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Economic Evaluation

Budget Impact Analysis of Hypertonic Saline Inhalations for Infant Bronchiolitis: The Colombian National Health System Perspective

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ABSTRACT

Objectives: Nebulized 3% hypertonic solution (HS) is associated with lower total cost and higher quality-adjusted life-years. Nevertheless, the expected budget impact of this drug had not been explicitly estimated. The aim of this study was to evaluate the budget impact of 3% HS in the treatment of acute bronchiolitis in Colombia.

Methods: A budget impact analysis was performed to evaluate the potential financial impact of the use of 3% HS. The analysis considered a 4-year time horizon and a Colombian national health system perspective. The incremental budget impact was calculated by subtracting the cost of the new treatment, in which 3 % HS (added to humidified oxygen) was reimbursed, from the cost of the conventional treatment without 3 % HS (only humidified oxygen or adrenaline nebulization). Univariate 1-way sensitivity analyses were performed.

Results: In the base-case analysis, the 4-year costs associated with HS and non-3% HS were estimated to be $47 792 230 and $53 312 832, respectively, indicating savings for Colombian national health system equal to $5 520 602 if HS is adopted for the routine management of patients with acute bronchiolitis. This result was robust in univariate 1-way sensitivity analysis.

Conclusion: HS was cost saving in emergency settings for treating infants with acute bronchiolitis. This evidence can be used by decision makers in Colombia to improve clinical practice guidelines and should be replicated to validate their results in other middle-income countries.

Keywords: acute bronchiolitis, Colombia, hypertonic solution.

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Introduction

Bronchiolitis is a respiratory, viral disease more frequent in infants younger than 12 months. Most infants develop bronchiolitis, and 3% of patients are admitted to hospitals in developed countries.[1] The hospitalization rates could be higher in developing countries because of barriers in access to health services.[2,3] The case fatality is 0.5% to 1.5% in high-income countries and 1.74% in Latin America.[4] In Colombia, we estimate 260 873 years of life (95% confidence interval [CI] 208 180-347 023) was lost because of bronchiolitis in children younger than 2 years.[5]

In developed and developing countries, bronchiolitis is associated with increased healthcare costs. For example, in the United States, the mean annual figures of hospitalizations by bronchiolitis were 17 hospitalizations per 1000 infants, 55 emergency department visits per 1000 infants, and 132 unplanned office visits per 1000 infants[6], accounting for total annual cost of $543 million.[7] In developing countries, the most relevant issue is the inappropriate use of drugs and medical tests in this disease. In Colombia, we reported that 74% of hemograms, 72% of chest X-rays, 40.4% of C-reactive protein tests, 96% of β-lactam antibiotics, 90% of bronchodilators, and 86% of corticosteroids and epinephrine were classified as "inappropriate"[8]; patients with longer periods of hospitalizations, absence of fever, and normal white blood cell count at admission were at most risk of inappropriate use of medications and medical tests.[9] In this context, having cost-effective and cost-saving drugs can reduce fatalities and allow efficient resource allocation.

Bronchiolitis clinical guidelines advocate only for the use of supportive therapy and discourage the use of bronchodilators, steroids, and antibiotics.[10] The 3% hypertonic solution (HS) showed a 16% reduction in the risk of hospitalization compared with patients who did not receive this treatment (risk ratio 0.84, 95% CI 0.71-0.98, *P*=.03).[11] In Colombia, the nebulized 3% HS is associated with lower total cost than treatment of infants without this medication ($200 vs $240 average cost per patient, respectively), and higher quality-adjusted life-years (0.92 vs 0.91 average per patient, respectively).[12] Nevertheless, these cost-effectiveness analyses alone do not provide information on the drug's impact on the total healthcare budget. Thus, the expected budget impact of this drug should be explicitly estimated, in addition to the traditional cost-effectiveness. The aim of this study was to evaluate the budget impact of 3% HS for treating acute bronchiolitis in Colombia.

Table 1. Assumption used to develop the base-case analysis.

Assumption	References
For all products, compliance is considered to be 100%.	Assumption based on the opinion of clinical experts
The incidence of adverse events is equal between patients treated with HS and without HS.	Buendía and Talamoni[25]
The incidence of bronchiolitis is stable over the time horizon.	Assumption based on the opinion of clinical experts
The incidence of bronchiolitis is stable over the time horizon.	Assumption based on the opinion of clinical experts
The market share for different types of HS are stable over the time horizon.	Assumption based on the opinion of clinical experts

HS indicates hypertonic solution.

