Process evaluation of a multi-component intervention to reduce infectious diseases and improve hygiene and well-being among school children: the Hi Five study

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Abstract

The Hi Five study was a three-armed cluster randomized controlled trial designed to reduce infections and improve hygiene and well-being among pupils. Participating schools (n = 43) were randomized into either control (n = 15) or one of two intervention groups (n = 28). The intervention consisted of three components: (i) a curriculum (ii) mandatory daily hand washing before lunch (iii) extra cleaning of school toilets. The aim of this study was to evaluate the implementation and to identify challenges to program implementation. Several data sources were used, including observations of school toilets, semi-structured interviews with school coordinators (n = 4), focus groups with pupils (n = 6) and teachers (n = 5), and questionnaires among pupils (n = 5440), teachers (n = 387) and school coordinators (n = 28). This study indicates that the curriculum was successfully implemented at most schools, and that teachers and pupils reacted positively to this part of the intervention. However, daily hand washing before lunch seems to be difficult to implement. Overall, the implementation process was affected by several factors such as poor sanitary facilities, lack of time and prioritization and objections against the increasing tendency to place the responsibility for child-rearing tasks on schools. This study reveals the strong and weak parts of the Hi Five study and can guide program improvement.

Introduction

Infectious diseases such as influenza, diarrhea or pneumonia are the leading causes of school absenteeism among children in Denmark [1, 2], and approximately every 10th pupil suffers from an infectious disease within a 14-day period [2]. This has consequences for the individual child, who must stay home from school and miss classes, but also for the parents who must care for the sick child and may miss work. Furthermore, there are economic costs associated with diseases among pupils such as parents’ lost earnings, costs of doctor visits and medication [3].

Studies have indicated that school-based hand hygiene interventions which include education and mandatory daily hand washing or the use of alcohol-based hand sanitizer can reduce school absenteeism due to infectious illness [4–9]. However, there is a lack of large cluster randomized controlled trials that aim to improve hand hygiene and reduce illness-related absenteeism. We are aware of only one such study involving 68 primary schools in New Zealand [10]. The study found no effect of hand sanitizer in reducing school absences due to illness [11]. Therefore, the overall aim of the Hi Five study was to develop, implement and evaluate a large multi-component school-based hand hygiene intervention at 43 schools in Denmark.

Previous studies have indicated that multi-component interventions are complex to implement.
and are seldom implemented as planned [13, 14]. Furthermore, several studies have provided evidence that the level of implementation affects intervention outcomes and that poor implementation diminished the outcomes [12, 13]. Therefore, process evaluation is needed to evaluate an intervention, and to explain the specific reasons why it succeeded or failed [15, 16]. For example, accurate interpretation of outcomes is dependent on knowing which aspects of the intervention were delivered and how well they were conducted. Negative results may be due to insufficient implementation or to shortcomings in the intervention’s design. On the other hand, positive results can be achieved through an intervention that, in practice, was very different from what was intended [13].

There is limited research on implementation of interventions in school settings. We are aware of only one prior study that has examined the implementation of a hand hygiene school intervention [17, 18]. Therefore, the aim of this study was to examine the extent to which the Hi Five intervention components were implemented as planned, and to identify the challenges to program implementation. The evaluation may be used to improve the intervention design and inspire future school interventions.

Materials and methods

Study description

The Hi Five study was a three-armed cluster randomized controlled trial designed to reduce infections and improve hygiene and well-being among pupils. The intervention consisted of three components: (i) a curriculum component (ii) mandatory daily hand washing before lunch (iii) daily extra cleaning of school toilets. There were two intervention arms: one including all three intervention components and one including only components 1 and 2. Participating schools (n = 43) from 20 municipalities across the country were randomized into either control (n = 14) or one of the two intervention groups (n = 28). The intervention targeted pupils at all grade levels (grade 0–9). The intervention period was August 2012 to June 2013. Each participating school selected a school coordinator for the study. The coordinator was a school leader, a teacher or a secretary. Their main tasks were to receive and redistribute information concerning the intervention and its evaluation to the school, pupils and parents, and to work as a Hi Five ambassador. All intervention schools were visited by Hi Five-employees at the beginning of the school year in which the intervention was planned to be implemented. The school leader, the school coordinator, the technical administrative manager and a teacher representative from each team (0–2, 3–6 and 7–9 grade) were invited to be present at the meeting where the intervention and evaluation elements were introduced [19]. For this study we used data from only the intervention schools.

