

# Child Care Center Hand Hygiene Programs' Cost-Effectiveness in Preventing Respiratory Infections

Ernestina Azor-Martinez, MD, PhD,<sup>a</sup> Leticia Garcia-Mochon, PhD,<sup>b,c,d</sup> Monica Lopez-Lacort,<sup>e</sup> Jenna Marie Strizzi, PhD,<sup>f</sup> Francisco Javier Muñoz-Vico, MD, PhD,<sup>g</sup> Carmen Pilar Jimenez-Lorente, MD,<sup>g</sup> Maria Amparo Fernandez-Campos, MD,<sup>a</sup> Cristina Bueno-Rebollo, MD,<sup>a</sup> Guadalupe del Castillo-Aguas, MD, PhD,<sup>h</sup> Josep Vicent Balaguer-Martinez, MD,<sup>i</sup> Francisco Gimenez-Sanchez, MD, PhD<sup>j</sup>

## abstract

**BACKGROUND:** We previously demonstrated that a hand hygiene program, including hand sanitizer and educational measures, for day care 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 to 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 hand-washing 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 per study period were CG: €522.25 (95% confidence interval [CI]: 437.10 to 622.46); HSG: €374.53 (95% CI: 314.90 to 443.07); SWG: €494.51 (95% CI: 419.21 to 585.27). The indirect costs constituted between 35.7% to 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 per 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.

<sup>a</sup>Distrito Sanitario de Atención Primaria, Almería, Spain; <sup>b</sup>Escuela Andaluza de Salud Pública, University of Granada, Granada, Spain; <sup>c</sup>Center for Biomedical Research Network in Epidemiology and Public Health, Madrid, Spain; <sup>d</sup>Institute of Biomedical Research Granada, University Hospitals of Granada, University of Granada, Granada, Spain; <sup>e</sup>Vaccine Research Department, FISABIO-Public Health, Valencia, Spain; <sup>f</sup>Department of Public Health, University of Copenhagen, Copenhagen, Denmark; <sup>g</sup>Unidad de Inmunología, Hospital Torrecardenas, Almería, Spain; <sup>h</sup>Centro de Salud Colonia de Santa Ines, Distrito Sanitario de Atención Primaria Guadalhorce, Málaga, Spain; <sup>i</sup>CAP St Ildefons, Cornellà de Llobregat, Barcelona, Spain; and <sup>j</sup>Instituto Hispalense de Pediatría, Instituto Balmis de Vacunas, Almería, Spain

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 revised the manuscript; Dr Garcia-Mochon and Ms Lopez-Lacort acquired and interpreted the data, conducted the statistical analyses, and revised the manuscript; Dr Strizzi conducted the initial analyses, provided interpretation of data, drafted the manuscript, and critically reviewed the manuscript; Dr Muñoz-Vico participated in the conception and design of the study, interpreted the data, and revised the manuscript; Drs Jimenez-Lorente and Bueno-Rebollo acquired and interpreted the data and revised the manuscript; Drs Fernandez-Campos, Castillo-Aguas, and Balaguer-Martinez participated in the conception and design of the study and drafted the manuscript; Dr Gimenez-Sanchez participated in the conception and design and

**WHAT'S KNOWN ON THIS SUBJECT:** 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 in children attending day care centers.

**WHAT THIS STUDY ADDS:** 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.

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

Studies in different populations and settings<sup>21-26</sup> show that hand hygiene programs decrease RIs between 9% to 21%, especially in the youngest children (<5 years of age).<sup>27</sup> In addition, several studies reveal their effectiveness in DCCs.<sup>28-33</sup> However, research on the cost-effectiveness of hand hygiene and hand sanitizer is needed because few studies exist,<sup>34,35</sup> and the majority were conducted in health care settings.<sup>36,37</sup> Moreover, no studies have been 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.<sup>33</sup> We aimed to assess whether educational and hand hygiene programs in DCCs and homes (hand sanitizers versus hand-washing versus 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.<sup>33</sup> This was a cluster randomized, controlled, and open study conducted 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 and guardians.

The study followed the Consolidated Health Economic Evaluation Reporting Standards<sup>38</sup> and recommendations for economic evaluation applied to health technologies in Spain.<sup>39</sup> 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 2 intervention groups (IGs) and the control group (CG). Parents received study informational e-mails 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; 1 per DCC). The content included education about hand-washing practices, the use of hand sanitizers, and possible side effects (only for the hand sanitizer group [HSG]).

