Identifying unit costs for use in regional economic evaluation: an illustrative analysis of childhood pneumococcal conjugate vaccine in Latin America and the Caribbean

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In conducting economic evaluations of new medical interventions, data from empirical studies offer a ready source of information regarding the use of health care resources by patients undergoing different treatments. Without major additions to the data collection burden, it is possible to record the frequency of consultations and hospitalizations, the length of hospital stays, and the number and type of diagnostic and therapeutic procedures used. However, converting the resource use data, which are measured in physical units, into cost data, for the purpose of cost-effectiveness analysis, requires the application of unit costs.

This poses problems when empirical studies are carried out on a multicenter basis, as unit costs vary across centers (i.e., unit costs observed in one center may not be representative of the country or health care system in which the study is being conducted), and direct measurement of unit costs in multiple centers to improve representativeness is usually expensive in terms of time and resources. While some countries have nationally recognized charges or reimbursement rates for particular procedures, these types of costs may not be at a sufficient level of disaggregation for use in the context of a research exercise, as they usually apply to episodes of care rather than individual consultations or treatments.

This problem is exacerbated when the empirical study is conducted on a multi-country basis (e.g., in an international study in which resource data have been collected across several countries). If the study has been designed to test hypotheses on the pooled data, the selection of unit costs (for converting resource use into costs) becomes even more problematic.

In conceptual and practical terms, the currently accepted method in economic evaluations is to measure resource use in the empirical study and apply unit costs derived from high-quality external sources (1). In international empirical studies, the most common practice is to apply the unit costs from one country to the pooled resource data for patients participating in the study, to facilitate cost-effectiveness comparisons. However, sources for this type of unit cost data are scarce, as are methods by which to develop such data for multinational studies.

Therefore, the main objective of this report is to provide a detailed example of how such costing might be done. The different methods of deriving unit costs are assessed and their appropriateness in particular situations discussed. Conceptual and practical problems of applying each method are addressed. The arguments are illustrated with examples from a 2006 regional economic analysis of a childhood pneumococcal conjugate vaccine (2).

COSTING METHODS

As with many economic concepts, cost is not uniquely defined. This is of particular importance in economic evaluations as such studies are context-specific (3) and therefore must be designed to reflect not only the nature of the problem being addressed but also the perspective of the decision-maker—the ultimate target of the results. In defining the unit costs required for an evaluation, it is helpful to consider four concepts: scope, scale, perspective, and measurement approach.

Scope

The scope of the resource unit being costed can range from very broad to very specific. For example, an economic evaluation of a pneumococcal conjugate vaccine designed to reduce the transmission of pneumococcal infections might use "number of pneumococcal disease cases avoided" as an appropriate indicator of benefit. Estimates of benefit might be based on "aggregated average cost for a pneumococcal disease episode" (i.e., the cost of the entire treatment process, from acute hospitalization through follow-up care and future long-term management of complications and sequelae) (4). On the other hand, an evaluation focused on the use of antibiotics for the treatment of pneumococcal disease would require a detailed breakdown of resource use within the treatment process, to determine whether the therapy changed the input mix (e.g., by reducing average hospital length of stay). In a micro-costing exercise of this nature, unit costs would be required for individual items of health care resource input, such as bed-days in different types of wards, specific diagnostic tests and drug therapies, and time spent by different groups of health care professionals.

While aggregate treatment costs can be calculated from detailed "bottom-up" costing exercises, they are more usually the result of "top-down" allocation of cost estimates. In the latter approach, costs for the elements of service directly attributable to a treatment strategy are combined with an allocation of overhead costs based on an accounting convention. The total is then divided by an activity rate to produce an average treatment cost. Pure "bottom-up" costing is based on the cost of a detailed list of items (disposables and consumables), laboratory tests, drugs used during treatment, and medical staff. Accounting methods similar to those described above are used to determine the per-patient cost of equipment used (e.g., respirators) as well as the department allocation (e.g., the cost of physical space). The selection of the approach is based on the degree of precision required in the analysis and the time and resources required to produce a detailed breakdown of unit costs.

Scale

Once the scope of the resource unit to be costed has been defined, the issue of scale, related to the level of activity in service provision, must be resolved. This issue is most critical if the service involves significant use of capital equipment, as in diagnostic imaging or radiography. The unit cost of an extra investigation will vary according to the capacity utilization of the equipment. Average costs can be high if utilization is low (and fixed costs are thus spread over a small number of investigations). They may also be high if utilization is high and average labor costs are increased by extra charges for working outside normal hours. On the other hand, marginal costs of extra investigations may be low when there is excess capacity.