Methods

Analytical Framework

A budget impact analysis was performed to evaluate the potential financial impact derived from the use of 3% HS. The analysis considered the perspective of the Colombian national health system and was conducted over a 4-year time horizon.

The Colombian health system is divided into 2 different levels: the contributive regime, in which the employer pays for two-thirds of the contribution and the employee pays for the rest and is guaranteed a comprehensive coverage of mandatory health plan and the subsidized regime in which the government covers 50% of the mandatory health plan; this regime is designed for the poorest population without employers.[13] Both regimes cover the 3% HS in their benefits packages.

We developed a budget impact model in Microsoft Excel® to evaluate the incremental budget impact of 3% HS for the treatment of acute bronchiolitis. The incremental budget impact was calculated as the difference between the cost of 3 % HS (added to humidified oxygen) and the cost of the conventional treatment without 3% HS or no-HS (only humidified oxygen or adrenaline nebulization). Full details of all assumptions used to develop the base-case analysis are provided in Table 1.

Target Population

The target population is represented by infants (0-12 months old), term newborns without cardiac, neurological, respiratory, or another chronic disease, with a diagnosis of bronchiolitis and requiring hospitalization. The inputs of this analysis were the following: population younger than 2 years in Colombia,[14] the incidence of bronchiolitis in Colombia,[15] and the frequency of infants with acute bronchiolitis requiring hospitalization in Colombia.[2,8,16] An annual population growth of 1.5% was assumed, considering the average national growth rate for the period from 2015 to 2019[14] (Table 2).

Intervention

Patients received 2 nebulization with 4 mL of HS, 3% (NaCl 240 mg), given 20 minutes apart. The medication is delivered using a jet nebulizer through a firmly applied facemask with an oxygen flow rate of 6 L/min.[17] Information regarding the effect of HS was extracted from a recent meta-analysis that compared HS nebulization with normal saline inhalations or standard treatment without HS nebulization.[11]

We assumed to progressively gain market sales from HS. In the base-case scenario, the uptake rate of surfactant therapy was assumed to be 25%, increasing by 25% each year respectively, according to the estimates of the marketing authorization holder.

Time Horizon

The time horizon defined was 4 years. The maximum follow-up time was set at 4 years. A longer perspective was not considered relevant for the budget holder. All results were depicted cumulatively from 1 to 4 years.

Table 2. Parameters used in the base case.

Type of parameter	Base-case value	Range for 1-way sensitivity analyses	Reference
Demographics			
Population	2 327 222		DANE[14]
Annual population growth	1.5%		DANE[14]
Epidemiology			
Acute bronchiolitis incidence	6.1%	4-8%	INS[15]
% bronchiolitis requiring hospitalization	12.1%	5-15%	Lara-Oliveros et al[2]; Buendia et al[8]; Rodriguez-Martinez, et al[16]
HS effectiveness			
Reduction in hospitalization	0.80	0.67-0.96	Zhang et al[11]
Reduction of LOS	–0.55	–0.15-0.96	Zhang et al[11]
Market share			
1 y	25%		
2 y	50%		
3 y	75%		
4 y	100%		

DANE indicates National Administrative Department of Statistics; INS, Instituto Nacional de Salud; LOS, length of stay.

Table 3. Cost ($) used in base-case and sensitivity analyses.