The CG maintained usual hand-washing practices, whereas the 2 IGs followed educational measures and hand hygiene, one soap-and-water group (SWG) and another hand sanitizer group (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 and 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.<sup>33</sup>

### 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<sup>40</sup> 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 the HSG, 24 in the SWG, and 8 in the CG) including salaries were calculated according to the Andalusian Health Service<sup>41</sup> salaries and informational material cost (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 used 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.<sup>42-44</sup> Medication costs included the use of prescribed and/or over-the-counter (OTC) medication and were calculated on the basis of the prices extracted from the BOT PLUS database, prepared by the General Council of Official Associations of Pharmacists.<sup>45</sup>

The cost per dose for antibiotics was calculated by 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 OTC medications costs used during RI episodes.

The cost for hospital admission due to RIs was based on the 771 diagnosis-related group registered in the Gesclin program Andalusian Public Health System.<sup>42</sup>

For indirect RI costs, we included costs incurred by families for private consultancy and lost productivity of parents. Lost productivity for parents was quantified by using the number of days that the children were absent from DCC for RIs,<sup>33</sup> as in another study.<sup>46</sup> We assumed that when children were absent from DCCs

because of 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.<sup>47</sup> 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<sup>48</sup> of €1749 and 154 monthly hours of work.<sup>49</sup>

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<sup>50</sup> (US\$1 (1999) = €0.91; 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, by 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 using 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.<sup>51</sup> Noninformative

**TABLE 1** Unit Cost per Resource Used in 2018 Euros and American Dollars

Resource Unit	Unit Cost (2018 €)	Unit Cost (2018 \$)	Reference
Primary care visits	53.75	61.28	BOJA 2018 <sup>43</sup>
Private primary care visits <sup>a</sup>	60	68.40	—
Emergency department visits	83.65	95.36	BOJA 2005 <sup>42</sup>
Primary care emergency	144.24	164.43	—
Hospital emergency without admission	70	79.80	—
Private hospital emergency without admission <sup>a</sup>	—	—	—
Hospital observation room	392.03	446.91	—
Hospitalization for RI without complications in the pediatric unit	4394.58	5009.82	BOJA 2005
Medication <sup>b</sup>	—	—	BOT PLUS <sup>45</sup>
Complementary analyses and diagnostic tests			
Hemogram/blood count	5.30	6.04	BOJA 2005
Biochemistry	18.92	21.57	BOJA 2005
Urine sediment	2.33	2.65	BOJA 2005
Urine culture	3.96	4.51	BOJA 2005
Urine dipstick test	1.90	2.17	BOJA 2005
Abdominal radiograph	9.23	10.52	BOJA 2005
Chest radiograph	9.23	10.52	BOJA 2005
Ultrasound	36.92	42.09	BOJA 2005
Computerized tomography without and with contrast	55.38 and 119.99	63.13 and 136.79	BOJA 2005
MRI without and with contrast	119.99 and 239.98	136.79 and 273.58	BOJA 2005
Intervention <sup>c</sup>	—	—	BOJA 2013
Hand sanitizer	8202	9350.28	—
Soap and water	792	902.88	—
Informational material/posters	154.77	176.44	—
59 workshops (1 h per workshop) imparted by a pediatrician (cost per h: 36.74€)	2167.76	2471.25	—
Productivity loss due to absence from paid work per day	79.45	90.57	INE <sup>48</sup>

BOJA, Boletín Oficial de la Junta de Andalucía Official Gazette of the Government of Andalusia; INE, Statistics National Institute; —, not applicable.

<sup>a</sup> Private hospital emergency without admission and private primary care visits cost were obtained from pediatricians that worked in a public hospital and also private practice

<sup>b</sup> Medication (including prescription charges and OTC) costs were estimated from the BOT PLUS database. General Council of Official Associations of Pharmacists.

<sup>c</sup> The resources associated with the hygiene program were obtained a grant from the Andalusia Department of Health.<sup>40</sup> The costs of these resources were based on the actual costs paid during the study.

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, in which 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, UK) were used to perform the analysis by using

Markov chain Monte Carlo methods. Markov chain Monte Carlo 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

A total of 52 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 the HSG, 274 children in the SWG, and 298 children in the CG). The participant flow diagram, sociodemographic, and DCC characteristics were

described in more detail elsewhere (Supplemental Fig 2).<sup>33</sup>

During the study period, 5201 RI episodes occurred; diagnoses were confirmed by a doctor in 87% of episodes. Pupils missed 5186 DCC days.<sup>33</sup> 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% to 43.6% of the total costs in the study groups.

