Effectiveness of a Hand Hygiene Program at Child Care Centers: A Cluster Randomized Trial

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abstract

OBJECTIVES: Respiratory infections (RIs) are an important cause of morbidity and excessive antibiotic prescriptions in children attending day care centers (DCCs). We aimed to assess the effectiveness of an educational and hand hygiene program in DCCs and homes in reducing RI incidence and antibiotic prescriptions in children.

METHODS: A cluster, randomized, controlled, and open study of 911 children aged 0 to 3 years attending 24 DCCs in Almería (Spain) with an 8-month follow-up. Two intervention groups of DCC families performed educational and hand hygiene measures, 1 with soap and water (SWG; n = 274), another with hand sanitizer (HSG; n = 339), and the control group (CG; n = 298) followed usual hand-washing procedures. RI episode rates were compared through multilevel Poisson regression models. The percentage of days missed were compared with Poisson exact tests.

RESULTS: There were 5211 RI episodes registered. Children in the HSG had less risk of RI episodes (incidence rate ratio [IRR]: 0.77; 95% confidence interval [CI]: 0.68–0.88) and antibiotic prescriptions (IRR: 0.69; 95% CI: 0.57–0.84) compared with the those in the CG. Children in the SWG had a higher risk of RI episodes (IRR: 1.21; 95% CI: 1.06–1.39) and antibiotic prescriptions (IRR: 1.31; 95% CI: 1.08–1.56) than those in the HSG. Pupils missed 5186 DCC days because of RIs, and the percentage of days absent was significantly lower in the HSG compared with the CG (P < .001) and the SWG (P < .001).

CONCLUSIONS: Hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children, and parents, reduce absent days, RIs, and antibiotic prescriptions for these infections in children at DCCs.

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The final multilevel analysis was adjusted for age at the start of DCC attendance, sex (female versus male), siblings at home (0 vs 1–2 and ≥3), mother's age, home smoking habits (no versus yes), children's recurrent wheezing (yes versus no), history of breastfeeding (mo), and 13-valent pneumococcal conjugate vaccine (no versus yes). The DCC characteristics considered were hygiene IGs at the DCCs (none, soap, or hand sanitizer).

The final multilevel analysis was adjusted for age at the start of DCC attendance, sex (female versus male), recurrent wheezing (yes versus no), history of breastfeeding (mo), and sleeping arrangements (shared bedroom or private). The DCC characteristics considered were hygiene IGs at the DCCs (none, soap, or hand sanitizer).

Dr Azor-Martinez conceptualized and designed the study, drafted the initial and final manuscript as submitted, supervised data collection, conducted the statistical analyses, and reviewed and

WHAT'S KNOWN ON THIS SUBJECT: Children attending day care centers (DCCs) have an increased risk of respiratory infections, according to previous studies. However, it is not clear which factors influence these infections and which measures can be adopted in these centers to reduce their transmission.

WHAT THIS STUDY ADDS: This randomized study revealed that a multifactorial hand hygiene program including hand sanitizer and educational measures for DCC staff, children, and parents reduced episodes due to respiratory infections and antibiotic prescriptions for these infections in children attending DCCs.

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Respiratory infections (RIs) in children <5 years old are a major public health problem because of their morbidity[1,2] and being the most frequent cause of excessive antibiotic prescriptions in the pediatric population, especially from ambulatory care visits.[3,4] In addition, attending day care centers (DCCs) increases the risk of these infections[1,5–9] and antibiotic prescriptions.[9–11] Children attending DCCs have between 6.5 and 10.4 RIs annually.[5] A recent study[12] revealed great variability in antimicrobial medication use across countries. Spain has 1 of the highest rates in Europe; among children aged 0 to 2 years, the rate of antimicrobial consumption per child-year was 1.55.

Hand-washing is the most important and effective measure to prevent infection transmission.[13,14] The bactericide and virucide properties of hydroalcoholic gels or sanitizers against gastrointestinal and respiratory pathogens have been demonstrated.[15–18] There are studies in which researchers assess the impact of hand hygiene programs on infectious disease transmission reduction in schools[19–24] and households.[25,26] However, there are few recent studies that reveal their effectiveness in DCCs,[27–31] specifically, those in which researchers examine hand hygiene health education importance for day care staff and parents to reduce infection transmission in DCCs.[26,32,33]

Few randomized studies revealing the effectiveness of hand hygiene programs (hand sanitizers versus hand-washing versus a control) linked to a decrease in RIs in DCCs in developed countries have been published. Our aims in this study were to assess the effectiveness of an educational and hand hygiene program in DCCs and homes in reducing the incidence of RIs and antibiotic prescriptions in children at the individual level.