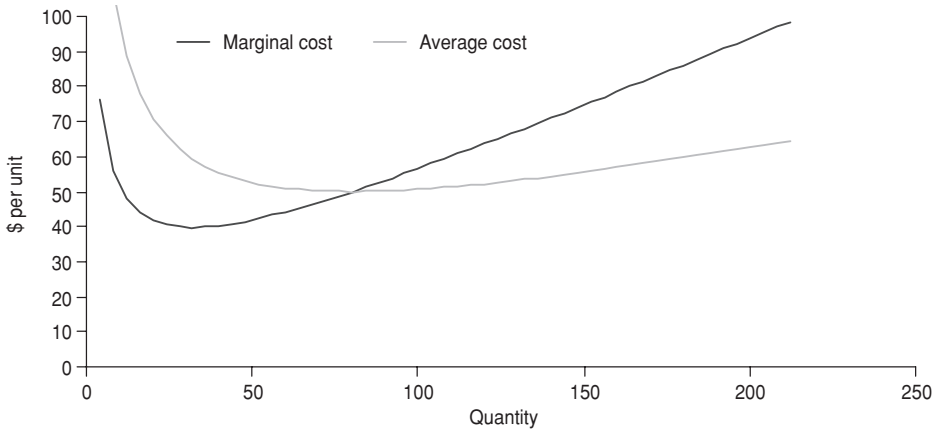
The achievement of true economies of scale by increasing the size of service provision facilities has not been generally observed beyond relatively low threshold output levels (3). For specialist services, these discounts may arise from more efficient use of highly trained human resources and, more commonly, from the purchase of bulk supplies (by larger hospitals and clinics). Further discussion of these issues is given below in relation to measurement approaches and the dimension of time.

Perspective

The decision on which costs and benefits to include in an economic evaluation is governed by the perspective being adopted in the analysis. The most frequent perspectives are those of the patient, the health care system, and society at large. The main impact of the choice of perspective is on the number of items for which unit costs are required. For example, the patient with no co-payment obligations may be interested in the cost of travel to the hospital as well as the cost of any treatment, whereas health service providers may not be concerned about the effect of illness or therapy on demands for other public services. The scope of costs required by the societal perspective is all-inclusive, because, in principle, all costs to any party must be included. The 2006 economic analysis described in this report was conducted exclusively from the health care perspective. Therefore, costing focused on the health care costs of treatment. The option of a health care perspective has specific implications in terms of modeling consumer and provider behavior and, because it only considers the costs and effects for which the health care provider is accountable, limits the validity of any conclusions that may be drawn about impact on public health. Adoption of a societal perspective is therefore recommended for this type of study. However, use of the latter approach may be problematic in Latin American and Caribbean (LAC) countries, where valuating productivity losses, detecting long-term disabilities, and assigning value to the associated loss of future earnings or productivity is difficult due to the large proportion of informal workers.

The degree of difficulty in obtaining precise estimates of unit costs for the disparate elements of the resource use often determines the perspective of costing. If other costs are highly correlated with the more read-

FIGURE 1. Marginal costs versus average costs: the effect of scale (level of activity) on unit costs associated with disease management



Source: Authors' compilation.

ily identifiable health care costs, then failure to be comprehensive may not bias the results of an incremental economic analysis (5).

Measurement approach

The most straightforward method of measuring the value of resources used in health care is to use the price paid by the acquiring organization. In the absence of market distortions (taxation, external effects, excess profits from market control, etc.), price is a good approximation of the social value of those resources, reflecting the demand for their use by different producers, and may therefore be close or equal to the unit cost indicated by the social opportunity cost approach. However, the possibility of skewed conclusions stemming from the assumption that charges reflect actual costs should be considered, especially in a public sector that typically does not know its costs. When results are assumed to be biased (due to pricing or market distortions), it is important to determine the extent or, at a minimum, the direction of the bias (i.e., whether the value is overestimated or underestimated).

A closely related set of problems in determining unit costs arises from the time dimension of cost definitions and the associated issue of capacity utilization. Most economic evaluations of health care are partial equilibrium analyses (i.e., aspects of the economic system not directly involved in the change in resource use under evaluation are assumed to be unaffected, and only marginal changes in the affected areas are considered relevant). These types of studies therefore demand the use of short-term marginal costs (whereas in practice it is much easier to obtain average costs, over larger ranges of output). Nonetheless, the dimension of time should be considered, as what is fixed in the short term can be variable over the medium and long term. For example, if there is spare cold chain (temperature-controlled storage and distribution) capacity, the extra cost of one additional vaccination—and the resource savings to be made by avoiding it—may be very small. However, if enough vaccinations can be avoided over the medium or long term to prevent the need for cold chain expansion, then the savings may be closer to average costs than marginal costs. In other words, the longer the time horizon the greater the flexibility of resource use, and the greater the chance of achieving genuine reallocation of resources.

To address these factors, and avoid confusion with the strict economic concept of marginal cost, it is now common to refer to the incremental costs of a change in health care programs (6). The range over which incremental costs are measured will depend on the characteristics of the technology. For technology involving investment in expensive equipment, the incremental cost is likely to be the average over a broad range of potential output levels. For pharmaceutical treatments, the relevant incremental and marginal costs may be quite similar, if special administration of a drug is not required.

Figure 1 depicts how marginal and average costs can vary depending on the scale (level of activity). Marginal costs can change dramatically with each additional unit of resource use. As average costs rise, marginal costs are generally above average costs, and when average costs decrease, marginal costs are generally below average costs. Marginal costs more accurately reflect diminishing marginal returns on productivity. This implies that with an increase in the variable inputs into production (material and labor), there is decrease in the rate of output.

