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REGULAR ARTICLE

Alcohol-based hand-disinfection reduced children's absence from Swedish day care centers

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Abstract

Aim: To determine if the use of alcohol-based hand-disinfection as a complement to regular hand washing at daycare centers (DCCs) can reduce the childhood rate of absenteeism.

Methods: Children aged 0–6 years attending DCC were studied in a cluster randomized controlled trial during 30 weeks. Thirty matched pairs of DCCs were included in the study, where one of the DCCs was randomized to intervention and the other to control within each pair. The intervention consisted in children and staff using alcohol-based oily disinfectant gel containing 70% ethanol after regular hand washing. The main outcome was the rate of episodes of absence from DCC due to infection. A regression model was fitted at the individual level and controlling several possible confounders for illness. Absences were reported by the parents.

Results: Differences in missing absence reports between the two groups led to only evaluating those 29 DCCs (1431 children) that were able to provide complete reports. In the multivariate regression, the intervention significantly reduced the rate of absenteeism of a child by 12% compared to a child in a control DCC (IRR 95% CI: 0.799–0.965).

Conclusion: Hand-disinfection used by children and staff significantly decreased childrens absences due to infections in Swedish DCCs.

INTRODUCTION

Strategies for reducing the frequency of infections among children attending daycare centers (DCCs) have attracted considerable attention (1–4). In recent years, the spread of antibiotic resistant bacteria, notably penicillin resistant *S. pneumoniae* (PRP) has emerged as a community problem (5), particularly in children at DCCs (6–8). Thus, intervention studies of procedures aimed at reducing infections among children at DCCs have become increasingly important.

For children, parents and employers it is desirable to minimize the DCC absentee rate due to infectious diseases. The importance of hand hygiene in reducing the transmission of microorganisms among staff and patients in hospitals has been established for generations, and this evidence was recently reviewed by WHO (9). Furthermore, hands have been identified as an important vehicle for the transmission of microorganisms at DCCs (1,10). Consequently, various hand hygiene practices have recently been tried in preschool settings and among children receiving care at home (11–13), all resulting in reduced infection rates. A variety of infection prevention strategies at DCCs, usually including hand hygiene, have been reported from USA, Finland, Canada and Australia (14–20). However, published studies from DCCs have been performed as multi-intervention strategies. Hence, hand disinfection as a single intervention has not been evaluated in the DCC setting. As it is simple and inexpensive, hand disinfection could likely be used in most daycare centers.

Our objective was to determine if the use of alcohol-based hand-disinfection as a complement to regular hand washing by children and staff at DCCs can reduce the rate of childhood absenteeism. The study was designed as a randomized cluster trial with DCC as the main unit of randomization. The intervention was applied at a cluster level given the convenience of assigning all children and staff to the same protocol, as well as the potential effect of the intervention on the infectiousness of the children. The study was approved by the Ethics Committee, Uppsala University, Sweden No 2004:M-174.

METHODS

Setting

In Sweden, 85% of children aged one to five years old receive daycare outside the home (21). At the age of one year 47% attend daycare, and at the age of two and five years this percentage rises to 90% and 98%, respectively. Of those receiving daycare, 93% attend DCCs and 7% family day care. Most

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DCCs enroll about 50 children divided into three groups or units (22). Some DCCs have only one unit and others have up to eight (22) with approximately 17 children in each (23). Typically, one unit is for infants younger than three years and the others are for older children. All children have the legal right to at least 15 h at daycare per week. On average, there are 5.1 children per staff member. Age-related pedagogic activities are pursued indoors and outdoors. The time spent in daycare depends on the parents' work hours, and the fee is contingent on the parents' salary. The parents enter into an agreement with the DCC on the number of hours of attendance per week and are charged accordingly. The fee, however, may not exceed 1260 SEK (210 US dollars) per month, per child.

Participants

DCCs located in ten different counties in south and mid-Sweden were eligible for inclusion. Initially two to ten DCCs were chosen in each county to represent communities with a wide range of demographic and socio-economic characteristics. The candidate DCCs were matched in pairs in order to minimize differences in the epidemiology of infectious diseases during the study period. The matching factors were: socio-demographic (measured as the type of area where the DCC was located and classified as urban, rural or mixed), location (preferably within 2 km distance of each other) and number of children enrolled in the previous year (less than 20 children difference between the two DCCs).