The curriculum component

The curriculum component consisted of five to six lessons, and included four topics: (i) Introduction to micro-organisms. (ii) Information on good practices to slow the spread of infections (e.g. hand washing after going to the toilet, after sneezing and before eating). (iii) How to wash hands properly. (iv) How to keep school toilets clean. For implementation, schools were expected to teach each of the four topics, and to do practical hand washing exercises that included the use of oil with glitter (zero to third grade) or Glitterbug lotion (a fluorescent lotion that used with a UV lamp makes it possible to illustrate how well hands are washed) (fourth to ninth grade). The educational material consisted of a teacher’s guide, containing detailed lesson plans and background knowledge on the topics, and worksheets for pupils with tasks and activities. Due to the sustainable intention of the intervention, the curriculum component was designed so it could be carried out by all teachers without further introduction, but relied solely on the teacher guide.

The hand hygiene component

Alongside of the curriculum component, pupils were required to wash hands every day before lunch. The teachers were required to remind pupils to wash hands and to inset aside time for it.
Furthermore, schools were given stickers with instructions on proper hand washing which were to be posted at each sink.

Component related to school toilet facilities
Half of the intervention schools received extra cleaning of school toilets. This included one extra daily cleaning of toilets and sinks, removing visible dirt, emptying bins and refilling soap, toilet paper and paper towels. The cleaning was carried out by the cleaning companies already affiliated to the schools. Furthermore, all 28 intervention schools were given small stickers to be mounted inside the toilet bowls as a target point to motivate male pupils to urinate straight and reduce spillage. Detailed information about the design of the Hi Five study is described elsewhere [19].

Process evaluation
The Hi Five process evaluation was designed following the guidelines presented by Linnan and Steckler (2002) [20]. They suggest documenting and describing a number of process evaluation concepts when evaluating the implementation of health interventions. In this study, four of these process evaluation concepts were examined: (i) ‘context’: contextual factors that may have influenced implementation (ii) ‘reach’: proportion of classes that participated in intervention activities (iii) ‘dose delivered’: the extent to which the intervention components were delivered to pupils (iv) ‘dose received’: the extent to which pupils received and used the intervention. Furthermore, we examined ‘the appreciation’ of the intervention: The extent to which the pupils and teachers appreciated the intervention. These process evaluation concepts formed the theoretical basis for the construction of questions for interviews, observations and questionnaires. Table I shows how the concepts have been operationalized. Data collected in the process evaluation are listed in Table II.

Interviews with teachers, school coordinators and pupils
Six intervention schools with geographical spread were strategically selected to be involved in pupil focus groups, teacher focus groups and school coordinator interviews. The selection was based on the researchers’ expectations of the level of implementation at the schools formed at visits early in the study period. Half of the schools were expected to achieve high-implementation fidelity and the other half were expected to achieve low fidelity. Twenty-one pupils participated in a total of six focus groups. To ensure that all grade levels were represented, we strategically selected different grades at each of the six schools to participate. Pupils were randomly selected from the classes. Focus groups were conducted with two to four pupils and took place during school hours in a variety of settings. Five focus groups were conducted with 12 teachers, and explored their views on the intervention components and identified challenges to program implementation. The teachers were selected by the school coordinator. Finally, four semi-structured interviews were conducted with school coordinators from the selected intervention schools. The interviewer was not part of the implementation or other parts of the evaluation, and therefore was able to remain neutral. Interviews lasted between 10 and 50 min. Three semi-structured interview guides were used for pupils, teachers and school coordinators, respectively. Digital recordings of interviews were transcribed verbatim. One researcher coded and categorized each interview according to the five process evaluation concepts using NVivo qualitative software program. A summary of the analysis was prepared and discussed by all researchers. The specific findings were then interpreted and broader conclusions identified.

Questionnaires
The intervention schools were asked to complete a set of questionnaires on the intervention components, which were sent to the school coordinators, teachers or pupils at several periods during the intervention. School coordinators (n = 28) were asked if all classes completed the Hi Five curriculum components and the practical hand wash exercise. The teacher questionnaire (n = 387) focused on how teachers implemented the curriculum as well as the hand hygiene component and their perceived...
### Table I. Key components of the process evaluation, operationalization and data sources