Costing in single- and multi-country analyses

The issues described above must be tackled in both single- and multi-country costing exercises. In multi-country (regional) analyses, a standardized form of resource data collection is required if pooled analysis of costs is planned. The range of cost-generating events recorded must be consistent, even if there are variations between patients in terms of the frequency of the events.

This report focuses on the unit costs that are applied to resource data to derive cost comparisons in multi-country analyses. In the absence of approved national costing lists, such as those used in Australia (7), or comprehensive cost databases from which average costs for each procedure can be calculated, as commonly used in the United States (8), it is difficult to obtain a consistent set of unit costs, particularly in LAC countries, where the bulk of care is provided free to patients at the point of use, and hospitals receive global annual budgets only loosely related to the volume of output.

Nevertheless, the task of developing unit costs must be undertaken, using whatever data are available. The particular problems encountered in an exercise of this kind are illustrated below using an example from the above-mentioned 2006 economic analysis, which evaluated a pneumococcal conjugate vaccine designed to reduce the incidence of acute otitis media (AOM), pneumococcal pneumonia, and invasive pneumococcal disease or IPD (e.g., pneumococcal sepsis and pneumococcal meningitis), as well as the number of deaths resulting from these conditions (9, 10).

COST-EFFECTIVENESS OF PNEUMOCOCCAL CONJUGATE VACCINATION IN LATIN AMERICA AND THE CARIBBEAN

Cost-effectiveness of Pneumococcal Conjugate Vaccination in Latin America and the Caribbean was a regional analysis conducted in 2006 that evaluated the costs and benefits of the pneumococcal conjugate vaccine compared with standard care (2). The main aim of this analysis was to inform local health authorities about the burden of pneumococcal disease and the economic value of implementing a pneumococcal conjugate vaccination program in the region. The study was chosen as an illustrative example for this report because it presented the full range of problems described above in terms of planning the costing, due to its complex mix of variables related to the provision of different types of care in multiple settings (e.g., hospital days, medical personnel time, outpatient visits, diagnostic tests, and medications).

In the 2006 study, data on resource utilization were collected in each country to allow for a regional economic evaluation. The study model estimated the health outcomes[8] and costs associated with a pneumococcal conjugate vaccine in a pooled annual birth cohort of children. The estimates were developed using a generalized model populated with a combination of country-specific data and (where data were lacking) data extrapolated from other countries. Health outcomes were evaluated at a regional level, and both costs and health outcomes were analyzed from the health care perspective, discounting costs at the appropriate rates for each country studied. Non-medical costs borne by governments and families were not considered in the analysis due to the lack of available data. Because of scarcity of reliable information, the approach used to derive resource use and cost data was considered suitable for the analysis. Although the omission of non-medical costs was deemed acceptable, given the circumstances of the study, it should be noted that the relative value of such costs is considerable, based on external evidence (e.g., in rural communities, travel costs may affect access to facilities much more than the actual cost of the service, and may sometimes be the main barrier).

The 10 countries studied in the 2006 analysis were Argentina, Brazil, Chile, Colombia, Dominican Republic, Honduras, Mexico, Panama, Uruguay, and Venezuela. These countries were selected because of their geographic representativeness, income diversity, availability of data, and potential to involve local experts in the analysis. The countries were divided into three income strata (low, ≤US$ 2 130; lower-middle, US$ 2 131–US$ 3 820; and upper-middle, ≥US$ 3 821), based on 2005 gross national income (GNI—formerly GNP) per capita (11). The study targeted low, lower-middle, and upper-middle income countries to help fill the gap in health economic evaluation data for these income brackets.

Resource use and unit cost data for the 2006 analysis were drawn from a mixture of national administrative data, specific hospital costs and charges, national average costs, and registered product/service pricing, as well as a previous multicenter economic study conducted in 2001 in Brazil, Chile, and Uruguay (12) in which 25 physician interviews were conducted to characterize the typical management of pneumococcal disease. All physicians interviewed in Brazil for the 2001 study were from the state of Goiás. Physicians interviewed in Chile were from the metropolitan region of Santiago and from the cities of Concepción and Temuco. Physicians interviewed in Uruguay came from Montevideo. The interview forms were piloted in each country, along with guidance interview forms. Three sets of questions were included in the interview forms. The first set focused on patients with IPD, the second set on patients with pneumococcal pneumonia, and the third set on patients with AOM. Clinicians were contacted during country visits, and interviews lasting no more than 45 min were conducted during the course of these visits. While the majority of the physicians interviewed were pediatricians working in the public sector, infectious disease specialists, neurologists, neurosurgeons, ear-nose-throat (ENT) specialists, and family doctors in both the public and private sectors were also consulted.

The 2001 study combined unit cost estimates with patient-based resource use data to estimate the unit costs of service provision. The unit cost estimates were obtained from the accounting departments of various health care institutions and national billing systems in each country.