Approvals from all of the staff and from at least 90% of the parents were required before a DCC could be accepted into the study. Study nurses met with DCC staff and parents during special evening 'question and answer' sessions to provide information one month before the study began. After the approvals had been obtained, all children enrolled in the DCCs were eligible as participants. For an individual child to be included in the study, however, written informed consent had to be sought from the parent(s).

Intervention

The present study was carried out for 30 weeks, between 15 November 2004 and 10 June 2005. In DCCs assigned to the intervention group, children and staff were instructed to wash their hands using liquid soap and water, then dry their hands on a towel and finally rub them with 1–2 mL alcohol-based oily disinfectant gel containing 70% ethanol. This protocol was to be followed after using the toilet, before eating and when dirty. The disinfectant dispensers were placed at the washbasin close to the soap. Children and staff applied the disinfectant themselves, and when necessary, younger children received assistance from the staff. In the control group, the hand hygiene routine was exactly the same except for the use of the disinfectant gel. The soaps used for hand washing in this study did not contain specific antibacterial components and would not interfere with the effect of hand-disinfection. The disinfectant gels were the same as those normally purchased by the local authorities for institutional care, and were produced by Sterisol AB, Vadstena, Sweden and Opus Health Care AB, Malmö, Sweden.

Verbal and written hand washing instructions for the use of the alcohol-based hand disinfection were identical for all DCCs. These instructions, along with demonstrations, were provided by the study nurses at the beginning of the study. The disinfection gel was distributed to DCCs by the study nurses, who also conducted monthly visits to check that the instructions were followed. During these monthly visits, the study nurses also collected absence reports (see the section 'Data collection').

The protocol for hand-disinfection was developed at a pilot DCC one year before the actual trial. From these preliminary data, we estimated that hand washing would be carried out 5 to 10 times per day and person.

Outcome

The main outcome was the rate of absenteeism due to infections measured at the individual level and defined as the number of absences per 100-child hours. Child-hours were defined as the difference between planned time at DCC and absent time due to infection, and was calculated for child i as follows:

$$\text{Child hours}_i = \left(\frac{\#\text{Weekdays}(\text{end}_i - \text{start}_i)}{5} - \sum_{j=1}^{n_i} \frac{\#\text{Weekdays}(\text{end}_{ij} - \text{start}_{ij})}{5} \right) \times \text{Hours/week at DCC}_i.$$

Here start_i refers to the child's start date at the DCC or start of the study, whichever occurred last; and end_i, refers to the child's last day at the DCC or end of the study, whichever occurred first. Division by five gives the number of calendar weeks. The first term in the parenthesis represents the number of calendar weeks the child planned to attend DCC during the study. The second term calculates the n_i absences in terms of calendar weeks, based on the dates of the absence reports. The number of child-hours is obtained by multiplying by the number of planned hours at DCC per week as reported in the background questionnaire (see the section 'Data collection').

The parents alone made the decision on whether their child was absent from DCC due to illness. All reported episodes, independently of the cause of the illness or symptoms, length of absence or number of days since the last absence contributed to the outcome.

Sample size

We assumed a mean of 4.3 episodes of absence per child per school year in the control group. This is equivalent to 0.36 episodes per 100 child-hours for a child attending DCC 30 h per week during a school year of 40 weeks. To detect a reduction of 20% in the absence rate, we calculated a sample size of 15 DCCs per arm given a power of 80%, a two-sided significance level of 0.05, an average size of 50 children per DCC and a design effect of three due to the clustering effect within DCC. To account for a 20% dropout proportion, 18 DCCs per arm were necessary, but to obtain power for additional analyses per subgroup, we finally aimed for 36 DCCs per arm.

Randomization

Randomization was carried out at the DCC level after approval from all DCCs. One of the researchers randomly allocated one of the DCCs in each matched pair to the intervention arm and the other to the control arm. All children and staff in the same DCC were expected to follow the same assigned hand-hygien protocol. Because it was not possible to produce a control gel with the same characteristic smell of the disinfectant gel, study participants as well as study nurses were aware of their group assignment (control vs. intervention).

Data collection

Background data on the children's families including health of the child, time at DCC, siblings, parents social position and education were collected by questionnaires completed by the parents during the initial weeks of the study (see Table 1). Information about DCCs and their units (such as number of staff, routines, localization and buildings) was provided by the staff (see Table 1).