<table>
<thead>
<tr>
<th>Evaluation components</th>
<th>Evaluation questions</th>
<th>Information acquired via interviews, questionnaires and observations</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>In which context did the intervention take place?</td>
<td>Decision-making&lt;br&gt;- How was it decided that the school should participate in the intervention?&lt;br&gt;Environment&lt;br&gt;- Did pupils have access to proper sanitary facilities including accessible toilets and sinks with cold and hot water in the taps?&lt;br&gt;- What proportion of classes received the curriculum component?&lt;br&gt;- What proportion of classes performed the practical hand washing exercise using oil with glitter or Glitterbug lotion?&lt;br&gt;- What proportion of schools initiated the extra cleaning of school toilets?</td>
<td>- Interviews with school coordinators and focus groups with teachers&lt;br&gt;- Observations</td>
</tr>
<tr>
<td>Reach</td>
<td>What proportion of classes participated in the intervention components?</td>
<td>- What proportion of classes received the curriculum component?&lt;br&gt;- What proportion of classes performed the practical hand washing exercise using oil with glitter or Glitterbug lotion?&lt;br&gt;- What proportion of schools initiated the extra cleaning of school toilets?</td>
<td>- Teacher questionnaire&lt;br&gt;- Focus groups with teachers&lt;br&gt;- Teacher questionnaire&lt;br&gt;- Focus groups with teachers&lt;br&gt;- Observations</td>
</tr>
<tr>
<td>Dose delivered</td>
<td>To what extent were the intervention components delivered to pupils?</td>
<td>Curriculum component&lt;br&gt;- How much time did teachers spend on teaching the curriculum?&lt;br&gt;- Which topics were taught to pupils?&lt;br&gt;Mandatory daily hand washing&lt;br&gt;- To what extent did teachers encourage their pupils to wash hands every day before lunch?&lt;br&gt;School toilet facilities&lt;br&gt;- To what extent were soap and paper towels available at sinks?&lt;br&gt;- To what extent were stickers with instructions on proper hand washing posted at sinks?&lt;br&gt;- To what extent were little stickers mounted on the inside of toilet bowls to make male pupils urinate straight?&lt;br&gt;Extra cleaning of school toilets:&lt;br&gt;- To what extent did toilets look clean?&lt;br&gt;- To what extent was toilet paper available?&lt;br&gt;- To what extent were trash bins filled?&lt;br&gt;- To what extent did pupils remember the curriculum?&lt;br&gt;- To what extent did pupils at intervention schools exhibit greater knowledge about micro-organisms, proper hand washing and prevention of infectious diseases after the intervention period?&lt;br&gt;- To what extent did pupils at intervention schools report better hand washing behavior (before lunch, use of soap, paper towels etc.) after the intervention period?&lt;br&gt;- To what extent did pupils at intervention schools report cleaner school toilets after the intervention period?</td>
<td>- Pupil questionnaire&lt;br&gt;- Focus groups with pupils</td>
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</tbody>
</table>
barriers to the implementation. Pupils in one class per grade level (zero to eighth grade) were asked to complete an internet-based self-administered questionnaire during a school-lesson at baseline (n = 5440) and follow-up (n = 5770). The questionnaire was developed in two versions: One for zero to fourth graders (6–10-year-olds) constructed as a ‘speaking questionnaire’, and one for pupils in grade fifth to eighth (11–14-year-olds). The children’s questionnaires focused on their hand washing behavior, use and experiences of toilet facilities, wellbeing and illness episodes. The children were also asked questions about micro-organisms and prevention of infectious diseases to test their knowledge before and after the intervention. At follow-up, they were asked to comment on whether they remembered specific parts of the curriculum. The baseline questionnaires for zero to fourth graders and fifth to eighth graders were pilot tested twice, and revised to a minor degree according to observations and the children’s comments [19]. The statistical analyses were all carried out using SAS 9.3 (SAS Institute, Inc, Cary, NC). Chi square-tests were conducted to evaluate the association between behavior at baseline and follow-up. A significance level of 0.05 was used.

Table I. Continued

<table>
<thead>
<tr>
<th>Evaluation components</th>
<th>Evaluation questions</th>
<th>Information acquired via interviews, questionnaires and observations</th>
<th>Data sources</th>
</tr>
</thead>
</table>
| Appreciation          | To what extent did teachers and pupils appreciate the intervention? | • How did teachers and pupils assess the curriculum?  
• To what extent has the teacher felt competent to teach the curriculum?  
• To what extent has the teacher felt that the curriculum was relevant to their subject and learning goals? | • Teacher questionnaire  
• Focus groups with pupils  
• Focus groups with teachers |

Table II. Summary of data collected in the process evaluation

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupil questionnaire (zero to eighth grade)</td>
<td>5440</td>
<td>5770</td>
</tr>
<tr>
<td>Invited</td>
<td>387</td>
<td>135</td>
</tr>
<tr>
<td>Responded</td>
<td>4854</td>
<td>4411</td>
</tr>
<tr>
<td>Teacher questionnaire</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Invited</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Responded</td>
<td>387</td>
<td>135</td>
</tr>
<tr>
<td>School coordinator questionnaire</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Invited</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Responded</td>
<td>387</td>
<td>135</td>
</tr>
<tr>
<td>Pupil focus groups (first to ninth grade)</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Number of focus groups</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Number of pupils</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Teacher focus groups</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Number of focus groups</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Number of teachers</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>School coordinator interviews</td>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td>Number of interviews</td>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td>Observations of pupil toilets</td>
<td>56</td>
<td>56</td>
</tr>
</tbody>
</table>
Observations
Observations were conducted at two toilets on each of the 28 intervention schools at baseline and follow-up. A standardized observation scheme was used to document the availability of facilities. The observations focused on cleanliness of school toilets, including availability of paper towels, toilet paper, soap, bins and the general condition of the toilets. The observation scheme was pilot tested on two schools before the intervention, and revised to a minor degree.