METHODS

Design

A cluster randomized, controlled, and open study of 3 cohorts of families with children aged 0 to 3 years attending 25 state DCCs in the Almeria metropolitan area (Spain) was designed. The study duration was 8 months (November 2013–June 2014). The Delegation of Education provided the information for 52 state DCCs. These were randomized after the administration of each agreed to participate; 25 DCCs were randomly selected, and after DCCs were assigned to either an intervention group (IG) or the control group (CG) by means of computer randomization with a 1:1:1 ratio, we used statistical software for the selections. Twenty-five randomly assigned DCC administrations informed parents by mail with the following documents: a study information sheet, an authorization form, and a questionnaire about risk factors for RIs (Table 1). Before starting the study, parents authorized their children's participation and knew which group their children belonged to.

Inclusion Criteria

Children between 0 and 3 years old enrolled at the aforementioned DCCs and attending for at least 15 hours per week whose parents and/or guardians had signed an informed consent document were included.

Exclusion Criteria

Children with chronic illnesses or medication that could affect their likelihood of contracting an infection were excluded.

Sample Size

A cluster sampling design[35] was used with proportional allocation to the size of the cluster. The clusters were the DCCs in Almeria.

There were 52 DCCs, each with an average of 50 children. As in other studies,[29] we assume an 11% reduction in the RI incidence rate in the experimental groups with respect to the CG during the study period. Minimum selections of 6 DCCs per group were needed for a statistical power of 80% and a 5% significance level. Note that a 5% variation coefficient was considered, and the average sample size was 30 children per cluster to take into account those families that may not want to

TABLE 1 Risk Factors for RIs Included in the Multilevel Model

Factors
Child
Age at the beginning of the study
Age at the start of DCC attendance
Hours per wk in DCC
Sex (female or male)
Country of origin
Recurrent wheezing
Duration of breastfeeding, mo
13-valent pneumococcal conjugate vaccine
Sleeping arrangements (private or shared bedroom)
Siblings at home (0, 1–2, or ≥3)
Home
Family size (≤3, 4–5, or ≥6 people)
Mother's age
Father's age
Mother's profession[a] (I, II, III, IV, V, VI, VII, VIII, IX, or X)
Father's profession[a] (I, II, III, IV, V, VI, VII, VIII, IX, or X)
Mother's educational level (low, middle, or high)
Father's educational level (low, middle, or high)
Housing (flat, house, semidetached house, or other)
Home smoking habits
Season
Month of infection
DCC
Hygiene IG at the DCC (none, soap, or hand sanitizer)
Average No. classrooms per DCC
Average space per child in classroom (children per square meter)
No. children per staff

[a] Professions are according to the European Socioeconomic Classification: I, managers and professionals of a high level; II, managers and professionals of a low level; III, white-collar employees of a high level; IV, small employers and self-employed nonagricultural workers; V, self-employed agricultural workers; VI, supervisors and technicians of a lower rank; VII, workers of services and commerce of a lower rank; VIII, skilled manual workers; IX, unskilled workers; and X, excluded labor market and long-term unemployed.[34]

participate in the study. Furthermore, an increase of 2 DCCs per group were randomly selected for the CG and the soap-and-water group (SWG) and 3 DCCs for the hand sanitizer group (HSG), with at least 240 children per group for possible losses during the follow-up period. The expected loss to follow-up was higher in HSG because of a possible refusal of parents to apply hand sanitizer on the hands of their children.

Intervention

One month before beginning the study (October 1–3, 2013), parents and DCC staff assigned to IGs (HSG and SWG) and the CG attended 1-hour hand hygiene workshops, which were designed and taught by researchers. The content included education about hand-washing practices and hand sanitizer use and possible side effects and precautionary measures (only for the HSG).

Children, parents, and DCC staff in the IGs were instructed by the researchers to maintain their usual hand-washing procedures after using the toilet and when their hands were visibly dirty. Both IGs had to follow protocol in the following circumstances: after coming into the classroom; before and after lunch; after playing outside; when they went home; after coughing, sneezing, or blowing their noses; and after diapering. In the HSG and SWG classrooms, hand sanitizer and liquid soap dispensers were installed, respectively, and an informational brochure about when and how to perform hand hygiene was made available, which was also provided to the participating families of both groups. The HSG also received a supply of hand sanitizer, and the SWG received liquid soap, to use at home during the study period. The HSG children were supervised by DCC staff and parents when using the hand sanitizer, and in the case of young children, it was administered by DCC staff and parents. The CG followed usual hand-washing procedures. The research assistant was responsible for providing hand hygiene materials to the DCCs, and they were responsible for giving these to the parents in the IGs. Characteristics of the hand sanitizer included 70% ethyl alcohol (pH = 7.0 to 7.5). The liquid soaps used for hand-washing in the SWG did not contain specific antibacterial components (pH = 5.5).

