Childcare Center Hand Hygiene Programs' Cost-effectiveness in Preventing Respiratory Infections

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Abbreviations: CI - confidence interval; CG - control group; DCCs- Day Care Centers; HSG - hand sanitizer group; IGs- intervention groups; RIs- respiratory infections; SWG-soap and water group

Table of Contents Summary.

This study shows the cost-effectiveness of hand hygiene programs (hand sanitizer vs handwashing vs control) in decreasing respiratory infections in children at day-care centers.

What's Known on this Subject

Children attending DCCs have an increased risk of RIs. Hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children, and parents reduced respiratory infections episodes more than a program with soap and water and initial observation.

What This Study

This study revealed that hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children, and parents are more effective and less costly than a program with soap and water and initial observation in children attending DCCs

Contributor´s Statement Page:

Dr. Ernestina Azor-Martinez: conceptualized and designed the study, drafted the initial and final manuscript as submitted, supervised data collection, carried out the statistical analyses, and reviewed and revised the manuscript.
Dr. Leticia Garcia-Mochon and Ms. Monica Lopez-Lacort: acquired and interpreted the data, carried out the statistical analyses, and revised the manuscript.
Dr. Jenna Marie Strizzi: conducted the initial analyses, provided interpretation of data, drafted the manuscript, and critically reviewed the manuscript.
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Dr. Francisco Gimenez-Sanchez: participated in the conception and design and critically reviewed the manuscript, expertise in infectious diseases.
All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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ABSTRACT

BACKGROUND: We previously demonstrated that a hand hygiene program including hand sanitizer and educational measures for daycare center (DCC) staff, children, and parents was more effective than a soap and water program with initial observation in preventing respiratory infections (RIs) in children attending DCCs. We analyzed the cost-effectiveness of these programs in preventing RIs.

METHODS: A cluster, randomized, controlled and open study of 911 children aged 0- 3 years, attending 24 DCCs in Almeria. Two intervention groups of DCC-families performed educational measures and hand hygiene, one with soap-and-water (SWG) and another with hand sanitizer (HSG). The control group (CG) followed usual handwashing procedures. RI episodes including symptoms, treatments, medical contacts, complementary analyses, and DCC absenteeism days were reported by parents. A Bayesian cost-effectiveness model was developed.

RESULTS: There were 5201 RI episodes registered. The adjusted mean societal costs of RIs per child/study period were CG: €522.25 (95%CI: 437.10-622.46); HSG: €374.53 (95%CI: 314.90-443.07); SWG: €494.51 (95%CI: 419.21-585.27). The indirect costs constituted between 35.7-43.6% of the total costs. Children belonging to the HSG had an average of 1.39 fewer RI episodes than the CG and 0.93 less than the SWG. It represents a saving of societal cost mean per child/study period of €147.72 and €119.15 respectively. The HSG intervention was dominant versus SWG and CG.

CONCLUSIONS: Hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children and parents are more effective and cost less than a program with soap and water and initial observation in children attending DCCs.

INTRODUCTION

Respiratory infections (RIs) are an important public health problem among young children, especially those attending DCCs [1-8]. This is due to RIs' high incidence ranging between 6.5-10.4 episodes/children/year, [9,10] the economic and social consequences of the direct costs of primary care and emergency visits, hospitalization, diagnostics tests, and medication prescription,[4-7,11-15] and indirect costs of missed parental workdays for caring for their sick children[13,14,16-18]. The societal costs estimates of RIs among children attending DCCs vary across countries, with a mean cost per episode of US$53-129 in Chile,[19] AU$ 626 in Australia[13,] and €196.32 in the Netherlands.[20]

Studies in different populations and settings[21-26] show that hand hygiene programs decrease RIs between 9%-21%, especially in the youngest children (< 5 years).[27] Further, several studies reveal their effectiveness in DCCs.[28-33] However, research on the cost-effectiveness of hand hygiene and hand sanitizer is needed, as few studies exist[34,35], and the majority were conducted in healthcare settings.[36,37] Moreover, no studies have focused on children so this remains an area that requires further analysis.

We previously demonstrated that a hand hygiene program that included hand sanitizer and educational measures for DCC-staff, children, and parents, was more effective than one with soap and water and initial observation in the prevention of RIs in children at DCCs.[33] We aimed to assess whether educational and hand hygiene programs in DCCs and homes (hand sanitizers vs handwashing vs control) are cost-effective measures in preventing RIs in children attending DCCs.

METHODS

Design

This cost-effectiveness analysis is part of the "Impact of a Multifactorial Program of Hand Hygiene on Infections in Children Attending at Day Care Centers" study. More details

about the study design are described elsewhere.[33] This was a cluster randomized, controlled, and open study carried out over 8 months (November 2013 to June 2014). The study populations were families with children between 0 and 3 years old attending 25 state DCCs in the Almeria metropolitan area (Spain), for at least 15 hours per week. Exclusion criteria included: children with chronic illnesses or taking medication increasing the risk of contracting an infection and lack of informed consent from parents/guardians.