Ethical considerations
There is no formal institution for ethical assessment and approval of questionnaire-based population studies in Denmark. When inviting the schools to participate, school leaders, parents, pupils and teachers received written information about the study. Pupils and their parents were informed that participation was voluntary, that their information would be used for research purposes only, and of the possibility of withdrawing during any stage of the study. The study is registered at the Danish Data Protection Agency, ref: 1 October 2011, ref: 2011-54-1240.

Results
Of the 387 teachers who implemented the curriculum component, 135 teachers completed the questionnaire. At baseline, 5440 pupils were enrolled, 4854 of whom responded to the questionnaire (89.2%). At follow-up, 4411 of 5770 pupils responded (76.4%). Of the 28 school coordinators, 20 returned the questionnaire. Key findings are described below according to the five process evaluation concepts.

Context of the intervention
Decision-making on participation
Information meetings were arranged with Hi Five staff, school coordinators and teacher representatives well in advance of the intervention start-up to ensure that teachers knew about the project and the intervention components. However, interviews with teachers revealed that they were asked to teach the curriculum very late:

Interviewer: You said that some teachers felt that the decision [to participate in Hi Five] was made top down and that it has been demotivating...
Teacher (5–6th grade): Yes, but most of all frustrating, because the annual calendar was already made, and then it was changed.
Teacher (3rd–6th grade): Suddenly the material was just there, and then we were told to start teaching it the week afterwards and be done in 4–5 weeks. So it came as a surprise for many of us.

As the quoted teachers expressed, some teachers felt they were not involved in the decision to participate in the project and that this was frustrating because they already had made their annual calendar. In continuation hereof, another teacher suggested:

Teacher (7th grade): In the future, it would be a good idea to incorporate it [the Hi Five curriculum] into the annual calendar – like that it will not become an extra task during the school year.

At some schools, the task of coordinating the project was given to a teacher; at other schools the principal took on the responsibility. However, principals were often very busy and the communication between coordinators and teachers seemed better when a teacher took on the coordinator role. A school coordinator, who was also a principal, explained:

School coordinator: I have not had time to acquaint myself with the project. If I had said to one of the teachers ‘you know what, you have 20 hours to coordinate the project and to acquaint yourself with the material’, then perhaps it would have been handled in a better way. It probably would have been better.
Access to proper sanitary facilities

Data from observations revealed that, the mean number of pupils per toilet was 18 (ranging from 6 to 34). Furthermore, we found that almost three out of four (73%) of school toilets observed had both cold and hot water available in the taps.

Reach—the proportion of classes participating in the intervention

Fifteen of 20 coordinators stated in the questionnaire that all classes had completed the curriculum; one reported that a few classes only used part of the curriculum and four coordinators were not aware of the specific use. Twelve of 19 school coordinators reported that all classes completed the practical hand wash exercise, two reported that a few classes missed the exercise and five school coordinators did not know.

According to the cleaning companies, the extra daily cleaning of school toilets was initiated at the beginning of the school year as planned.

Dose delivered—the extent to which the intervention was delivered

Time spent teaching Hi Five

Sixty-four percent of teachers who responded to the questionnaire used five lessons or more teaching the educational material as recommended in the intervention manual, 32% used two to four lessons and 4% used zero to one lessons. The least time was spent in ninth grade, where just over half (52%) of the teachers reported that they had used five lessons or more compared with 69% among fourth to sixth grade teachers.

The interviewed teachers explained that ninth graders have a tighter time schedule than younger pupils. They have a lot to catch up with before exams and therefore it was difficult to devote time to external projects such as Hi Five:

Teacher (9th grade): I have run the course in 9th grade, and I won’t say that it was a waste of time, but the time is short in 9th grade, so we rushed through the practical exercises.

Hi Five topics taught

Almost all teachers responding to the questionnaire reported that their pupils were taught prevention of transmission of infectious diseases and proper hand washing, 96 and 98%, respectively. The topic with the lowest coverage was ‘micro-organisms’, which 83% of pupils were taught. Almost all teachers, 95%, reported that the pupils conducted the practical hand washing exercise.

Teacher’s encouragement to hand wash

Approximately one-third (35%) of the teachers responding to the questionnaire reported that they encouraged pupils to wash their hands every day before lunch, one third of the teachers did so once in a while, and 30% rarely or never did so. Only 2% of the teachers encouraged pupils to use alcohol-based instant hand sanitizer.