During the follow-up, 3 identical training sessions per DCC were given 1 month apart, the first 3 on RIs and their treatments and the second 3 on fever. These were organized by researchers for the parents and/or DCC staff of the IGs. Those who were unable to attend training in their own DCC were invited to attend sessions at other centers. The content of the workshops was sent by e-mail to the IGs.

Every 2 weeks, the research assistant and the DCC staff performed the same activities, including stories, songs, and posters in the classrooms and DCCs regarding hand hygiene and infection transmission.

Data Collection and Illness Definitions

During October 2013, the parents completed the baseline questionnaire and gave it to the DCC staff. Information about DCCs was provided by the staff (Table 1). Beginning on November 1, 2013, the parents of children who suffered RI episodes (with or without DCC absenteeism) reported RI symptoms, antibiotic treatment, contact with medical services, and complementary analyses and gave the completed form to the DCC staff weekly. The research assistant collected the episode sheets from the participating classes weekly and telephoned the parents of absent children to inquire about the cause of their absence. The DCC staff and/or parents in the IGs were asked if the hand sanitizer or soap caused any side effects in the children.

Respiratory illness was defined as the presence of 2 of the following symptoms during 1 day or the presence of 1 of these symptoms for 2 consecutive days[25,26]: (1) runny nose, (2) stuffy or blocked nose or noisy breathing, (3) cough, (4) feeling hot or feverish or having chills, (5) sore throat, or (6) sneezing.

During follow-up, the research pediatricians extracted RI episode medical data from the Department of Health's electronic records. The following Anatomic Therapeutic Chemical Classification System (code J01)[36] and *International Classification of Diseases, Ninth Revision, Clinical Modification*[37] diagnosis codes were used: nonspecific upper respiratory tract infection (465.9), otitis media (382.9), pharyngotonsillitis (463), lower respiratory tract infections (485 and 486), acute bronchitis (490), and bronchiolitis (466.19). We combined the bronchopneumonia code (485) and pneumonia code (486) under the label "lower respiratory tract infections." If >1 antibiotic was prescribed during an episode, we used the first prescription for analysis. The final diagnosis was done by the medical researchers on the basis of the symptoms described above and a review of the medical history of children with RIs.

In this study, a DCC absenteeism episode was defined as when a child fails to attend a DCC because of an RI. We also record RI episodes without absenteeism at DCCs. A new RI episode was considered to be the occurrence of an RI after a period of 3 symptom-free days, as in other studies.[26,29] The duration of absenteeism was defined as the number of DCC days missed due to an RI, excluding weekends and holidays.

Outcome Measures

The primary outcome was the RI incidence rate, which was calculated by the number of RI episodes divided by the number of children during the study period. The incidence rate ratio (IRR) is defined as the ratio of RIs between 2 groups.

The secondary outcomes measured were as follows: (1) the presence or absence of at least 1 antibiotic prescription for each new RI episode during the study period (topical antibiotics were excluded), and (2) the percentage of RI absenteeism days in the 3 groups calculated as the ratio of RI absenteeism days to all possible days of attendance. Rates were calculated for the study period. The total possible days of attendance was calculated as the total number of children multiplied by the possible days of attendance.

Statistical Analysis

Children's sociodemographic and DCC characteristics in the 3 study groups were compared by using χ^2 tests, Fisher-Snedecor distribution from analysis of variance, and Welch *t* and Brown-Forsythe tests with 95% confidence intervals (CIs).