Parents were instructed to report every episode when the child was absent from daycare due to an infection. The report included dates of absence, symptoms, contact with medical services and antibiotic treatment. Staff and parents were also asked to report any suspected side effects from the disinfectant to the study nurses.

The study nurses collected the questionnaires and the absence reports during their monthly visits to the DCCs. When single answers were missing or ambiguous, the nurses tried to complete the questionnaires and reports by follow-up questions to the parents or staff when necessary and possible. The study nurses reminded the parents repeatedly if they failed to hand in the questionnaire or an absence report after a known episode of absenteeism.

Statistical methods

Questionnaires and absence reports were sent by the study nurses to the Unit for Infectious Disease Control at Örebro University Hospital, where data were entered into an MS Access 2000 (version 9.0) database. A quality control procedure was implemented to ensure data quality at the entry stage and included double entry of questionnaires from DCCs and units, as well as additional checks, controls and cleaning of the entire database before analysis. All information containing personal identity was deleted after quality control and before further processing.

When comparing child-specific variables between groups, children were pooled into an intervention group and a control group, disregarding the DCC clusters and matching. The statistical tests that were used included the *t*-test in the case of continuous variables, and the Fisher's exact test for categorical or binary variables. Similar tests were carried out when comparing children from DCCs included in the analysis and DCCs lost to non-compliance. The statistical tests used for matching criteria included conditional logistic regression as well as Wilcoxon exact paired test.

The rate of absenteeism was fitted as a quasi-Poisson regression using generalized estimating equations (GEE) that allows for cluster design (24). The number of absences was included as outcome and the number of child-hours as offset. The model included a log link and an independent correlation matrix. The matched design was taken into account by

Table 1 Characteristics of the intervention and control daycare centers (DCCs) at baseline

Characteristics	Intervention	Control	p-value
No. of day care centers	16	13	
Mean number of staff per 10 children (SD)	1.89 (0.38)	2.00 (0.23)	0.32
Median number units/DCCs	3	3	
Mean number children per unit (min–max)	16.5 (11–21)	17.0 (10–24)	0.43
Total number of children	753	724	
Mean number of children/DCCs (SD)	47.1 (15.2)	55.7 (21.4)	0.23
Mean age (SD)	3.20 (1.3)	3.10 (1.4)	0.15
Percentage of children < 3 years old	32.5	36.7	0.09
Mean number h/week at DCCs (min–max)	29.1 (8–55)	29.3 (5–50)	0.79
Percentage of children present ≤ 15 h/week	16.0	19.6	0.19
Percentage of boys	51.5	46.1	0.17
Percentage of single parent households	10.5	10.6	1.00
Percentage with at least one sibling ≤ 6 years old	43.4	42.3	0.67
Percentage with at least one smoker at home	20.4	18.9	0.47
Percentage with at least one parent with more than 12 years education	48.6	53.0	0.11
Percentage with at least one parent at home (unemployed or parental leave)	19.9	18.3	0.46
Percentage with at least one parent born in Sweden	89.1	86.3	0.11

including the matched pairs as strata. Confidence intervals were calculated using robust sandwich estimators at a 95% level. All incidence rate ratios (IRR) were estimated with this model.

Since cluster randomization does not guarantee an even distribution of important determinants for the outcome among the individuals, we considered background factors known or suspected to affect the health of children and that might confound the observed result. The following child-specific variables were regarded as possible confounders: age at baseline; if the child had at least one sibling six years or younger; if there was at least one smoker at home; if the child had asthma or allergies; and the number of hours per week planned to attend DCC, categorized as <15, 16–20, 21–25, 26–30, 31–35, 36–40, >41 h/week. Furthermore the unit specific possible confounders were: the mean number of hours per week that the children in the unit spent in outdoor activities; if disinfectant gel was only being used by the staff in the unit for diaper change or outbreaks; and the total number of children in the unit.

The multivariate model with intervention and background factors as covariates and stratified by matched pairs was fitted in a stepwise backward fashion; at each step we excluded the variable with the largest non-significant p-value obtained from the Wald test, using a significance level of 5%. The procedure was repeated until only significant variables remained.

All analyses were performed in the R language, version 2.6.2 (25), and the GEE fitting was done with the R package gee, version 4.13 (26).