The majority of interviewed teachers confirmed that they did not remind pupils to wash their hands nor build in time for hand washing. They explained that there was often a lot to sum up at the end of each lesson implying that they forgot to remind pupils, just as pupils forgot to wash their hands themselves.

School coordinator: You simply just forget it... In the end of the lesson you often have a lot to follow up, and then hand washing is perhaps not prioritized. I can imagine how it passes into oblivion.

In three out of five schools, however, the teachers interviewed explained that hand washing before lunch was an integral part of daily routine among children in primary school even before Hi Five.

Interviewer: Did the pupils wash hands before lunch prior to the Hi Five project?
Teacher (1st grade): The pupils in primary school did, but I have to admit that I did not wash hands with my pupils in 1st grade.

More than half of the teachers (60%) responding to the questionnaire perceived that poor sanitary facilities were the main barriers to the implementation of daily hand washing. Almost half of the teachers (46%) believed that it took too much time
from the general education and 13% felt that it disrupted teaching time. Approximately a quarter (28%) reported that their pupils did not want to wash their hands and 4% stated that pupils leave school during lunch breaks. Only 18% of teachers perceived no barriers for the implementation of daily hand wash. Teacher interviews confirmed that lack of conveniently located sinks was a main barrier. One school coordinator working at a school with few sinks per pupil, explained:

School coordinator: Some pupils need to walk relatively far to find a sink, and then they need time to wash their hands and get back to the classroom, which also takes time.

Additionally, a teacher explained:

Teacher (0–3rd grade): When pupils go to the toilet to wash hands it quickly turns into a party down there, and then they forget to come back to the classroom.

However, the interviews indicated that also at schools in which hand washing facilities were available in every classroom, teachers perceived it to be disturbing and time consuming. One teacher explained:

Teacher (0–3rd grade): We do have a sink in the classroom and over a period we tried to allocate 15 minutes before lunch to wash of hands, but primarily they are too young. There has to be an adult who can show them how to do it, and all the other kids think it’s very exciting to see what’s going on at the sink. It spoils the teaching, so we don’t do it anymore.

At some schools, eighth and ninth graders are allowed to leave the school grounds during the lunch break. A teacher reported:

Teacher (7–9th grade): 8th and 9th graders are allowed to leave the school during the break so the oldest pupils go to the supermarket to buy food. They leave and I don’t know if they remember to wash hands when they come back.

Interviewed pupils also explained that they do not have time to wash hands because they enjoy going to the supermarket to buy lunch. Furthermore, at some schools pupils are allowed to eat during classes, because their teachers believe it can help them concentrate and improve their learning. However, this makes it difficult to implement the daily hand washing before lunch because it is disturbing if pupils wash their hands at different times during class:

Teacher (7th grade): My pupils are allowed to eat during the class. We rather want focused pupils than pupils thinking about food for two hours. So they can sit and eat quietly . . . but that means they don’t do it [wash hands] before they eat.

**Access to soap, paper towels and stickers**

Observations revealed that soap was available at 96% of the school toilets, and that it was possible to dry hands at almost all school toilets (98%). It was observed that at less than half (48%) of intervention schools, stickers with instructions on proper hand washing were posted at all school sinks. At 37% of the schools they were posted at more than half of the sinks and at 15%, no stickers were posted. Some of the interviewed pupils found stickers with instructions on proper hand washing to improve hand washing practices. A pupil from a school where stickers were not posted explained:

Pupil (6th grade): It is more fun to wash hands if there are stickers [with instructions on proper hand washing], because then you are following some guidelines. I have tried it once and I washed my hands four times or something and I thought it was absolutely hilarious [to follow the guidelines].

At 10 schools (37%), no stickers were mounted in the urinals. Some school coordinators experienced problems mounting the stickers, and as a consequence they did not implement this part of the intervention. In interviews, pupils mentioned that they had been wondering why stickers were mounted in the urinals. They did not understand that the stickers were placed so that they could aim at them when going to the toilet.
Extra cleaning of school toilets
Table III shows observations of toilets at intervention schools with extra cleaning. The observations indicated that toilet paper, water, urine, etc. was found on the floor at 71% of toilets at baseline and 57% of toilets after the intervention period. Contrary to this, we observed that fewer toilets looked clean at follow-up (43%) compared with baseline (54%), more sinks looked dirty (25 versus 21%), more trash bins were filled (37 versus 32%) and toilet paper was available for the rest of the day at fewer toilets (82 versus 93%).