The 2006 analysis applied the information from the 2001 study, using the methodology described

[8] In this case, health outcomes refers to cases averted, hospital admissions averted, outpatient visits averted, life years saved, and disability-adjusted life years (DALYs) averted.

above, supplemented by data from an additional 57 physician interviews conducted in the 10 countries participating in the research. As in the 2001 study, the resources used for management of pneumococcal disease were classified based on type of care provided. A comprehensive list was drawn up of items for which unit costs were required in each country. The list included administered antibiotics and other medications, by type, frequency, duration, and route of administration; in-patient days, by specialty (level of care) and duration; outpatient clinic consultations, by type and frequency; laboratory tests and radiography, by type and frequency; and surgery and other procedures, by type and frequency.

Scope of costing

The 2006 analysis examined various questions related to effects on costing, such as whether costs were reduced because patients receiving the vaccine had fewer pneumococcal infections, and whether treatment therapies were less costly because patients receiving the vaccine experienced reduced length of stay in the hospital.

Due to the need to calculate the breakdown of costs within treatment strategies, the use of aggregate treatment costs based on hospital charges or health system reimbursement rates was not possible without additional data. The scope of the resource units to be costed had to be more detailed. This level of micro-costing required unit costs for each element of care, including per diem costs[9] for intensive care and regular hospital ward care, and prices paid by hospitals for drugs and diagnostic tests and procedures.

The solution adopted was to use the specialty per diems when there was confidence that they were the closest estimate of the per diem rate. This approach assumes the possibility of some element of double-counting. The seriousness of this risk and the extent of potential bias introduced are related to the intervention rate in the specialty concerned. For example, if patients with deafness related to pneumococcal meningitis stayed in the hospital for just one night after receiving a cochlear implant, the average cost related to the procedure (versus ward costs) would be high. Applying this cost as the specialty's average daily cost to additional days spent in the hospital after a procedure would lead to serious over-estimation of costs. On the other hand, if the typical pneumococcal patient in a specific specialty spends several days in the hospital for diagnostic tests and medical management, the average specialty cost per day will be a much closer estimate of the additional cost of extra days in hospital. The data available in the 10 selected countries allowed varying degrees of confidence that these problems were minimized. In future economic evaluations of this type, the importance of precision in these costs should be tested through sensitivity analysis.

[9] Accommodation and administration costs (bedding, building, utilities, maintenance, administration, and equipment); food; and personnel.

Scale and timing

The use of incremental costs was another important feature of the 2006 analysis (which assessed the impact of a pneumococcal conjugate vaccine on the frequency of cost-generating events). The incremental ranges over which these costs were estimated varied, resulting in the use of both marginal and average costs. The costs of diagnostic tests for chest x-rays, for example, were largely average costs. On the other hand, prices for items such as hospital stays were clearly marginal costs to the health care system. The costs of procedures such as lumbar puncture and tympanoplasty fell between these two categories. It should be noted, however, that many of the resources used in patient management in the 2006 analysis were likely to be convertible to other uses within a relatively short time horizon, so the use of average as well as marginal costs was not thought to be a serious problem.

Perspective and measurement

The goal of the 2006 costing exercise was to estimate, by country, the costs of specific health care resources. Although these costs were not strictly health care system costs (as there were elements of patient co-payment for certain items of care in all 10 countries studied), they were analyzed exclusively from the health care perspective, as described and explained above.

In most of the countries studied, the predominant mode of health care provision is organized by central government and funded by social insurance or directly from taxation. The preferred method of measurement was therefore social opportunity cost, based on the assumption that this approach was the most relevant to top-level health-policy developers. In some instances, however, hospital charges or health system reimbursement rates had to be used. In these cases, the data were assumed to reflect actual resource costs. As stated above, the potential distortions stemming from the assumption that these types of institutional charges reflect actual costs may be considerable.

Unit costs for the 10 LAC countries

The results of the 2006 unit cost collection exercise are presented in Tables 1–4. To estimate regional average costs, country data were weighted by population size, to reflect the contribution of each country to the total regional population. As shown in the tables, the relative costs of the different items were consistent region-wide. For example, in all countries studied, the cost of a day in intensive care was higher than that for a day in a pediatric ward; radiographs cost more to perform than laboratory tests; and antibiotics were generally more costly than other medications (e.g., paracetamol, decadron, and dexamethasone).