A multilevel Poisson regression model was applied to fit the number of RI events. Two levels were considered: children grouped into classrooms by age (0–1, 1–2, and 2–3 years) and DCC random effect level. In addition, infant random effect was included to take into account overdispersion in the Poisson mode.[38–40] We used observation-level random effects to model overdispersion in counting data for ecology and evolution. First, an unadjusted covariate model was applied to check the IRR of RI for each covariate of the study applied. Thus, adjustment for infant group, sex, and age when starting at a DCC was calculated. Finally, a full multivariate model with all variables under study was applied, and model reduction was conducted by using a backward procedure. Covariates were removed if no significant association with the parameter was detected, if no interaction effect with a group was found, and when no change in the rest of the parameters was observed after removal (considering a 30% change as a possible confounder).[41,42] Goodness of fit of the model in each step was performed by checking residuals and the Bayesian information criteria. The adjusted IRR from the multivariate model is provided along with its 95% CI. The number of times antibiotics were prescribed was analyzed by using a predicted Poisson regression mixed model with subject random variation to account for overdispersion and DCC as well as classrooms random effects. The percentage of days absent from a DCC was compared with Poisson exact test results.

The statistical tests were performed at a 5% significance level by using SPSS version 19.0 (SPSS, Inc, Chicago, IL) and R version 3.1.3 (R Foundation, Vienna, Austria).

This study was reviewed and approved by the ethical review board for clinical trials at Hospital Torrecardenas (Almeria, Spain), and permission to review medical records was also granted.

RESULTS

Fifty-two DCCs were initially contacted, of which 25 were randomized with 1176 children and 960 (81.63%) had parental participation authorization. Approximately 95% of the children's parents returned the completed questionnaire and data collection notebook on RIs; the final simple size was 911 children. Approximately 5% of the children did not complete the study; this did not affect the results as confirmed by using nonreported analyses. One child in the HSG showed a worsening of localized atopic dermatitis due to hand sanitizer gel use and was excluded during the follow-up (Fig 1).

Table 2 includes the 3 groups' sociodemographic and DCCs characteristics. Although significant differences between groups were found, among others, the SWG families have a higher proportion with immigrant status, and the parents had lower social class and educational levels. All DCCs met the requirements regarding facilities, material conditions, square meter per child, number of courses per DCC, and number of children per staff member stipulated by the government.[43] The potential biases were controlled by including these variables in the multilevel analysis, adjusting the incidence rates of RIs and antibiotic prescriptions by them (Table 1).

During the study period, 5211 RI episodes occurred (1907 CG, 1633 SWG, and 1671 HSG); diagnoses were confirmed by a doctor in 87% of episodes. Antibiotics were prescribed in 39.4% of RIs, 28.20% of nonspecific upper respiratory tract infections, 83.20% of otitis media cases, 87.20% of pharyngotonsillitis cases, 87.50% of lower respiratory tract infections, 16.6% of acute bronchitis cases, and 25% of bronchiolitis cases.

Figure 2 includes the mean RI episodes and antibiotic prescriptions per child and per month. The significant differences between the HSG versus the SWG and CG were found when children had more RI episodes, in winter and late spring.

Pupils missed 5186 DCC days because of RIs (1891 days for the CG versus 1627 for the SWG versus 1668 for the HSG). The total possible days of attendance were 44 998 (CG), 41 374 (SWG), and 51 189 (HSG). The percentage of RI absenteeism days were significantly lower in the HSG (3.25%; 95% CI: 3.1%–3.4%) compared with the SWG (3.9%; 95% CI: 3.71%–4.09%; $P < .001$) and CG (4.2%; 95% CI: 4.01%–4.39%; $P < .001$) and in the SWG versus CG ($P = .026$).