Dose received—the extent to which pupils received and used the intervention
Pupils report on the Hi Five curriculum
Sixty-eight percent of zero to fourth graders and fifth to eighth graders reported that they had performed a hand washing exercise during the school year. In total 64 and 68% reported to have learned how to avoid transmission of infectious diseases, but only 49 and 41%, respectively, reported to have discussed how pupils can contribute to keep the school toilets clean.

Pupils’ knowledge about micro-organisms and proper hand washing
Pupils in zero to fourth grade increased their knowledge on two out of three variables, e.g. at baseline 72% of pupils answered correctly that germs are not visible on hands and this proportion increased post intervention (78%). Among pupils in fifth to eighth grade, the proportion that answered correctly increased on 8 out of 10 questions (by 3–11%). For example, at baseline, 59% of pupils answered correctly that you should take off rings before washing hands while 70% answered this correctly at follow-up.

Pupils’ hand washing behavior
Table IV shows pupils’ answers to questions about their hand washing behavior. For the majority of variables, hand washing behavior did change post intervention. For example, at baseline, 21% of pupils reported that their teacher encouraged them to wash their hands before lunch once in a while or most of the time, and this proportion significantly increased at the end of the intervention (46%). Interviews with pupils showed that although pupils do not perceive to be prompted by teachers, some pupils reported to have improved their hand-hygiene as a result of Hi Five. Pupils explained that they wash their hands more often and more thoroughly and that they think about the risk of becoming infected more often.

We found that 56% of pupils reported that they washed hands before eating lunch at school at baseline and that this proportion was increased at follow-up (70%, \( P < 0.001 \)). Some of the interviewed pupils, who did not wash their hands before lunch, explained that they did not consider
hand washing to have any effect, because they needed to turn off the tap afterwards, and that the tap is full of bacteria. They also stated that hand washing will only have an effect if all pupils wash their hands.

Pupils’ report on school toilets
For the majority of questions about school toilets, differences between baseline and follow-up were not statistically significant, but were in the hypothesized direction (Table V). For example, almost half...
of the pupils from schools receiving extra cleaning stated at baseline (40%) and follow-up (38%) that they had experienced that school toilets were disgusting ($P = 0.058$). However, 35% of pupils at baseline indicated that they had seen toilet paper, water or urine lying on the floor of the school toilets and this proportion were decreased to 31% at follow-up ($P = 0.014$).

**Appreciation of the intervention**

*Teachers’ and pupils’ opinion about the curriculum*

Teachers were asked to evaluate the Hi Five-curriculum in the questionnaire, and most of them reported it to be ‘good’ (83%) or ‘very good’ (11%), while only a few teachers reported it to be ‘not so good’ (5%) or ‘bad’ (1%). Interviews with teachers and pupils revealed that particularly the practical hand washing exercises and YouTube videos with people sneezing in slow motion made a big impression on pupils.

Teacher (grade 3rd–6th): If I should point out what made the biggest impression on the pupils it would be a combination of the YouTube videos, and then the hand washing exercises—where they could see how good they were and how many bacteria were left afterwards.

Furthermore, teachers expressed enthusiasm for the worksheets because they included tasks which the pupils could work on independently, while other pupils washed their hands.

Teacher (2nd grade): The pupils really enjoyed it [the practical hand washing exercise]. It worked quiet well and it was nice that it [the educational material] was so easy to implement—while I did the practical exercises with some of the pupils, others worked with the tasks in the worksheet.

**Teacher competence**

Some of the interviewed teachers pointed out that the subject ‘micro-organisms’ was too poorly described in the teaching material. The interviews revealed that the teachers’ judgment of the teaching material depended on which professional group they belonged to. In general, teachers of biology and nature-technology were more positive and excited about the material than teachers of other subjects. One reason for this may be that some of the Hi Five topics are part of the curriculum in biology and nature-technology, and that teachers of these subjects may have felt more qualified to teach these topics than e.g. teachers of Danish. Some teachers felt it had been too difficult and time-consuming to prepare for classes:

School coordinator: Some teachers were complaining a bit, because they did not feel competent enough to teach the Hi Five topics. It may be a challenge to teach a topic such as micro-organisms in 7th, 8th and 9th grades if you are not a biology teacher. In contrast, one of the biology teachers accepted the teaching material enthusiastically because ‘oh, it was just a biology topic’ while the reaction from other teachers was ‘oh how will I ever get through this.’

**Relevance of curriculum**

In interviews, several teachers and coordinators pointed out that there is tendency to place an increasing amount of responsibility for child rearing tasks on schools. Previously, schools were primarily responsible for teaching children basic skills such as reading, writing and math while parents bore the major responsibility for raising their children. Today, schools are responsible for providing education in many different areas such as sexuality and health education. Some teachers perceived the Hi Five topics to be good and relevant, but considered it a parent’s job to teach their children how to wash hands properly. It leads to discontent when teachers are told to devote time for yet another task, as one of the school coordinators explained:

School coordinator: It’s my impression that especially teachers in 7–9th grades thought “Now we are also asked to teach pupils how...
to wash their hands properly—will this never end?"