RESULTS

At the beginning of the study, 90 DCCs (45 matched pairs) were contacted (see Fig. 1). Of these, 60 DCCs (30 matched pairs) agreed to participate and obtained approvals from the

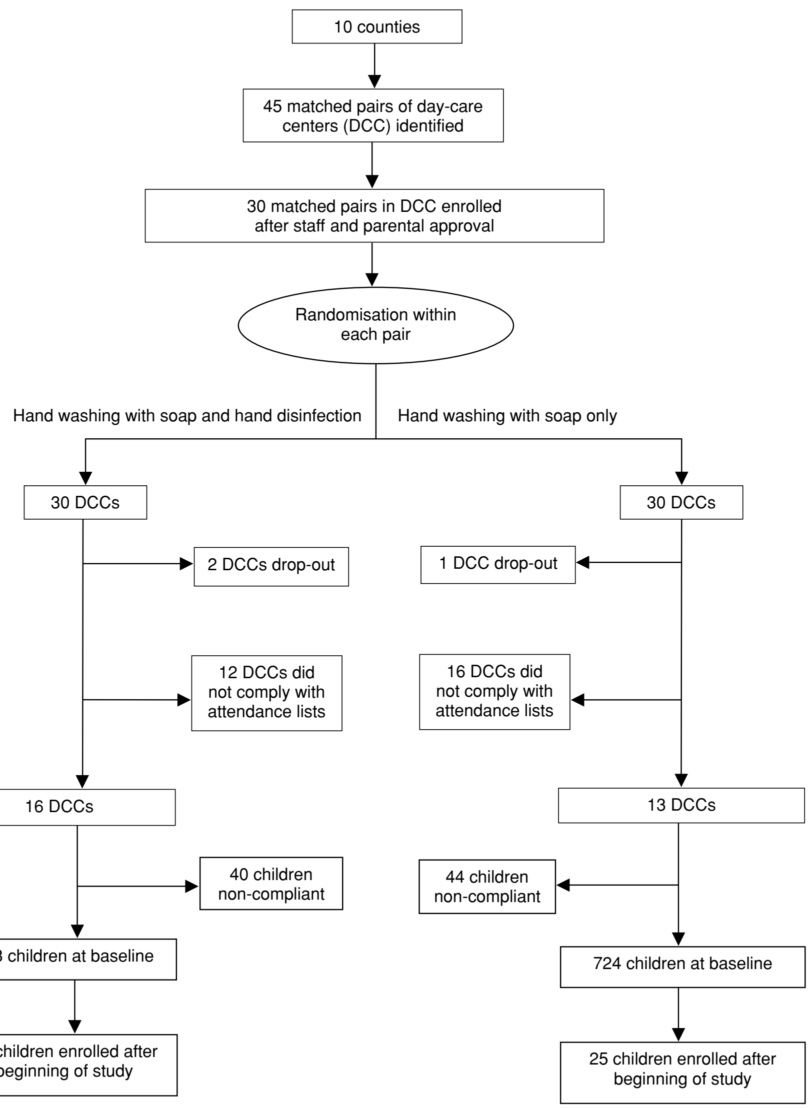

Figure 1 Participant flow diagram.