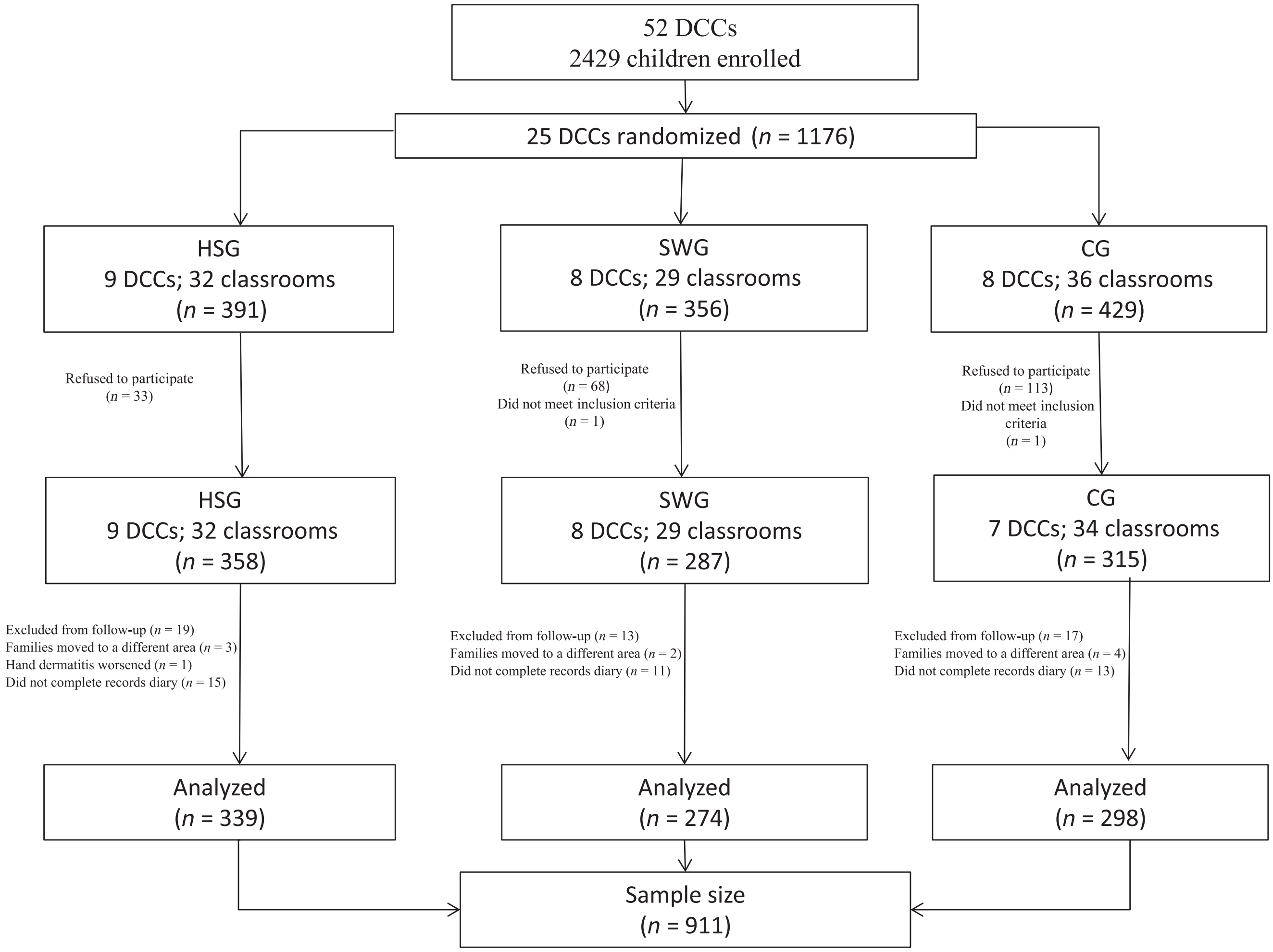

FIGURE 1
Participant flow diagram.

The adjusted final multivariate model (Table 3) reveals that the adjusted RI episodes rate was significantly lower in the HSG (IRR: 0.77; 95% CI: 0.68–0.88) than the CG; for the SWG, the IRR was ~21% higher than for the HSG. The adjusted final multivariate model (Table 4) revealed that the IRR for antibiotic prescriptions was significantly lower in the HSG (IRR: 0.69; 95% CI: 0.57–0.84) than the CG; for the SWG, the IRR was ~30% higher than for the HSG.

DISCUSSION

With this trial, we support the importance of hand hygiene programs for DCCs and families to reduce RIs and antibiotic prescriptions in children attending DCCs, with relevant repercussions seen in public health and the prevention of bacterial resistance, as other authors state.[44–47]

To our knowledge, this study is the first in which researchers measure the individual impacts of hand-washing with soap and hand sanitizer use as well as compare with a CG in DCCs. We found a 21% and 31% higher risk of RI episodes and antibiotic prescriptions, respectively, when belonging to the SWG instead of the HSG. Lennell et al[31] separately measure both interventions and found a 12% reduction of absenteeism due to infections in the HSG compared with using soap, probably because of the virucidal effect and greater adherence to the hand hygiene program with hand sanitizer than to the soap-and-water program because educational measures were the same in both groups in our study.