The study followed the Consolidated Health Economic Evaluation Reporting Standards (CHEERS)[38] and recommendations for economic evaluation applied to health technologies in Spain.[39] This study was reviewed and approved by the ethical review board for clinical trials at Torrecardenas Hospital (Almeria, Spain), and permission to review medical records was also granted.

Randomization and Interventions

The Delegation of Education provided information on 52 state DCCs in the metropolitan Almeria area. After DCC administrations agreed to participate, 25 centers were randomly selected and group randomization was conducted employing statistical software for a 1:1:1 ratio to the two intervention groups (IGs) and the CG. Parents received study informational emails from the DCC administrations, the parents authorized their children's participation and knew which group their children belonged to. One month before study commencement, parents and DCC staff attended 1-hour hand hygiene workshops (25 workshops, one per DCC). The content included education about handwashing practices, the use of hand sanitizers, and possible side effects (only for the HSG).

The CG maintained usual handwashing practices while the two IGs followed educational measures and hand hygiene, one with soap-and-water (SWG) and another with hand

sanitizer (HSG). The researchers instructed children, parents, and DCC staff in the IGs to perform their usual hand-washing procedures after using the toilet and when their hands were visibly dirty. Both IGs followed protocol in these 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. Hand sanitizer and liquid soap dispensers were installed in the appropriate HSG/SWG classrooms, and an informational brochure about when and how to perform hand hygiene was made available and provided to the IGs families. HSG families received a supply of hand sanitizer, and SWG families received liquid soap to use at home during the study period. The hand sanitizer included 70% ethyl alcohol (pH = 7.0 to 7.5). The liquid soap did not contain specific antibacterial components (pH = 5.5). 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 research assistant was responsible for providing hand hygiene materials to the DCCs and IGs parents. The researchers organized a total of 34 workshops for IGs' parents and DCC staff. Each IG center was offered one workshop on RIs and their treatment and another on fever, these were held at one month and 2 months.

Data collection and Effectiveness measures

The effectiveness of the hand hygiene programs was measured in terms of averted RI episodes. The parents of children who suffered RI episodes (with or without DCC absenteeism) reported RI symptoms, treatments, contact with medical services, complementary analyses, DCC absenteeism days, 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 IGs' DCC staff and/or parents were asked whether the

hand sanitizer or soap caused any side effects in the children. More detailed definitions of respiratory illness, episode, and duration of DCC absenteeism, as well as, the RI diagnostic codes used and risk factors can be found elsewhere.[33]

Resource Use and Valuation

Analyses from both health care and societal perspectives were conducted separately. Therefore we considered the intervention costs and RI-related direct and indirect costs, which were estimated in 2018 Euros. The intervention costs[40] included the hand sanitizer used in the HSG (1660L, total price: €8202), and soap in the SWG (890L, total price: €792), and the costs incurred in the 59 workshops (27 in HSG, 24 in SWG and 8 in CG) including salaries were calculated according to the Andalusian Health Service[41] salaries and informational material cost (see Table 1).

For direct health care costs, we included resource use associated with each RI episode including primary care and emergency visits, hospitalization, treatments, and complementary analyses. The costs of these resources used are provided in Table 1. The costs per resource unit per RI episode were calculated as the number of resource units utilized multiplied by the costs per resource unit. The prices were estimated from standard health service costs of 2005 and 2018 and accounted for inflation to 2018 prices when necessary[42-44]. Medication costs included the use of prescribed and/or over-the-counter (OTC) medication and were calculated based on the prices extracted from the BOT PLUS database, prepared by the General Council of Official Associations of Pharmacists.[45]

The cost per dose for antibiotics was calculated using the number of doses required to treat an RI episode of likely bacterial etiology. For other medications, the costs were calculated per medicine container prescribed by the doctor and withdrawn from the

pharmacy by the parents and/or information provided by the parents regarding over-the-counter medications (OTC) costs used during RI episodes.