Model input	Base-case value	Range for 1-way sensitivity analyses	Distribution
Intervention cost			
HS cost per patient day	3.83	3.81-3.84	γ(SD 0.05)
Hospitalization cost			
Daily cost in pediatric ward	48.82	47.64-50.00	γ(SD 3.20)
Length of hospital stay (days)	5.8	4.00-6.01	γ(SD 2.03)
PICU related cost			
Daily cost in PICU	327.35	326.26-328.43	γ(SD 5.49)
Length of PICU stay (days)	10	9.01-15.05	γ(SD 3.08)
Cost of emergency visit before hospitalization			
Daily cost of emergency ward	12.83	12.19-13.46	γ(SD 3.20)
Direct medical cost per patient day			
Specialist referrals	10.67	10.31-11.01	γ(SD 1.72)
Chest physiotherapy	5.15	4.90-5.39	γ(SD 1.23)
Chest radiography	2.84	2.70-2.98	γ(SD 0.73)
Others diagnostic imaging	0.01	0.0-0.022	γ(SD 0.08)
Complete blood cell counts	1.12	1.05-1.17	γ(SD 0.28)
RSV test	2.71	2.83-3.03	γ(SD 2.72)
Other laboratory tests	4.40	4.23-4.47	γ(SD 0.37)
Oxygen	1.37	1.28-1.45	γ(SD 0.41)
Nebulization	16.23	1.28-1.45	γ(SD 4.52)
LEV	1.10	1.07-1.13	γ(SD 0.16)
Antibiotics systemics	1.21	1.11-1.30	γ(SD 0.49)
Systemic or inhaled corticosteroids	0.08	0.0-0.90	γ(SD 4.18)
Bronchodilators	0.04	0.03-0.04	γ(SD 0.02)
Other drugs	0.65	0.60-0.68	γ(SD 0.04)
Medical devices	10.24	9.71-10.76	γ(SD 2.66)
Indirect cost patient day	17.24	16.38-18.07	γ(SD 4.30)

HS indicates hypertonic solution; LEV, intravenous fluid; PICU, pediatric intensive care unit; RSV, respiratory syncytial virus.

Resource Use and Cost

The costs of each outcome defined previously were published previously by our group.[8] Briefly, we estimated the direct medical costs (medical consultation at the emergency room, specialist referrals, chest physiotherapy, diagnosis support, medications, medical devices, hotel services in the intensive care unit, and hotel services) of 193 patients with bronchiolitis in a multicentric study in Rionegro, Colombia. This study included indirect cost because the perspective of this study is of the Colombian national health system.[8] For the valuation of the indirect costs associated with the loss of parents' productivity, the human capital method was used, assuming everyone received an income of at least a legal minimum wage for formal or informal work. We used US dollars (currency exchange rate 2019 $1.00 = COP$3000)[18] to express all costs in the study.

Table 4. Budget impact.

	Overall number of patients	Number of patients treated with HS	Cost with HS ($)	Cost without HS ($)	Savings ($)	% savings
Year 1	6672	1668	12 496 239	13 032 044	535 805	4.11
Year 2	6772	3386	12 139 841	13 227 525	1 087 683	8.22
Year 3	6874	5155	11 769 940	13 425 937	1 655 998	12.33
Year 4	6977	6977	11 386 210	13 627 327	2 241 117	16.45
Total	27 294	17 186	47 792 230	53 312 832	5 520 602	10.36

HS indicates hypertonic solution.

Sensitivity Analyses

The robustness of the base case was evaluated with 1-way sensitivity analyses. The parameters used in the analysis were varied once as detailed in Table 3. Expert opinion and literature data were used to determine ranges of parameters to be tested in the sensitivity analysis. Results of the sensitivity analysis are presented in a tornado diagram showing the impact on the base case of uncertainty in the parameters used in the model. Threshold analysis of HS cost was performed to determine their threshold value. Microsoft Excel® was used in all analyses (Microsoft Corporation, Redmond, WA).

Results

Base-Case Results

In the base-case analysis, the 4-year costs associated with HS and no-HS were estimated to be $47 792 230 and $53 312 832, respectively, indicating savings for Colombian national health system equal to $5 520 602 if HS is adopted for the routine management of patients with acute bronchiolitis (Table 4). Savings by HS increased over the years because of the greater number of patients progressively receiving HS, with a final percentage of savings of 10.36%.

Univariate 1-way sensitivity analysis was performed to assess the robustness of the results from the base case. The major parameters used in the analysis were varied once, as detailed in Tables 2 and 3. Results of the sensitivity analysis are presented in a tornado diagram showing the potential impact of uncertainty about the main parameters used in the model on the base-case results (Fig. 1). In all analyses, the expected cost of HS was always lower than that without HS. In the threshold analysis of HS cost, the threshold value was $20.8 (Fig. 2). An increase in the total cost of HS per patient higher than this value resulted in a greater expected cost per patient in the HS scenario than the no-HS scenario ($259 vs $254) (Fig. 2) and a loss of the savings expected in the population, consequently.