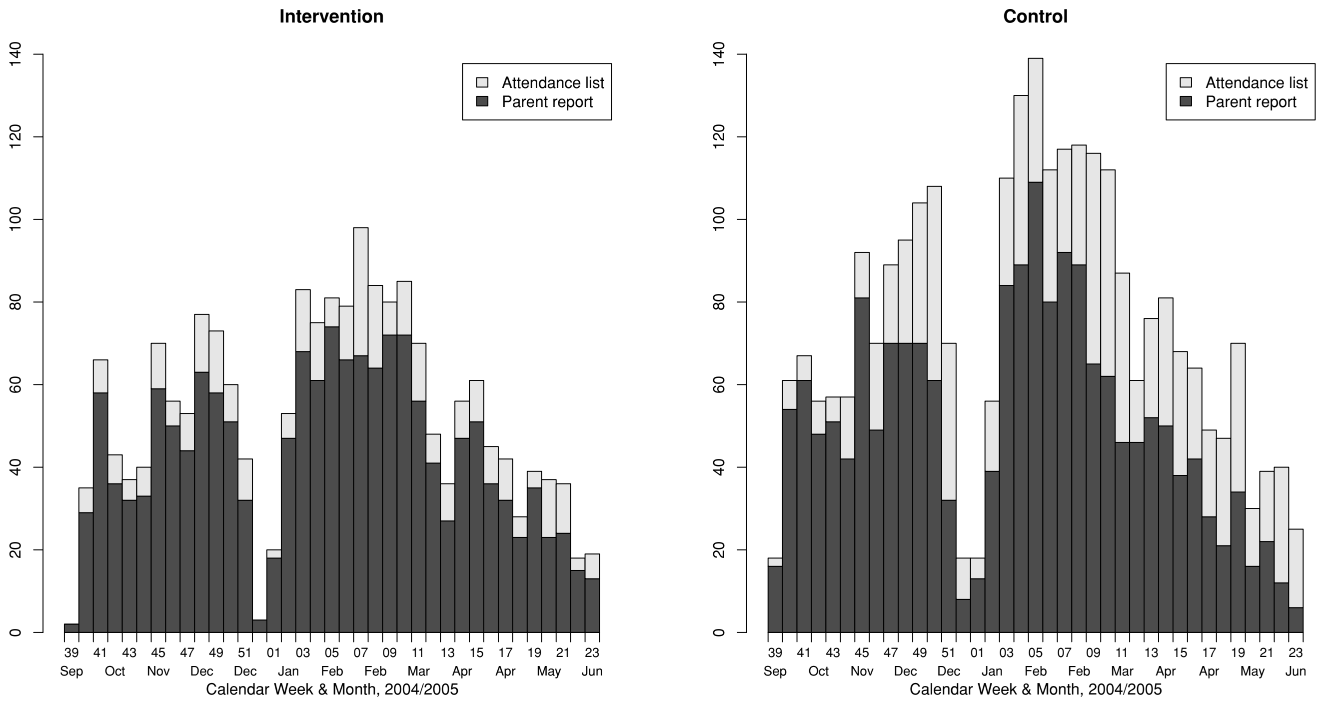

Figure 2 Submitted absence reports from the parents (black columns) and from the DCCs attendance list not reported by parents (white columns) at intervention (left) and control (right) groups by calendar week.

staff and parents. Three DCCs (2 intervention and 1 control) dropped out soon after start of the study.

Reports from the study nurses during the fieldwork phase suggested that missing absence reports of episodes not submitted could potentially introduce bias. For this reason it was decided, at the end of the study and before analysis, to request attendance lists from all participating DCCs. Attendance lists are kept by the staff for internal use and only include absences due to illness. By comparing the attendance lists to the parent reports, we could identify episodes of absence not previously reported, including the dates of absence. Although most attendance lists did not contain the specific cause of the absence, 96% of the episodes of absences from Swedish DCCs are attributed to infectious diseases (27). A total of 29 DCCs (48%) provided attendance lists, of which 16 were intervention DCCs and 13 control DCCs (see Fig. 1).

Figure 2 shows the weekly number of reports submitted by parents and number of reports only found in the attendance lists of the 29 DCCs that provided such lists. This figure suggests that underreporting occurred in both groups, and that it was relatively constant during the study period. During that time, 18% of the total episodes found in the attendance lists were not reported by the parents in the intervention group, compared to 32% in the control group (p-value < 0.001). The clear discrepancy between the groups confirmed our suspicions of reporting bias, and therefore it was decided that all analyses were to be carried out using the absence data from the lists collected by the staff. This meant that all subsequent analyses were restricted to the 29 DCCs that provided attendance lists. Background variables were compared between children at baseline in the 29 DCCs included in the analysis and the 28 non-compliant DCCs, as well as the number of child hours for all children during the entire study period (data not shown). In the non-compliant DCCs children were in average younger (p-value < 0.001) and attended DCC fewer hours per week (p-value < 0.001). Also a larger proportion of children in non-compliant DCCs had parents that stayed at home due to occupation (p-value $<$ 0.001), and a larger proportion of children had both parents born abroad (p-value < 0.001).

The DCCs included in the analysis were located in nine different municipalities distributed throughout the south and mid-Sweden covering a large geographical area.

The 13 matched pairs among the 29 complying DCCs were compared according to the matching criteria. The number of children at the beginning of the study was not significantly different (p-value $= 0.102$). For socio-economic status, in only two pairs was there no exact agreement, but the difference was not significant (p-value $= 1$). The median distance between DCC pairs was 1.2 km, with a maximum distance of 6 km if not including one particular pair of DCC located at 60.3 km from each other on the island of Gotland.