The cost for hospital admission due to RIs was based on the 771 DRG (Diagnosis-Related Group) registered in the Gesclin program Public Health System of Andalusia.[42]

For indirect RI costs, we included costs incurred by families for private consultancy and lost productivity of parents. Lost productivity for parents was quantified using the number of days that the children were absent from DCC for RIs[33] as in another study.[46] We assumed that when children were absent from DCCs due to a RI, one of the parents missed work to care for them. For this, we assume that in cases in which both parents work, 80.26% of the time one would stay home to care for their children.[47] Lost productivity was estimated by multiplying the number of days off work due to a child's illness by average gross daily earnings in the Andalusian Region (€79.45) assuming an average monthly gross salary[48] of €1749 and 154 monthly hours of work.[49]

From a societal perspective, the total cost per RI episode was calculated as the sum of all direct health costs plus the indirect costs, and the intervention costs in the IGs. The total cost of each episode was summed to obtain a total cost per child during the study period. To contextualize these results, the costs estimated in other studies were converted to 2018 Euros for the discussion section[50] (US$1 (1999) = €0.91, and AU$1 (2003)= €0.66, AU$1 (2010)= €0.50, and €1 (2018)= US$1.14.

Statistical Analysis

Bayesian cost-effectiveness analysis was developed to assess the cost-effectiveness of the hand hygiene program by the IGs compared with the CG, using both health care and societal perspectives. The time horizon was 8 months and therefore considered no discount rate. Effectiveness was expressed in terms of averted RI episodes. RI episodes were analyzed by a linear regression adjusted by parental smoking, children´s recurrent

wheezing, and the number of siblings. Considering the asymmetry in the cost distribution, the cost was modeled with a log-normal regression adjusted by pneumococcal vaccination, recurrent wheezing, and hospitalization. Interaction between costs and RI was considered.[51] Non-informative priors were considered for the parameters. The expected mean effectiveness and costs, and 95% Bayesian credible interval were then estimated from the posterior distributions. Moreover, we assessed the incremental effectiveness and cost, and the probability that the interventions HSG and SWG would be more effective or cheaper than the control condition. To illustrate the results, we used the cost-effectiveness plane, where the joint posterior distribution of the incremental effectiveness and costs are displayed in an x-y plot for societal perspective.

The statistical software programs R (Foundation for Statistical Computing, Vienna, Austria) and WinBUGS (Cambridge Biostatistics Unit and the Imperial College School of Medicine, London) were used to perform the analysis using MCMC methods. MCMC convergence was assessed by visual inspection of history plots of posterior samples, the Brooks-Gelman-Rubin scale reduction factor, and the effective sample size implemented in the R2WinBUGS package of R.

RESULTS

Fifty-two DCCs were initially contacted, of which 25 were randomized with 1176 children, 960 (81.63%) had parental participation authorization. Approximately 95% of the children's parents returned the completed questionnaire and data collection notebooks on RIs, thus the final sample size was 911 children (339 children in HSG, 274 children in SWG, and 298 children in CG). Participant flow diagram, sociodemographic, and DCC characteristics were described in more detail elsewhere.[33]

During the study period, 5201 RI episodes occurred, diagnoses were confirmed by a doctor in 87% of episodes. Pupils missed 5186 DCC days[33]. The mean use of resources

and costs due to this infection per study group are shown in Table 2. The indirect costs constituted between 35.7%-43.6% of the total costs in the study groups.

The adjusted mean of RI episodes and the costs per child/study period from healthcare and societal perspectives are provided in Table 3. The adjusted mean RI episodes per child/study period in HSG, SWG, and CG were 5.14 (95%IC: 4.67 -5.59), 6.07 (95%IC: 5.54- 6.53), and 6.53 (95% IC: 6.06 -6.97) respectively.

From a societal perspective, the adjusted mean societal costs of RI episodes per child/ study period were €374.53 (95%CI: 314.90-443.07) for the HSG, €494.51 (95%CI: 419.21-585.27) for the SWG, and €522.25 (95%CI: 437.10-622.46) for the CG. The differences in adjusted cost per child/study period were €-147.72 (95%CI -232.07 -72.58) for HSG s CG, and €-119.15 (IC95%: -196.77 -45.84) when comparing the HSG with the SWG. When we compared the SWG vs CG, the difference was €-27.74 (95%CI: -115.17-60.97).

Hence, the incremental cost-effectiveness ratio (ICER) of the HSG and SWG interventions is dominant (less costly and more effective) in all scenarios considered. From a societal perspective, the estimated probability that this dominance was 100% when comparing HSG vs CG and HSG vs SWG and 72.26% when comparing SWG vs CG (Figure 1).

DISCUSSION

To our knowledge, this study is the first cost-effectiveness study of hand hygiene programs in DCCs. The findings support that hand hygiene programs that include hand sanitizer and educational measures for DCC-staff, children, and parents, were more effective and cost less than a program with soap and water and initial observation in the prevention of RIs in children at DCCs. The probabilistic Bayesian analysis indicated that this result is maintained in 100% of the simulations.