The adjusted mean of RI episodes and the costs per child per study period from health care and societal perspectives are provided in Table 3. The adjusted mean RI episodes per child per study period in HSG, SWG, and CG were 5.14 (95% confidence interval [CI]: 4.67 to 5.59), 6.07 (95% CI: 5.54 to 6.53), and 6.53 (95% CI: 6.06 to 6.97), respectively.

**TABLE 2** Descriptive Analysis of the Use of Resources and Their Related Cost (in 2018 Euros) for RIs per Child During 8-Month Follow-up

Resource	HSG (N = 339)				SWG (N = 274)				CG (N = 298)			
	Mean Resource Use (SD)	Mean Cost (SD)	Median Resources Use (IQR)	Median Cost (IQR)	Mean Resource Use (SD)	Mean Cost (SD)	Median Resources Use (IQR)	Median Cost (IQR)	Mean Resource Use (SD)	Mean Cost (SD)	Median resources use (IQR)	Median Cost (IQR)
Intervention cost (hand hygiene program)	—	2.93 (—)	—	—	—	3.21 (—)	—	—	—	0.99 (—)	—	—
Workshops	1 (—)	24.19 (—)	—	—	—	—	—	—	—	—	—	—
Hand sanitizer	—	—	—	—	1 (—)	2.89 (—)	—	—	—	—	—	—
Soap	—	—	—	—	—	0.25 (—)	—	—	—	—	—	—
Informational material (photocopies, posters, brochures)	—	0.25 (—)	—	—	—	—	—	—	—	—	—	—
Direct health care cost	4.15 (3.7)	222.93 (198.5)	3 (1–6)	161.25 (53.75–322.5)	5.43 (4.3)	291.7 (231.3)	4 (2–8)	215 (107.5–430)	5.95	319.97 (229.7)	5 (3–9)	268.75 (161.25–483.75)
Primary care visits	0.79 (1.1)	110.38 (169)	0 (0–1)	0 (0–)	1.33 (1.6)	217.63 (325.6)	1 (0–2)	144.24 (0–288.48)	1.11 (1.4)	159.32 (235.4)	1 (0–2)	83.65 (0–288.48)
Emergency visits <sup>a</sup>	0.02 (0.1)	6.94 (51.8)	0 (0–0)	0 (0–0)	0.07 (0.3)	25.75 (118.2)	0 (0–0)	0 (0–0)	0.06 (0.3)	25 (128.3)	0 (0–0)	0 (0–0)
Hospital observation	0 (0.01)	25.93 (477.4)	0 (0–0)	0 (0–0)	0.03 (0.2)	112.27 (694.6)	0 (0–0)	0 (0–0)	0.01 (0.1)	44.24 (568.5)	0 (0–0)	0 (0–0)
Hospitalization for RI	0.23 (0.7)	1.72 (8.1)	0 (0–0)	0 (0–0)	0.32 (0.9)	2.99 (10)	0 (0–0)	0 (0–0)	0.57 (1.5)	6.29 (18.1)	0 (0–0)	0 (0–0)
Complementary analyses and diagnostic tests	12.76 (17.8)	6.51 (6.9)	6 (1–16)	4.58 (2.29–9.16)	18.85 (22.4)	9.59 (9.1)	11 (3–28)	6.87 (2.29–14.51)	21.97 (26.4)	9.99 (9.6)	12 (4–33)	7.59 (2.29–14.92)
Pharmaceutical treatments	12.18 (8.15)	28.04 (24.9)	11 (6–6.50)	21.86 (11.11–37.93)	14.83 (9.25)	36.17 (31.07)	13 (8–20)	27.84 (14.69–49.93)	16.29 (9.53)	38.49 (30.87)	15 (9–22)	31.07 (16.26–55.59)
Antibiotic	28.5 (30.9)	306.44 (545.2)	19 (6–38)	24.53 (0–429.28)	38.2337.7 (746.9)	369.38 (746.9)	26 (11.25–53)	0 (0–)	41.71 (38)	449.2 (722.2)	31 (15–56.75)	0 (0–723.64)
Other pharmaceutical treatments	0.09 (0.4)	6.19 (29.3)	0 (0–0)	0 (0–0)	0.12 (0.6)	8.69 (42.3)	0 (0–0)	0 (0–0)	0.11 (0.6)	6.81 (37.3)	0 (0–0)	0 (0–0)
Indirect cost	0.2 (0.6)	9.88 (30)	0 (0–0)	0 (0–0)	0.25 (0.9)	12.59 (46.3)	0 (0–0)	0 (0–0)	0.21 (0.8)	10.4 (42.2)	0 (0–0)	0 (0–0)
Lost productivity of parents' absenteeism	—	429.50 (606.74)	—	318.72 (148.29–571.82)	—	701.96 (1004.36)	—	435.14 (237.16–818.01)	—	603.27 (860.29)	—	466 (235.86–749.8)
Private hospital emergency without admission	—	752.02 (904.83)	—	470.25 (242.51–987.81)	—	1092.62 (1337.27)	—	682.62 (322.47–1180.11)	—	1069.68 (1235.89)	—	669.67 (329.2–1396.88)
Private primary care visits	—	—	—	—	—	—	—	—	—	—	—	—
Total crude cost	—	—	—	—	—	—	—	—	—	—	—	—
Total direct health care cost	—	—	—	—	—	—	—	—	—	—	—	—
Total societal cost perspective	—	—	—	—	—	—	—	—	—	—	—	—