A total of 768 children were included in the 16 intervention DCCs and 749 in the 13 control DCCs, including 40 children that enrolled after the beginning of the study. An additional 40 children in the intervention group and 44 in the control group did not obtain approval from their parents to take part in the study (p-value $= 0.64$). These

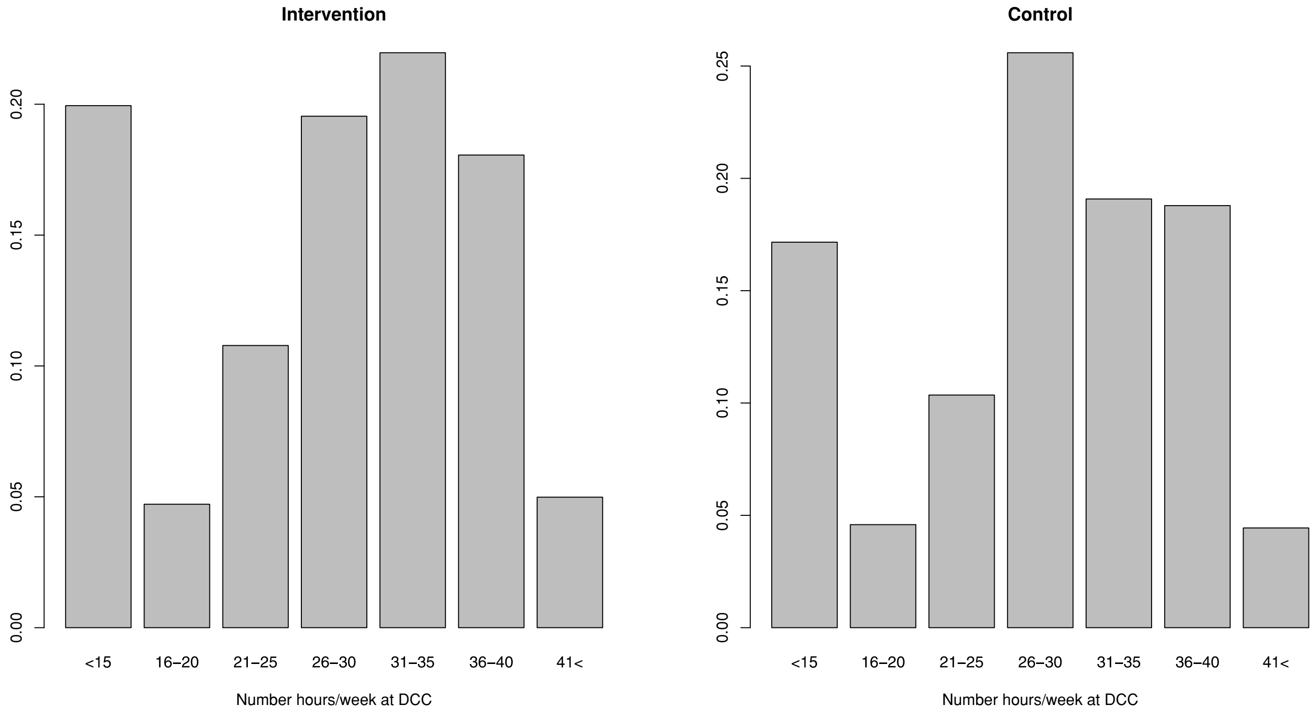

Figure 3 Histogram of the number of hours per week at DCCs at intervention (left) and control (right) groups.