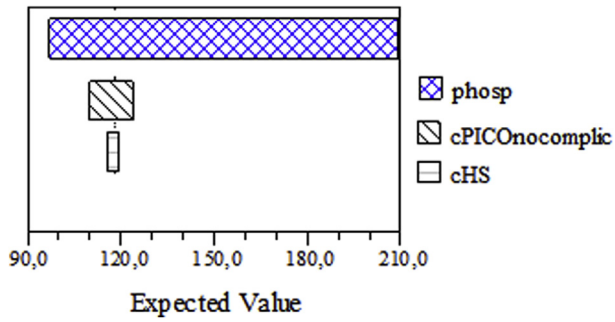
Discussion

Our study suggests that HS is cost saving for the treatment of infants with acute bronchiolitis. Bronchiolitis has a relevant impact on healthcare resources and related expenditures, especially in severe cases. Any intervention that reduces the burden of disease and costs is highly appropriate to any health system.[8,16] Compared with the current therapy without HS, in a 4-year analysis, the alternative with HS provided a total cost saving of $5 520 602. This study is the first economic analysis performed in Colombia showing the real impact that this therapy will have if adopted for the current treatment of patients with acute bronchiolitis. Perhaps HS has a "small" clinical effect, only reducing the hospital stay in each patient by 1 day on average,[19] but when this effect is evaluated at the population level, it transforms into a relevant alternative for saving resources of the Colombian health system. This is a clear example of an intervention that impacts outcomes such as duration of hospital stays—an outcome that is often undervalued in the clinical setting—that can be as relevant as interventions that impact mortality or complications to policy makers.

We consider this cost saving as relevant if we compare this saving with the budget allocated in Colombia for communicable diseases. The potential savings that could be achieved by routinely using HS in all cases of acute bronchiolitis would correspond to almost 6% of all spending on communicable diseases in Colombia, which is not a negligible value.[20] Our model was robust—HS was always the cost-saving strategy in all ranges of probabilities and costs evaluated. A relevant result was to find a per patient drug cost of the HS at which this therapy does not save cost. This threshold ($20.8) can be used as a reference for the control and regulation of prices in the country. Evidence related to the economic impact of this drug is essential to policy makers and physicians,[21] especially in developing countries where the economic evaluation of drugs and medical devices in pediatric patients is increasing.[12,22-25] In a previous publication, we demonstrated that HS was cost-effective in the inpatient treatment of infant bronchiolitis in Colombia,[24] In this economic model, HS was associated with lower total cost than controls ($200 vs $240 average cost per patient) and higher QALYs (0.92 vs 0.91 average per patient), showing dominance. Our study complements this cost-effectiveness analysis, explicitly showing the economic benefit of HS.

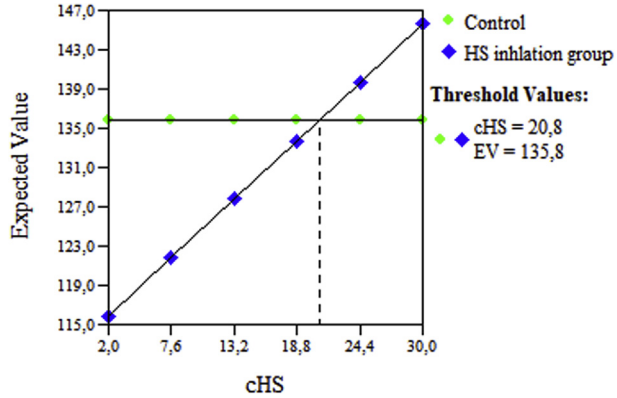
Our study has some limitations. We used retrospective data reported in a previously cost-effectiveness study, and this information did not exclude the possibility of missing data or that medical invoices were incomplete. This study reported that several measures were employed to ensure data accuracy, including software with automatic calculation functions and error alerts and a review of outliers by the research team. Another limitation in the design was the assumption of complete adherence to this therapy, which can reduce the budget impact of HS.

Figure 1. Tornado diagram.



cHS indicates cost of hypertonic solution.

Figure 2. Threshold analysis of HS cost.



cHS indicates cost of hypertonic solution; EV, expect value; HS, hypertonic solution.

Conclusion

HS was cost saving in emergency settings for treating infants with acute bronchiolitis. This evidence can be used by decision makers in Colombia to improve clinical practice guidelines and should be replicated to validate their results in other middle-income countries.

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