**Discussion**

This process evaluation combined qualitative and quantitative methods to enhance understanding of implementation of the Hi Five intervention. The results indicate that there was a large variation in the way the intervention components were implemented. The curriculum was implemented successfully by all intervention schools, in three-quarters of classes (based on the number of lessons taught). However, the hand washing component was poorly implemented in most schools. Just over a third of teachers reported that they encouraged their pupils to wash hands every day before lunch, and half of the pupils indicated that they washed hands before eating lunch at school post intervention. Stickers with instructions on proper hand washing and stickers in urinals were posted on most schools. Observations did not reflect that the extra cleaning was implemented as planned by the cleaning companies and pupils from schools receiving extra cleaning of toilets did not report any changes in their experiences of the cleanliness of the school toilets.

These findings are consistent with previous studies that have highlighted that interventions are rarely, if ever implemented as intended [21]. Also research shows that it is easier to achieve high fidelity of simple than complex multi-component interventions [12], which have greater scope for variation in their delivery, and so are more vulnerable to one or more components not being implemented as they should be. On the other hand, studies have suggested that multi-component interventions are more effective than single component strategies due to synergistic effects between components [22].

All pupils were included in the intervention. However, we did not ask ninth graders to complete the questionnaires for evaluation of the study, because the last year in school is focused on exams, and teachers and pupils often de-emphasize activities not relevant for exams. In accordance with this, teachers stated that they perceived time as one of the main barriers to the implementation of the curriculum, and it was highlighted that especially ninth graders have a tight schedule. It was suggested that the curriculum should only be implemented among the younger pupils or alternatively that ninth graders receive a shorter curriculum. For a long-term implementation covering several school years this is an excellent idea. However, the intervention was implemented in only one school year and therefore needed to target all pupils because they are together across classes and often share toilets and class rooms. Therefore, there is a greater risk that the older pupils will infect the younger if the intervention is only carried out among the youngest pupils. Some teachers also pointed out that the lesson on 'micro-organisms' for seventh to ninth graders was too poorly described in the teaching manual. Hence, it might be useful to elaborate on this subject in the teaching manual and thereby help teachers to feel more confident teaching that lesson. In consequence, this may support successful implementation. Alternatively, we recommend that only teachers of biology and nature-technology are made responsible for this curriculum component in seventh to ninth grade. Although there is room for improvement of this part of the intervention, the overall rating of the educational material was positive. In conclusion, it may be worthwhile, and possible, to include teaching of hand washing in the curriculum for younger pupils, but in the long run focus more on creating environments where hand washing is acceptable and accessible for the oldest pupils.

Some teachers expressed that education on hand hygiene is important and relevant, but that it is a parent’s job to teach their children how to wash hands properly and prevent the spread of diseases. To accommodate this issue somehow, parental involvement (e.g. through newsletters and homework activities) should be considered as part of the intervention. This might help stimulate conversations with the children on related topics and play a direct role in the children’s hand washing behavior at home and at school.
The children were asked questions about microorganisms and prevention of infectious diseases. The proportion of pupils that answered correctly on these questions increased on most topics but in varying degrees. Overall, the knowledge level among pupils was high before the intervention and the pupils improved on the questions where there was room for improvement in particular. Therefore, the modest improvement seen in some questions might be due to a ceiling effect.

Teachers’ main critique of the hand washing component was that its implementation required more time than expected and took time away from teaching or time allocated to eating lunch. This finding is consistent with previous studies indicating that lack of time was a reason why pupils and teachers did not wash their hands [17, 23]. A solution may be to incorporate time for hand washing in the daily curriculum. In the present study, poor sanitary facilities such as few and/or inappropriately located sinks and lack of soap and paper towels was another important barrier for teachers implementation of the daily hand washing, in accordance with previous hand hygiene studies [4, 17, 23–25]. In addition to education on hand hygiene, hand washing might be improved in schools by providing easily available and attractive facilities with soap and effective hand drying options. Although existing schools may work on making facilities attractive and well equipped with soap and paper, it may be more challenging to provide easily available facilities. However, this should be considered when refurbishing or building new schools.