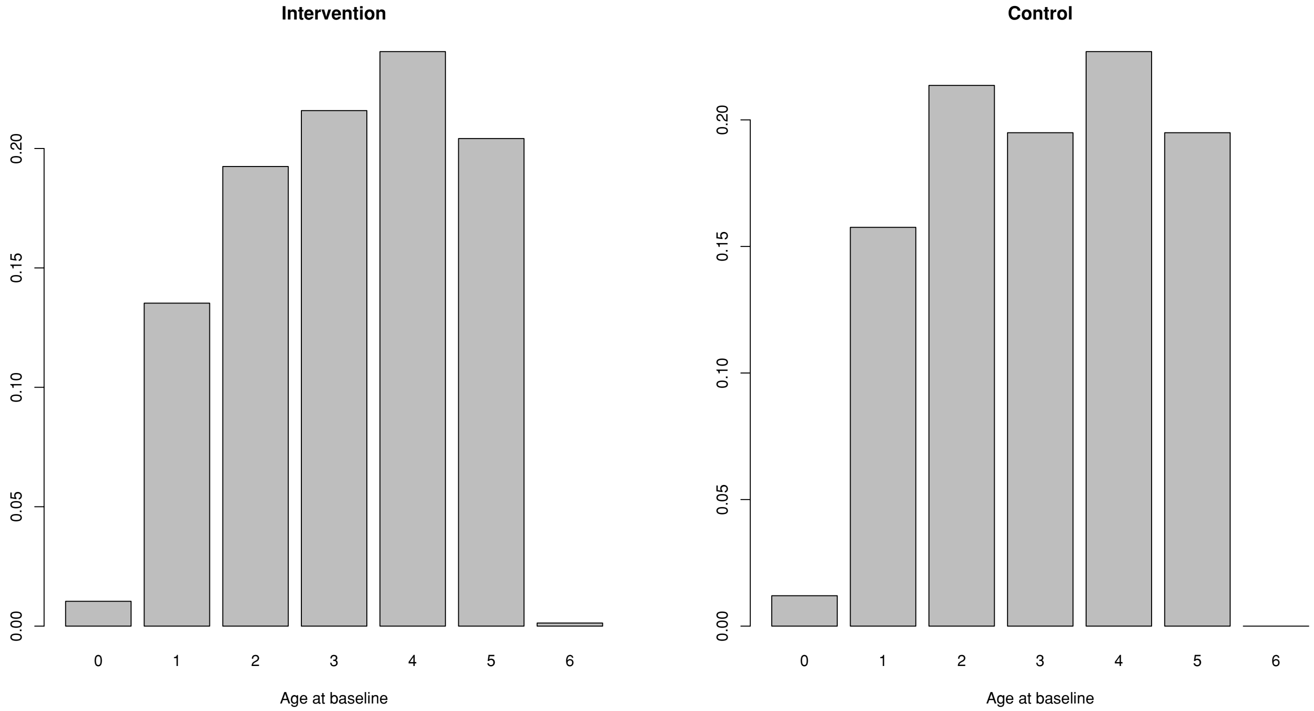

Figure 4 Histogram of children's age at baseline, in intervention (left) and control (right) groups.

children followed the assigned protocols, but did not use hand disinfection and no information about their background or absences was collected.

DCCs in intervention and control groups were similar in terms of units, staff and children at baseline (see Table 1). On average, every DCC had close to 50 children. The distribution of hours per week planned to attend DCC and age are shown in Figures 3 and 4, and no significant difference was observed (h/week: p-value = 0.79, age: p-value = 0.15). More than 40% had siblings six years or younger (p-value =

Table 2 Adjusted incidence rate ratio (IRR) and numbers analysed in multivariate model[a]

Group	DCCs	Children	Abscence episodes	Child hours	Episodes per 100 child hours	Adj. IRR[a] (95% CI)
Intervention	16	745	2293	695749	0.33	0.88 (0.80; 0.96)
Control	13	686	2429	650713	0.37	
Total	29	1431	4722	1346462		

[a]Adjusted for age, number of h/week at DCCs, asthma or allergies.

0.67), and about 20% lived in a household with at least one smoker (p-value = 0.47).

The regression analysis included 745 children from intervention DCCs and 686 from control DCCs; these children contributed to 695749 and 650713 child-hours and 2293 and 2429 episodes of absence in each group, respectively. The corresponding rates of absenteeism per child in intervention DCCs were 0.33 absences per 100 child-hours, compared to 0.37 per 100 child-hours in control DCCs. The unadjusted estimated IRR for the intervention was 0.86 with a 95% confidence interval of [0.78;0.94], i.e. a significant reduction of 14% in the absence rate.

The adjusted estimates from the multivariate analysis are shown in Table 2. The estimated effect of the intervention was a reduction in the rate of absenteeism by 12% (95% CI 4%–20%) compared to only using soap. The average adjusted estimated rate of absenteeism was 0.37 episodes per 100 child-hours in the intervention group and 0.42 episodes per 100 child-hours in the control group.

The significant confounders were age, number of hours per week planned to attend DCC and if the child had asthma or allergies.