IQR, interquartile range; —, not applicable.

<sup>a</sup> includes emergency visits to primary care and hospital.



**TABLE 3** Adjusted Cost-Effectiveness Analysis of the HSG and SWG Compared With the CG per Both Health Care and Societal Perspective

Interventions	Cost, € (95% CI)		Incremental Cost, € (95% CI)		Effectiveness, RI Episodes (95% CI)	Incremental Effectiveness (95% CI)
	Health Care Perspective	Societal Perspective	Health Care Perspective	Societal Perspective		
CG	404.92 (334.70 to 481.39)	522.25 (437.10 to 622.46)	—	—	6.53 (6.06 to 6.97)	—
SWG	394.57 (327.92 to 471.99)	494.51 (419.21 to 585.27)	−10.35 (−76.58 to 62.90) <sup>a</sup>	−27.74 (−115.17 to 60.97) <sup>a</sup>	6.07 (5.54 to 6.53)	0.46 (1.00 to 0.05)
HSG	295.67 (246.61 to 350.69)	374.53 (314.90 to 443.07)	−109.25 (−173.18 to −52.76) <sup>b</sup>	−147.72 (−232.07 to −72.58) <sup>b</sup>	5.14 (4.67 to 5.59)	1.39 (0.88 to 1.89)
HSG versus SWG	—	—	−101.03 (−165.40 to −45.32)	−119.15 (−196.77 to −45.84)	—	0.93 (0.44 to 1.48)

Cost is expressed in 2018 Euros. The costs were adjusted by 13-valent pneumococcal conjugate vaccine (no versus yes), children's recurrent wheezing (yes versus no), and hospitalization (yes versus no). The effectiveness was adjusted by home smoking habit (no versus yes), children's recurrent wheezing (yes versus no), and siblings at home (0 vs 1 to 2 and  $\geq 3$ ). —, not applicable.

<sup>a</sup> SWG versus CG.

<sup>b</sup> HSG versus CG.