From a societal perspective, hand hygiene programs that include hand sanitizer reduce RIs by 21.29% and save € 147.72 per child/study period when compared with the CG and a 15.32% RI reduction with a savings of €119.15 when compared with the SWG. The cost differences between study groups are predominantly caused by the lower direct cost per child/study period in the HSG €295.67 (€404.92 CG; €394.57 SWG) driven by the lower number of RI episodes in HSG. In addition to the virucidal effect of hand sanitizer, there was probably greater adherence to the hand hygiene program in this group. We estimated that each child performed the corresponding hand hygiene procedures between 6-8 times/day in the HSG compared with 3-5 times/day in the SWG.[33,52] The intervention costs per child were 3.64% (€27.37) in the HSG and 0.58% (€6.36) in the SWG of the total costs. When we compared with our CG, the indirect costs were estimated at 43.6% of total costs, similar to the estimate in a study prospective made in Canada.[16]

Comparison of our results with the literature is difficult because currently, no randomized studies have assessed the cost-effectiveness of hand hygiene programs in preventing RIs at DCCs. Previous studies show hygiene hand programs that included hand sanitizer are effective in reducing RIs in children in different settings.[24,26, 27,29,31-33,53] However, few studies estimate the societal costs of RIs at DCCs. The societal cost estimates of RIs per child/study period in CG were compared with results from a prospective study in Canada[16]. This study estimated the average total cost due to illness (cold and gastroenteritis) per child over a 6 month study period was €236.6 and our study was €522.25 in 8 months. These differences are likely due to the longer duration of our study, the inclusion of more direct costs (hospitalizations and all consultations in the health system for each RI episode), the number of included illnesses, the cost per resource units and the differences in the healthcare systems between the two countries.

In our study, the societal cost per RI episode was €79.98 (43.6% indirect costs) in the CG, contrasting findings from the Netherlands[20] and Australia[13,17] of costs for an influenza-like illness episode of €196.33 (80% indirect costs) and acute respiratory infection episode between €203.94 and €313 (65%-78% indirect costs) respectively. The higher indirect costs found in previous research are likely due to socio-economic characteristics of those countries, Lambert et al[17] found that children from families with the lowest household income reported the lowest costs per episode.

A prospective study in the USA[46] of a multidimensional infection control education program that included handwashing and education among other measures in preschool children with Down syndrome reported the mean costs of illness (RI and gastroenteritis) per child/year was €559.65. In our study, the mean cost of RI per child/study period in the SWG was €494.51. These differences could be due to different study designs, mean age, the possible differences in the immune system of the population studied, as well as a higher cost of the intervention of the American study because, in addition to handwashing they included environmental cleaning, a cleaning service was hired to decontaminate all toys 3 times per week among other measures.

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 and their associated costs for DCC children in our area. These could be generalized in similar DCCs in Spain because most of the RI episodes were diagnosed by a doctor. Therefore, these results may not be generalizable to DCCs where sociodemographic factors, infrastructure, and the nature of the healthcare system are substantially different.

Future epidemiological and health economic evaluation studies are needed to investigate which measures are more cost-effective in preventing RIs in DCCs, including long-term

follow-up designs to see whether hand hygiene habits are maintained over time. The COVID-19 pandemic has amplified the importance of physical measures such as these to interrupt viral transmission, with the advantages of their rapid deployment and ability to be independent of the infective agent, including novel viruses.[26]

Limitations

1-The absence of masking both participants and researchers was not feasible given the characteristics of this study. However, the statistical analysis was masked until completion 2- We did not record which parents were absent from work to take care of their sick children, as in other studies.[46] When registering the days of DCC absenteeism per RI, we assumed that when the children were absent, one of the parents missed work for child care. The societal costs were calculated as in a previous study[20] based on standardized unit costs rather than actual costs. This approach assumes that identical costs apply by group, when in fact these costs may differ, given the sociodemographic differences among study participants. 3- We did not perform microbiological diagnoses of the RIs, this may have influenced cost estimates, although in most cases (87%) we have a medical diagnosis. Secondly, we did not include transport costs for medical care, though these were presumably low given the study location. A previous study[54] reported that transport services made up < 1% of the total cost of illness, so the exclusion of transport costs likely did not significantly alter the results. We did not include intrafamily transmission as other studies have.[17,20,46] 4- We did not record in our study the cost per dose for each type of medication, as in other studies[16],[17,55] although we registered the cost per dose of antibiotics.

CONCLUSIONS: Hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children and parents are more effective and cost less than a program with soap and water and initial observation in children attending at DCCs.

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Table 1. Unit Cost per Resource used in Euros and American Dollars 2018

Table 2. Descriptive Analysis of the Use of Resources and their related Cost (in Euros 2018) for RIs per Child During 8-Month Follow-up

Table 3. Adjusted Cost-effectiveness Analysis of the HSG and SWG compared with the CG per both Health care and Societal Perspective. Cost is expressed in 2018 Euros

Figure 1. Cost-effectiveness Planes from Societal Perspective

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