Though the main focus of the 2006 study was on country-specific analyses, the estimated costs were

TABLE 1. Resource unit costs[a] for chest x-ray–confirmed (clinical) pneumonia, by income group,[b] based on pneumococcal conjugate vaccine economic analysis conducted in 10 Latin American and Caribbean countries[c] in 2006

	Low income (≤$2 130)[d,e]	Lower-middle income ($2 131–$3 820)[d,e]	Upper-middle income (≥$ 3 821)[d,e]
Inpatient			
Diagnostics (per test)			
Polymerase chain reaction (PCR)	5.59	0.86	0.23
Blood test	4.40	7.02	2.53
Bacteriology	3.80	3.35	0.17
Antibiotics[f] (per treatment course)	13.78	16.66	17.08
Other medications[g] (per treatment course)	11.51	20.01	8.40
Outpatient visits preceding or following hospitalization (per visit)	6.02	8.85	30.89
Hospitalization (per bed-day)			
Pediatric ward	37.60	81.96	155.97
Intensive care unit (ICU)	50.70	154.08	218.05
Radiography (per study)	15.15	11.92	32.16
Procedures[h] (per procedure)	940.69	1,323.01	1,797.43
Oxygen therapy (per session)	9.72	6.19	15.51
Physiotherapy (per session)	8.88	5.24	4.46
Outpatient			
Diagnostics (per test)			
Blood test	5.40	7.02	2.41
Bacteriology	NR[i]	1.04	NR
Antibiotics[f] (per treatment course)	9.19	17.50	17.08
Other medications[g] (per treatment course)	11.37	20.04	8.40
Outpatient visits preceding or following hospitalization (per visit)	6.02	4.65	30.89
Physiotherapy (per session)	8.14	9.14	4.46

[a] Unit costs were drawn from previously published work by the lead author (D. Constenla, Evaluating the costs of pneumococcal disease in selected Latin American countries, Rev Panam Salud Publica 2007;22(4):268–78) and a mixture of national administrative data, specific hospital costs and charges, national average costs, and registered product/service pricing.
[b] Based on 2005 per capita gross national income (GNI—formerly referred to as GNP), calculated according to the World Bank Atlas method (World development indicators, World Bank Group, 2005).
[c] Argentina, Brazil, Chile, Colombia, Dominican Republic, Honduras, Mexico, Panama, Uruguay, Venezuela.
[d] Updated from 2006 USD (as used in the original study) to 2007 USD by the authors of the current study.
[e] Regional average (weighted by country population).
[f] Average cost based on data on specific antibiotics used in management of chest x-ray–confirmed (clinical) pneumococcal pneumonia patients.
[g] Paracetamol, decadron, dexamethasone, ranitidine, and acyclovir, among others.
[h] Lumbar puncture, tympanoplasty, transfusion, thorascentesis, and catheter insertion, among others.
[i] NR = not reported.

TABLE 2. Resource unit costs[a] for pneumococcal meningitis, by income group,[b] based on pneumococcal conjugate vaccine economic study conducted in 10 Latin American and Caribbean countries[c] in 2006

	Low income (≤$2 130)[d,e]	Lower-middle income ($2 131–$3 820)[d,e]	Upper-middle income (≥$ 3 821)[d,e]
Diagnostics (per test)			
Blood test	20.53	2.80	0.29
Bacteriology	NR[f]	1.78	0.50
Lumbar puncture	NR	4.13	0.66
Cerebral spinal fluid (CSF)	NR	11.37	0.30
Ligase chain reaction (LCR)	3.98	NR	5.49
Latex	1.21	NR	NR
Chemistry	0.66	NR	11.51
Antibiotics[g] (per treatment course)	21.69	13.33	20.55
Other medications[h] (per treatment course)	19.23	14.39	11.71
Outpatient visits preceding or following hospitalization (per visit)	NR	NR	30.44
Hospitalization (per bed-day)			
Pediatric ward	87.10	60.02	174.93
Intensive care unit (ICU)	130.68	114.37	245.13
Oxygen therapy (per session)	3.98	6.19	16.74
Radiography (per study)	NR	20.46	31.91
Procedures[i] (per procedure)	3 338.98	2 609.98	1 687.61

[a] Unit costs were drawn from previously published work by the lead author (D. Constenla, Evaluating the costs of pneumococcal disease in selected Latin American countries, Rev Panam Salud Publica 2007;22(4):268–78) and a mixture of national administrative data, specific hospital costs and charges, national average costs, and registered product/service pricing.
[b] Based on 2005 per capita gross national income (GNI—formerly referred to as GNP), calculated according to the World Bank Atlas method (World development indicators, World Bank Group, 2005).
[c] Argentina, Brazil, Chile, Colombia, Dominican Republic, Honduras, Mexico, Panama, Uruguay, Venezuela.
[d] Updated from 2006 USD (as used in the original study) to 2007 USD by the authors of the current study.
[e] Regional average (weighted by country population).
[f] NR = not reported.
[g] Average cost based on data on specific antibiotics used in management of pneumococcal meningitis patients.
[h] Paracetamol, decadron, dexamethasone, ranitidine, and acyclovir, among others.
[i] Lumbar puncture, tympanoplasty, transfusion, thorascentesis, cochlear implantation, and catheter insertion, among others.