The 23% reduction in RI episodes in the HSG compared with the CG coincides with estimates from previous randomized studies,[27,29,48] meta-analyses, and systematic reviews[49,50] in diverse populations, revealing that hand hygiene programs decrease RIs between 9% and 21%, especially in the youngest children.[51] Researchers of intervention cohorts and other randomized studies[52,53] didn't observe a significant reduction in RI episodes in children attending

TABLE 2 Sociodemographic and DCC Characteristics in Experimental Groups and CGs

	CG (*N* = 298)	SWG (*N* = 274)	HSG (*N* = 339)	*P*
Age at the beginning of the study, mean (SD)	20.67 (7.94)	21.10 (7.73)	21.59 (8.21)	.13[a]
Age at the start of DCC attendance (SD)	11.32 (5.56)	11.91 (5.79)	12.63 (6.31)	.02[b]
Hours per wk in a DCC, mean (SD)	27.6 (7)	29.6 (7.7)	28.2 (7.1)	.05[b]
Duration of breastfeeding in mo, mean (SD)	5.85 (6.45)	6.38 (6.14)	5.83 (6.28)	.81[a]
Female sex, *n* (%)	126 (42.28)	146 (53.28)	149 (43.95)	.018[c]
Immigrant status, *n* (%)	20 (6.71)	43 (15.69)	20 (5.90)	.001[c]
Recurrent wheezing, *n* (%)	47 (15.77)	58 (21.17)	50 (14.75)	.086[c]
13-valent pneumococcal conjugate vaccine, *n* (%)	263 (88.26)	191 (69.71)	294 (86.73)	<.001[c]
Family size, people, *n* (%)				.050[c]
≤3	124 (41.61)	108 (39.42)	123 (36.28)	
>3–≤5	161 (54.03)	137 (50)	187 (55.16)	
>5	13 (4.36)	29 (10.58)	29 (8.55)	
Siblings at home, *n* (%)				.017[c]
0	135 (45.30)	117 (42.70)	128 (37.76)	
1–2	158 (53.02)	139 (50.73)	191 (56.34)	
≥3	5 (1.68)	18 (6.57)	20 (5.90)	
Father's age, mean (SD)	35.4 (6.6)	34.3 (6.7)	35.5 (5.7)	.06[a]
Mother's age, mean (SD)	33.1 (5.7)	31.2 (5.7)	33.3 (5.2)	.21[a]
Father's educational level, *n* (%)				<.001[c]
Low	91 (30.06)	108 (40.00)	91 (27.16)	
Middle	162 (52.29)	114 (42.22)	151 (45.07)	
High	40 (13.65)	48 (17.78)	93 (27.76)	
Mother's educational level, *n* (%)				.002[c]
Low	69 (23.15)	87 (31.75)	78 (23.01)	
Middle	146 (48.99)	117 (42.70)	134 (39.53)	
High	83 (27.85)	70 (25.55)	127 (37.46)	
Father's profession,[d] *n* (%)				.002[c]
I–III or VI	74 (25.26)	59 (21.85)	107 (31.94)	
IV–V	53 (18.09)	43 (15.93)	71 (21.19)	
VII or X	95 (32.42)	76 (28.15)	74 (22.09)	
VIII or IX	71 (24.23)	92 (34.07)	83 (24.78)	
Mother's profession,[d] *n* (%)				.001[c]
I–III or VI	93 (31.21)	72 (26.28)	136 (40.12)	
IV–V	47 (15.77)	34 (12.41)	40 (11.80)	
VII or X	43 (14.43)	29 (10.58)	44 (12.98)	
VIII or IX	115 (38.59)	139 (50.73)	119 (35.10)	
Type of dwelling, *n* (%)				<.001[c]
Flat	226 (75.84)	161 (58.76)	204 (60.18)	
House	33 (11.07)	68 (24.82)	59 (17.40)	
Semidetached house	35 (11.74)	44 (16.06)	69 (20.35)	
Other	4 (1.34)	1 (0.36)	7 (2.06)	
Shared bedroom, *n* (%)	206 (69.13)	190 (69.34)	214 (63.13)	.166[c]
Smoking at home, *n* (%)	63 (21.14)	63 (22.99)	53 (15.63)	.054[c]
DCC characteristics	*N* = 7	*N* = 8	*N* = 9	
No. classrooms per DCC, mean (SD)	4.9 (3.2)	3.6 (1.9)	3.6 (1.4)	.035[b]
Children per square meter of space in classroom, mean (SD)	3.7 (1.7)	3.1 (1.1)	2.8 (1.4)	.452[a]
No. children per staff, mean (SD)	6.6 (1.8)	7.2 (2.1)	7.7 (3.1)	.029[a]

[a] Fisher-Snedecor.

[b] Welch *t* test.

[c] χ^2 test.