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

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

## DISCUSSION

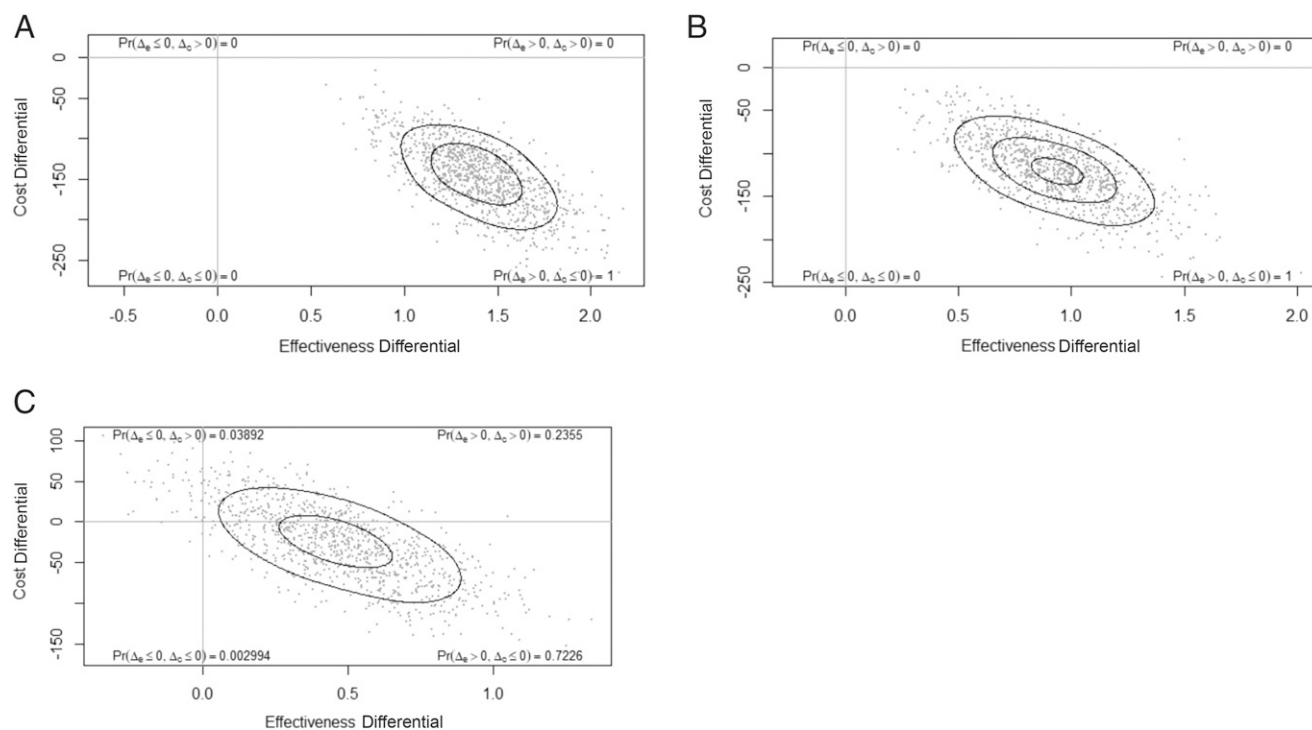
To our knowledge, this study is the first cost-effectiveness study of hand hygiene programs in DCCs. The findings support that hand hygiene programs that include hand sanitizer and educational measures for DCC staff, children, and parents,

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 per 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 per study period in the HSG (€295.67 [€404.92 for the CG; €394.57 for the 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 and 8 times per day in the HSG compared with 3 to 5 times per day in the SWG.<sup>33,52</sup> 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.<sup>16</sup>

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.<sup>24,26,27,29,31–33,53</sup> However, few studies estimate the societal costs of RIs at DCCs. The societal cost estimates of RIs per child per study period in CG were compared with results from a prospective study in Canada.<sup>16</sup> 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 health care systems between the 2 countries.



**FIGURE 1**

Cost-effectiveness planes from societal perspective revealing the distribution of posterior incremental costs and effects of interventions considered. The comparisons of the HSG versus CG and HSG versus SGC (A and B) reveal that the probability of the HSG being more effective and reducing health care system costs is 100% (southeast quadrant). In the comparison between the SWG and CG (C), the probability that the SWG is more effective and reduces costs is 72.26%. A, HSG versus CG. B, HSG versus SWG. C, SWG versus CG.

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

In a prospective study in the United States<sup>46</sup> of a multidimensional infection control education program that included hand-washing and education among other measures in preschool-aged children with Down syndrome, researchers reported the mean costs of illness (RI and

gastroenteritis) per child per year was €559.65. In our study, the mean cost of RI per child per 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 hand-washing 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 in which sociodemographic factors, infrastructure, and the nature of the health care 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 coronavirus disease 2019 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.<sup>26</sup>

### Limitations

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. We did not record which parents were absent from work to take care of their sick children, as in other studies.<sup>46</sup> 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,<sup>20</sup> on the basis of 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. We did not perform microbiologic 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, although these were presumably low given the study location. A previous study<sup>54</sup> 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.<sup>17,20,46</sup> We did not record, in our study, the cost per dose for each type of medication, as in other studies,<sup>16,17,55</sup> 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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### ABBREVIATIONS

CI: confidence interval  
CG: control group  
DCC: day care center  
HSG: hand sanitizer group  
IG: intervention group  
OTC: over-the-counter  
RI: respiratory infection  
SWG: soap-and-water group

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critically reviewed the manuscript with expertise in infectious diseases; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

This trial has been registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (identifier NCT03294772).

Deidentified individual participant data (including data dictionaries) will be made available, in addition to study protocols, the statistical analysis plan, and the informed consent form. The data will be made available on publication to researchers who provide a methodologically sound proposal for use in achieving the goals of the approved proposal. Proposals should be submitted to [monica.lopez@fisabio.es](mailto:monica.lopez@fisabio.es).

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Address correspondence to Ernestina Azor-Martinez, MD, PhD, Distrito Sanitario Atención Primaria Almería-C, Haza de Acosta S/N, Almería, Spain 04009. E-mail: [eazorm@yahoo.es](mailto:eazorm@yahoo.es)

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