TABLE 3. Resource unit costs[a] for all-cause acute otitis media (AOM), by income group,[b] based on pneumococcal conjugate vaccine study conducted in 10 Latin American and Caribbean countries[c] in 2006

	Low income (≤$2 130)[d,e]	Lower-middle income ($2 131–$3 820)[d,e]	Upper-middle income (≥$ 3 821)[d,e]
Diagnostics (per test)	4.02	5.96	0.66
Antibiotics[f] (per dose)	9.54	17.88	2.71
Other medications[g] (per dose)	9.80	20.04	2.41
Outpatient visit (per visit)	5.10	8.86	1.51
Procedures[h] (per procedure)	106.75	292.42	337.46

[a] Unit costs were drawn from previously published work by the lead author (D. Constenla, Evaluating the costs of pneumococcal disease in selected Latin American countries, Rev Panam Salud Publica 2007;22(4):268–78) and a mixture of national administrative data, specific hospital costs and charges, national average costs, and registered product/service pricing.
[b] Based on 2005 per capita gross national income (GNI—formerly referred to as GNP), calculated according to the World Bank Atlas method (World development indicators, World Bank Group, 2005).
[c] Argentina, Brazil, Chile, Colombia, Dominican Republic, Honduras, Mexico, Panama, Uruguay, Venezuela.
[d] Updated from 2006 USD (as in the original study) to 2007 USD by the authors of the current study.
[e] Regional average (weighted by country population).
[f] Average cost based on data on specific antibiotics used in management of AOM patients.
[g] Paracetamol, decadron, dexamethasone, ranitidine, and acyclovir, among others.
[h] Lumbar puncture, tympanoplasty, transfusion, thorascentesis, and catheter insertion, among others.

TABLE 4. Resource unit costs[a] for pneumococcal sepsis, by income group,[b] based on pneumococcal conjugate vaccine study conducted in 10 Latin American and Caribbean countries[c] in 2006

	Low income (≤$2 130)[d,e]	Lower-middle income ($2 131–$3 820)[d,e]	Upper-middle income (≥$ 3 821)[d,e]
Diagnostics (per test)			
Blood test	7.01	NR[f]	0.29
Polymerase chain reaction (PCR)	4.85	NR	1.09
Ligase chain reaction (LCR)	19.16	NR	NR
Blood culture	0.86	NR	NR
Urine culture	3.90	NR	0.50
Antibiotics[g] (per treatment course)	19.35	NR	2.71
Other medications[h] (per treatment course)	17.08	NR	2.41
Outpatient visits preceding or following hospitalization (per visit)	7.99	NR	1.51
Hospitalization (per bed-day)			
Pediatric	47.87	NR	187.71
Intensive care unit (ICU)	51.03	NR	267.92
Oxygen therapy (per session)	8.40	NR	0.57
Radiography (per study)	14.32	NR	NR
Procedures[i] (per procedure)	826.85	NR	NR

[a] For all countries except Chile (where average costs were calculated and provided by in-country physicians), unit costs were drawn from previously published work by the lead author (D. Constenla, Evaluating the costs of pneumococcal disease in selected Latin American countries, Rev Panam Salud Publica 2007;22(4):268–78) and a mixture of national administrative data, specific hospital costs and charges, national average costs, and registered product/service pricing.
[b] Based on 2005 per capita gross national income (GNI—formerly referred to as GNP), calculated according to the World Bank Atlas method (World development indicators, World Bank Group, 2005).
[c] Argentina, Brazil, Chile, Colombia, Dominican Republic, Honduras, Mexico, Panama, Uruguay, Venezuela.
[d] Updated from 2006 USD (as used in the original study) to 2007 USD by the authors of the current study.
[e] Regional average (weighted by country population).
[f] NR = not reported.
[g] Average cost based on data on specific antibiotics used in management of pneumococcal sepsis patients.
[h] Paracetamol, decadron, dexamethasone, ranitidine, and acyclovir, among others.
[i] Lumbar puncture, tympanoplasty, transfusion, thorascentesis, and catheter insertion, among others.

applied to a set of resource use data derived from health centers across several countries, so the items being costed proved consistently defined in terms of income level (e.g., unit costs from upper-middle income countries were higher than those in lower-income countries). As shown in Tables 1–4, this held true for all variables except diagnostic tests (e.g., polymerase chain reaction (PCR), blood tests, and bacteriology tests), where consistencies arose from genuine variance in the relative costs of the items, differences in financial responsibilities between health and non-health agencies, and multiple definitions of the item or service being used. These findings are consistent with those in the 2001 study (12).

Although the health care resource use items for the 2006 study were defined a priori, some items were not used consistently in certain countries (e.g., the technology required for laboratory tests such as PCR and latex was not always available). In addition, some resources use item cost estimates were missing from the hospital records from which the study data were drawn. This variance in the level of country-specific data on the predefined health resource items required the use of a variety of costing methods. In some cases,

costs could not be obtained. It should also be noted that in some cases the costs of certain procedures seemed disproportionately high, sometimes due to hospital stays in the intensive care unit (ICU).

In addition, several a priori hypotheses did not hold true throughout the course of the costing exercise. For example, the expectation that all resource items (including diagnostic tests) would be more expensive in higher-income countries compared to lower-income countries was not supported by the study results (i.e., in some higher-income countries diagnostic testing was noticeably cheaper). This was attributed to the fact that capacity was always available in higher-income countries for such items and therefore the acuteness of the patient's condition did not appear to influence resource use for treatment. In addition, the assumption that out-of-hours emergency procedure staffing costs were always higher than those for regular procedures was disputed by clinical advisers, who asserted the extra costs of calling in higher-level staff during off hours might be offset by the smaller numbers of regular staff present at such procedures.