A recent meta-analysis of hand hygiene interventions showed that hand sanitizer reduced the rate of gastrointestinal illness and of combined illness [26] and alternatively, implementation of hand disinfection could be considered. Hand sanitizer is an alternative hand cleaning method, which requires only the gel, and needs minimum maintenance. However, although it might have been easier and less time consuming to implement hand sanitizers, hand disinfections do not work if children have soil or gross contamination on their hands, and this is often the case for children in the youngest age groups. Furthermore, we believe that it is an important and more sustainable intervention to teach children to wash their hands. Finally, soap and water are the amenities available to children in most settings of their life, including at home. This is not the case for hand disinfection. Therefore, hand disinfection may not have the same lasting pedagogical effect as hand washing [19].

Extra cleaning was implemented as planned by the cleaning companies, but visibility of the cleaning was somewhat equivocal in our observations. We used data from observation checklists to evaluate dose delivered of the extra cleaning of school toilets. Overall, observations indicated that no changes were seen post intervention. However, we only made observations at two toilets at each school and this may be an insufficient proxy measure of the implementation of the extra cleaning. The pupils did not report any changes in their experiences of the cleanliness of the school toilets either. A previous study found that many pupils based their negative perceptions of school toilets on the physical appearance of the toilets, offensive smell and feelings of insecurity when visiting the toilet [27]. In Denmark, school toilets are often run-down, dirty and lack basic amenities [28]. It may not be enough to implement extra cleaning if the facilities are old and look uninviting. Making facilities more attractive e.g. by painting the room or changing damaged toilet seats, may change their perceptions of the school toilets.

Lack of communication between school coordinators and teachers posed a barrier to the implementation of both the curriculum and the hand washing component. Before the implementation of the intervention, a kickoff-meeting with the project team and the schools was conducted. It was recommended that a teacher representative for each age group was present at the meeting to introduce the teachers to the intervention components and to ensure teacher commitment. However, it was far from every school where teachers attended the meeting and since they were not part of the decision-making process, they may have felt dissatisfied that the decision to participate in the intervention was made top down. School staff pressured by the school coordinators to offer new intervention programs seldom
implement them very effectively since they do not become committed to the project [29]. It was suggested that in the future, teachers should be informed before they start planning the annual calendar so that they have the opportunity to integrate the Hi Five topics in the curriculum. This was also part of the original plan, but the teachers never got the information because of the breakdown in communications between school coordinators and teachers.

A previous study has shown that pupils’ appreciation of a fruit and vegetable intervention was associated with changes in fruit and vegetable intake [30]. This suggests the importance of involving pupils from the early stages when developing an intervention, in order to make more attractive interventions. Involving pupil in the planning may increase their sense of ownership and result in facilities being appreciated more and better looked after. Furthermore, we think it would be interesting to see how teachers can be involved in planning and conducting future hand washing interventions. It is important that teacher prioritize hand washing if studies like this are to be implemented as intended.

**Strengths and limitations**

In this study, we gathered data from several data sources and used both qualitative and quantitative methods to get a precise and comprehensive picture of the implementation process from all actors involved. Analyses of qualitative data give an in-depth understanding of challenges of the intervention. Getting the perceptions and experiences from all involved parts adds strength to the study. In addition, focus groups enabled pupils as young as seven years to contribute valuable information to the study. Furthermore, our study was characterized by a large number of participating pupils and relatively high response rates among pupils. Another strength of this study is that the process evaluation analyses were conducted before the effect evaluation so key processes likely to affect outcomes were not influenced by prior knowledge of trial results.

This study had some limitations that must be considered. Because this study was nested within a large cluster-randomized controlled trial, it was possible to ensure that those schools included in the qualitative part of the process evaluation were representative by geography and represented schools with expected low and high implementation fidelity. However, for practical reasons the total number of schools included (six intervention schools) was relatively small because of the in-depth nature of the data collection and time-consuming nature of qualitative data analysis. Furthermore, the teachers who participated in interviews for the present study might have been a selected group, as the school coordinators recruited the teachers for group interviews. The results may be different in other parts of the study population. Other limitations of our study are that the questions and interview guides developed specifically for the process evaluation were not validated. However, this is a common weakness with health interventions, as the specific scope of intervention studies makes material from previous studies unfit for the purpose, and the limited resources allocated to process evaluation preclude further pilot work [31, 32]. The teacher questionnaire had a quite low response rate (35%) and if a selected group of enthusiastic teachers responded, the findings may overestimate the level of the implementation or vice versa. The results may therefore not represent the views of all teachers at all schools.

**Conclusion**

Data from the process evaluation of the Hi Five study have shown that teaching the importance of hand washing may be necessary to improve knowledge, but it may not be sufficient for initiating and maintaining good hand washing practices. Environmental factors such as accessible and high-quality facilities, time provided and opportunity also strongly influence how likely a hand washing intervention is to be implemented. This study revealed the stronger and weaker parts of the Hi Five study and can guide future program
improvement of interventions aimed at improving hygiene and decreasing the rate of infections among school children.

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Conflict of interest statement

None declared.

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