[d] Professions are according to the European Socioeconomic Classification: I, managers and professionals of a high level; II, managers and professionals of a low level; III, white-collar employees of a high level; IV, small employers and self-employed nonagricultural workers; V, self-employed agricultural workers; VI, supervisors and technicians of a lower rank; VII, workers of services and commerce of a lower rank; VIII, skilled manual workers; IX, unskilled workers; and X, excluded labor market and long-term unemployed.

DCCs related to hand hygiene interventions. Our results may have differed for several reasons. We also collected data on RI episodes with and without DCC absenteeism; 87% had medical diagnoses. Pupils washed their hands more frequently than in previous studies.[29,31,52] Families and/or DCC staff used 1660 L of hand sanitizer during the study period; with an expected use of 1 to 2 mL of hand sanitizer per disinfection, we estimated that each child used hand sanitizer between 6 and 8 times per day, a point that is supported by Pandejpong et al.[54] To our knowledge, this is the first multicomponent intervention in which researchers provide educational measures and hand hygiene products to DCC staff, children, and parents. Previous studies reveal that the individual measures used in our study are effective. Zomer et al[55] showed that DCC staff intervention increased caregiver compliance to a hand hygiene program. Moreover, the use of a hand sanitizer at home can greatly reduce the exposure of family members to viruses in the household.[18] The children whose parents attended a health education session about RIs had fewer RIs in comparison with the CG.[48] Researchers in a systematic review[56] concluded that the effectiveness of hand hygiene interventions varies depending on the setting, the context, and compliance. Interventions to improve hand hygiene in educational settings may reduce RI incidence among younger children.[51,57]

Approximately 40% of those with RIs were prescribed antibiotics. The 30% reduction of antibiotic prescriptions for RIs in the HSG compared with the CG in our study correspond with previous reports[27,48] of 18% to 24%. Previous researchers[44,58,59] found that interventions directed toward parents and/or clinicians can reduce rates of antibiotic prescriptions for RIs in children.

TABLE 3 Factors Associated With Episodes Due to RI in Children at DCCs: Multivariate Final Adjustment

Variables	IRR	95% CI
Groups		
SWG versus CG	0.94	0.82–1.08
HSG versus CG	0.77*	0.68–0.88
SWG versus HSG	1.21*	1.06–1.39
Age at the start of DCC attendance	1.01	1.01–1.02
Duration of breastfeeding, mo	0.99**	0.99–1.00
Mother’s age	0.99*	0.98–0.99
Female sex	0.98	0.91–1.05
Recurrent wheezing	1.37*	1.25–1.50
No 13-valent pneumococcal conjugate vaccine	0.90**	0.81–1.00
No smoking at home	0.88*	0.80–0.96
Siblings at home (reference category = 0)		
1–2	0.94	0.87–1.01
3–4	0.81*	0.66–0.98

* $P < .05$
** $P < .1$

The pupils in the HSG had fewer DCC absence days due to RIs than those in the CG. These results coincide with those from previous studies[31,48]; this can reduce the use of medical resources and parent work absenteeism.

Families from different socioeconomic levels and countries of origin as well as children who used public and private health services took part in our study, so our findings can be representative of the RI episodes in children at DCCs in our area. These could be generalized in similar DCCs in Spain because most of the RI episodes were diagnosed by a doctor. As other authors indicate,[60,61] the risk and protective factors of infections in children at DCCs are difficult to identify, and their importance may vary between societies and countries. Therefore, these results may not be generalizable to DCCs where sociodemographic factors or infrastructure are substantially different.

Future studies are needed to assess which factors of multicomponent interventions may be most effective in reducing infections in children attending DCCs.

Although 87% of those with RI episodes had medical diagnoses, microbiological confirmation wasn’t conducted. Approximately 90% of children <3 years old in Almeria attend state and state-subsidized, privately run DCCs, but we did not have access to exclusively private centers. The number of parents who did not authorize the study was greater in the CG; however, this does not affect the sample size. The absence of masking both participants and researchers was not feasible given the characteristics of this study, so the statistical analyses were masked until completion. We did not monitor compliance to the programs through continuous observation of hand hygiene behaviors in the IGs as is done in most DCC intervention studies[30,31,52]; however, previous researchers[55,62,63] found that individuals might change their behavior when they know they