Costs of follow-up care for children with pneumococcal disease were difficult to estimate, due to the lack of reliable data sources for follow-up care in the LAC region. For this reason, the cost estimates used in the 2006 analysis were based on those collected in the 2001 study (12). It should be noted that although these costs were comprehensive and internally consistent for the three countries studied in 2001, they might not be regionally representative. In addition, as long-term care costs varied widely, sensitivity analysis of the unit costs would be essential to confirm the robustness of any conclusions.

On the question of potential double-counting of medical staff costs in procedures and per diems, there was a variable experience across countries. This was not considered a problem with regard to ICU costs, as the staff in that unit work separately from those providing regular pediatric care. However, there was a possibility of overlap in regular pediatric care, and in pediatric ward care—the main area of difficulty for estimating costs. In some of the lower-middle income countries covered in the study (e.g., Brazil), it was considered feasible to estimate a per diem (including hotel, nursing, and medical costs) without including the cost of medical staff elements of the procedures, which were costed separately. In the higher-income countries, however, some of the general pediatric ward per diems may have included some medical time spent on procedures. It should be noted that in the case of Chile, hospitals are only allowed to claim 80% of the per diem rate if they are claiming the procedure rate. Consideration of this 80% cap might be a useful rule of thumb in sensitivity analysis on this issue for all countries.

Cost data sources

Examples of cost data sources for the main resource items in each country are summarized in Table 5. As shown in the table, the largest costs are those for hospital stays in different types of wards for pneumococcal meningitis and pneumococcal sepsis. The costs for these items were either drawn from previously published studies or national administrative data, or constructed from detailed micro-costing exercises in specific institutions. The results from each source were consistent for the three income categories (low, lower-middle, and upper-middle). A regional average cost (weighted by country population) was calculated for each category. For the low-income countries (Colombia, Dominican Republic, and Honduras), national administrative data and data from local finance departments proved good sources of costs for inpatient and ambulatory care. For the lower-middle income countries (Argentina, Brazil, Uruguay, and Venezuela), the equivalent figures were calculated using data from finance departments of local hospitals, and national administrative data. The 2001 study (12) was also a good source of cost estimates. For the upper-middle income

TABLE 5. Examples of resource unit cost sources in pneumococcal conjugate vaccine study conducted in 10 Latin American and Caribbean countries, 2006

Country	Hospital stays	Drugs	Diagnostic tests	Procedures
Argentina	Specific hospital costs	Registered prices	Hospital charges	Hospital charges
Brazil	National administrative data, cost studies[a]	Registered prices	National administrative data	National administrative data, cost studies[a]
Chile	Specific hospital costs, cost studies[a]	Registered prices	Hospital charges, cost studies[a]	Hospital charges, cost studies[a]
Colombia	National average cost	Registered prices	Hospital charges	Hospital charges
Dominican Republic	National average costs	Specific hospital price paid	Hospital charges	Hospital charges
Honduras	National average costs	Specific hospital price paid	Hospital charges	Hospital charges
Mexico	Major academic hospital costs	Registered prices	Hospital charges	Hospital charges
Panama	National average costs	Registered prices	Hospital charges	Hospital charges
Uruguay	Specific hospital costs, cost studies[a]	Specific hospital price paid	Hospital charges, cost studies[a]	Hospital charges, cost studies[a]
Venezuela	National average costs	Registered prices	Hospital charges, cost studies	Hospital charges

[a] Constenla D. Evaluating the costs of pneumococcal disease in selected Latin American countries. Rev Panam Salud Publica. 2007;22(4):268–78.

countries (Chile, Mexico, and Panama), these estimates were constructed in a micro-costing exercise using data from specific hospitals and groups of hospitals, and national average statistics.

In many of the 10 countries studied in the 2006 analysis, there were significant differences between the costs of care in the public and private sector, presenting an added complication. However, data on the private sector was scarce. For these reasons, only public health sector costs were considered in the analysis. While the exclusive use of public sector data seemed justified for this study, given the circumstances, it most likely resulted in an underestimation of overall costs, especially in the poorer countries, where private providers (and private expenditures) tend to outnumber public ones. Follow-up research on this issue is recommended.

The potentially significant costs of surgeries (e.g., cochlear implant) and other procedures (e.g., lumbar puncture, tympanoplasty, and thorascentesis) were generally based on cost data from a small sample of hospitals in each of the participating countries. In the lower-middle income countries, for example, costs were based on national average figures calculated for use in the hospital reimbursement process. The cost per stay as an inpatient was calculated by taking into account the per diem rate by the length of stay and adding the cost of diagnostics and medications.

The cost per outpatient visit was calculated as the weighted mean of the cost of visiting a pediatrician or emergency unit based on the proportion seen in each of the two outpatient settings. Costs for the two types of outpatient visits in the public sector were based on the average given by the finance departments of public institutions, and administrative sources described above.