The use of alcohol-based disinfection gel among intervention DCCs varied between 19 L and 60 L per 50 children during the study-period. From an expected use of 1–2 mL gel per disinfection, we estimated that each child disinfected its hands 2–6 times per day. Less than 10 reports on side effects due to occasional spots of discoloration on clothing were collected. Furthermore no instances of eczema, dry hands or swallowing of disinfectant were reported.

DISCUSSION

To our knowledge, this is the first study to investigate the effect of alcohol-based hand-disinfection as the only intervention to reduce absenteeism in DCCs. The study was conducted as a cluster randomized trial, where DCCs where matched in pairs and the intervention applied to one DCC in each pair. Since randomization at the cluster level does not ensure randomization of individual factors, the effect of the intervention was evaluated after correcting for possible confounders at the individual and unit levels. As a result, we were able to show that hand-disinfection as a complement to hand washing reduced children's absences from Swedish DCCs by 12%.

Previously published studies have been concerned with more extensive interventions, which are not only more difficult to follow over the long-term but also more expensive and difficult to implement. Uhari et al (16), for example, included alcohol-based hand-disinfection together with cleaning of toys, cleaning of DCCs and withdrawing of tooth brushing. The effect of these multiple interventions was a reduction of absenteeism among children of 8–9%. Since these results are in line with those presented here, it suggests that hand-disinfection might have been the most contributing factor to the decrease seen in Uhari et al (16). Similar studies have also included other concurrent interventions, such as specific staff for food preparation, diaper-changing equipment and early sick leave for staff, additional to some of those described above (14–20). A decrease in absenteeism due to the use of hand-disinfection has also been seen in other settings than DCCs with older children (28).

Considering that most children in the present study attended DCC 30 h/week, a child would be expected to have 5.3 absences during the Swedish school year consisting of 42 weeks, from late August to mid June. With the use of hand-disinfection, the same child could be expected to instead be absent in average 4.7 times. The costs of providing care for children up to 12 years of age at home due to short-time illness were 3.2 billion SEK (0.5 billion US dollars) (29) in Sweden in 2005. If we assume that half of these costs can be attributed to the care of children 0–6 years, then a reduction by 12% could save 192 million SEK (32 million US dollars) per year, while the cost for the hand-disinfection gel would be less than 10 million SEK (1.7 million US dollars) per year for all 8750 DCCs in Sweden (29).

Several factors may have affected the estimate of the effect. The children whose parents did not give approval were few, and approximately the same number in the control as well as intervention groups. Those in the intervention group followed the hand washing protocol but refused to apply the alcohol gel. The number of children that did not comply is, however, small and therefore not likely to have affected the results. This suggests a potential underestimation of the true effect of hand-disinfection. The DCCs that complied with attendance lists were distributed over a large geographical area of Sweden. We found that children from non-complying DCCs were significantly younger and attended DCC fewer hours per week than those included in the analysis. However, as age and number of h/week in DCC were taken into account in the analysis, we do not believe that this led to any bias. Differences in the parent's birthplace and occupation were also seen, but it is not clear if and how they affect children's absences from DCC.

In addition, absence reports were analysed as an indirect measure of disease. The parents alone made the decision on whether their child attended DCC or not when presenting symptoms, and no clinical or microbiological diagnosis was required to confirm the presence of an actual infection. This means that different families were likely to have evaluated the same situation in different ways regarding whether the child should stay home or not. One of the factors clearly influencing this decision is the ability of the parent or another adult to stay at home; in Sweden, parents are entitled to economic compensation for staying at home to care for a sick child. However, another Scandinavian study found that only about 27% of days with infectious symptoms resulted in absenteeism from DCCs (30). Nevertheless, if we assume that the difference between absence and disease is the same in the intervention and the control group, then the relative decrease in absenteeism seen in the intervention group should, to some degree, be also valid for disease.

In future studies, other consequences of hand-disinfection in DCCs will be further analysed, focusing on specific infections and other factors influencing child absence from DCCs.

CONCLUSION

Using hand-disinfection as a complement to hand washing at DCCs is effective in reducing absenteeism. The method is easy to introduce and implement, inexpensive and cost-effective, making it a desirable intervention over the long-term. For these reasons we prefer hand-disinfection to other interventions in DCCs. Finally, the hand-disinfection intervention may also be beneficial in other countries with similar daycare systems.

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CONFLICTS OF INTERESTS

We declare that we have no conflict of interest.

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