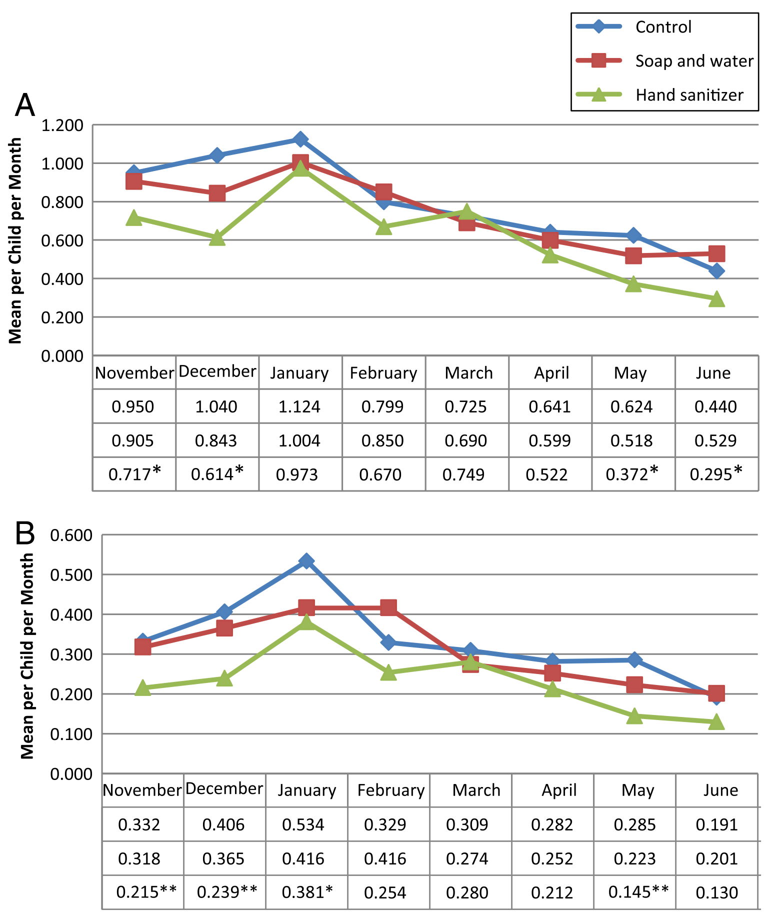

FIGURE 2
RI episodes and antibiotic prescriptions due to RI means in the CG, SWG, and HSG per child per month at DCCs in Almeria (Spain), November 2013 to June 2014. A, Mean RI episodes per child per month. * $P < .05$ for the HSG versus CG; $P < .05$ for the HSG versus SWG. B, Mean antibiotic prescriptions due to RIs per child per month. * $P < .05$ for the HSG versus CG. ** $P < .05$ for the HSG versus CG.

TABLE 4 Factors Associated With Antibiotic Prescriptions Due to RIs in Children at DCCs: Multivariate Final Adjustment

Variables	IRR	95% CI
Groups		
SWG versus CG	0.91	0.75–1.10
HSG versus CG	0.69*	0.57–0.84
SWG versus HSG	1.31*	1.08–1.59
Age at the start of DCC attendance	1.01*	1.00–1.02
Duration of breastfeeding	0.99*	0.98–0.99
Female sex	0.88*	0.79–0.99
Recurrent wheezing	1.17*	1.02–1.35
Shared bedroom	1.14*	1.02–1.29

* $P < .05$

are being observed. Nevertheless, we monitored hand hygiene material consumption in the IGs. Only the IGs received educational intervention, making the relative contributions of education versus hand hygiene in the reduction of RI episodes unattainable in this study.

CONCLUSIONS

Hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children, and parents reduce absent days, RIs, and antibiotic prescriptions for these infections in children at DCCs.

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ABBREVIATIONS

CG: control group
CI: confidence interval
DCC: day care center
HSG: hand sanitizer group
IG: intervention group
IRR: incidence rate ratio
RI: respiratory infection
SWG: soap-and-water group

revised the manuscript; Dr Yui-Hifume and Mr Torres-Alegre acquired data, supervised data collection, interpreted the data, and revised the manuscript; Dr Muñoz-Vico participated in the conception and design of the study, interpreted the data, and revised the manuscript; Dr Jimenez-Noguera and Ms Martinez-Martinez acquired and interpreted the data and revised the manuscript; Dr Strizzi conducted the initial analyses, interpreted data, and drafted and critically reviewed the manuscript; Dr Garcia-Fernandez conducted the statistical analyses, interpreted the data, and reviewed and revised the design of the study and the manuscript; Drs Seijas-Vazquez and Fernandez-Campos participated in the conception and design of the study and drafted the manuscript; Dr Gimenez-Sanchez participated in the conception and design of the study, critically reviewed the manuscript, and provided expertise on infectious diseases; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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