of action planning, which is also supported by theory (Sands et al. 2020).

Whilst the positive effects of promoting handwashing have been established, there is the potential to optimise the benefits. We recommend large scale, longer, and better controlled cluster trials to identify the most effective BCTs in this context.

Limitations of this study

A limitation was the number and quality of existing studies in this field. We expected high heterogeneity, but we did not have sufficient data to undertake meta regression, our planned method to explore this. Nevertheless, heterogeneity was lower in subgroups, suggesting these factors partly explain the heterogeneity.

Conclusion

National guidelines recommend school-based hand-hygiene interventions. We found no evidence supporting current guideline-recommended intervention components. We found that interventions reduce infection-related absence and, therefore, should be implemented. To maximise effectiveness, interventions should use more than seven BCTs, target both adults and children, provide information on the risks of inadequate hand-hygiene as well as instruction.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10389-023-02044-7.

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Data sharing As this was a systematic review, we did not collect first-hand data.

Authors' contributions JJL, CA and EH all contributed to the systematic review's conception and design. NR assisted in development of the search strategy. EH, CA and HD all screened search results. Data was extracted by EH and HD; behavioural analysis was performed by EH, JB and CA. Statistical analysis was carried out by EH and JJL. The manuscript was drafted by EH, and revised critically for important intellectual content by CA and JJL.

Availability of data Not applicable.

Code availability Not applicable.

Declarations

Ethics approval Not applicable

Consent to participate Not applicable

Consent for publication Not applicable

Conflicts of interest JJL is funded by the National Institute for Health Research (NIHR) [Doctoral Research Fellowship NIHR300738]. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.
In 2022 CA was contracted qualitative methodologist for the Behavioural Insights Team (BIT) for which she was paid personally. She has worked as a consultant qualitative methodologist for Wildfowl Wetlands Trust, Linney Create, and Adelphi Real World, and received personal payment.

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