Drug costs were based on average doses used in the LAC region. In most countries, prices charged to hospitals were used, but in one of the upper-middle income countries (Chile), these were considered too variable to produce reliable data, considering the small number of hospitals. In these cases, registered prices were used. In each country, the price basis for all drugs was consistent.

For the lower-cost items, such as diagnostic tests, costs were generally obtained from hospital charges. For diagnostics normally absorbed in other charges, such as blood tests, estimates were calculated using micro-costing, based on resource input data from clinicians. Minor procedures for which standard charges or reimbursement rates did not exist were also costed this way (e.g., transfusions and catheter insertions).

DISCUSSION

To the best of the authors' knowledge, this is the first study to explore issues surrounding the selection and construction of unit cost data for use in multi-country economic analyses—and the first to discuss their appropriateness within the context of the LAC region. It is evident from the illustrative study described in this report that deriving unit costs for the purpose of assessing treatment costs is an empiric process. While it is helpful to consider the scope, scale, perspective, and measurement approach in deriving unit costs, the application of these principles is not straightforward.

Using data from the 2006 analysis, this report illustrates how a credible set of unit costs, based on a judicious mix of published data, reimbursement rates, charge data, and new micro-costing methods, was assembled for use in an economic evaluation of pneumococcal conjugate vaccine in 10 LAC countries. While it may not be reasonable to expect similar costing exercises to be carried out in each country to test the cost-effectiveness of each new medical technology, in order to make the best use of cost data from past evaluations (and to expand and improve cost data over time), it would be helpful if future costing exercises were carried out using a comparable approach. In the 10 countries analyzed in 2006, an attempt was made to standardize some elements of costing by producing an official manual of resource items and unit costs for use in economic evaluations of drugs (however, according to the 2006 analysis, further micro-costing of a drug is necessary when its use alters the rate or cost of treatment). Until these types of standardized listings are produced in each country, practitioners of economic evaluation must exercise judgment in the selection of appropriate unit costs. In future analyses, it would also be useful to investigate different methods for costing time and non-medical costs.

Another issue recommended for future study is whether the results of cost-effectiveness analysis are sensitive to differences in unit costs. For example, in the three middle-income LAC countries studied in 2001, analyses of the cost-effectiveness of the pneumococcal conjugate vaccine were moderately sensitive to changes in aggregated disease costs per case (12). However, to the best of the authors' knowledge, no published analyses have considered variation in the unit costs underlying aggregated disease costs per case in sensitivity analysis, underscoring the need for further work in this area.

The 2006 study's use of a variety of data sources, including reimbursement rates and unadjusted charge data, and the small number of hospitals sampled within countries, may be considered limitations. However, this method provides one solution to the challenge of developing unit cost data for multi-country analyses, particularly when resources, including analytic time, are constrained. Another potential limitation of the 2006 study was its exclusive focus on the public health care system (resulting from the deliberate exclusion of private health care providers described and explained above). Despite this exclusion, it should be noted that the methods developed in this study are, in general, appropriate for analyses that include the private health care system. It should also be noted that several important issues deemed beyond the scope of this report, such as discounting and updating costs; evaluation of indirect unit costs; and valuation of non-

medical direct unit costs, such as caregiver time, are pertinent to multi-country analyses and should be considered in any future costing exercises.

While there is no single theoretically correct approach to identifying unit costs for use in regional economic evaluations, certain generally accepted principles should be adhered to, including the adoption of a societal perspective, where possible; the inclusion of all relevant costs and effects; the use of an adequate sample size, and sensitivity analysis, for all areas of uncertainty; verification that the data is representative; and synthesis of data sources through mathematical models, when required. Beyond these core principles, several issues remain regarding optimal collection and valuation of unit cost data.

For example, many factors cause cost variations. The findings of the multiple linear regression analysis conducted in the 2001 study (12) highlighted some of the key sources of variation in unit cost estimates for pneumococcal pneumonia (e.g., level of service provided, and country in which costs are incurred). The disparate nature of national health care system organization, delivery of care, and reimbursement of providers leads to a variable quantity and quality of readily available data on costs across countries. While the methods described in this report are applicable in the development of country-level unit cost data sets, use of the regional-level unit costs presented here are not recommended for individual countries, as the applicability and reliability of regional data at the country level can not be assured.

One last consideration is cost variance between country groupings by income. For example, health care costs among the poorest inhabitants of the rich countries are likely to be higher than those among the richest inhabitants of the poorer countries. Understanding the variance between these country groupings is a complex process that requires innovative approaches to tackling the myriad of potential factors involved. The challenge lies in identifying relevant factors to consider under different circumstances. Future studies should include more in-depth evaluation of the causes of this variance.

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SINOPSIS

Identificación de los costos unitarios para evaluaciones económicas regionales: análisis ilustrativo de la vacuna conjugada infantil antineumocócica en América Latina y el Caribe

Se analizan algunos temas relacionados con la selección y la construcción de los datos de costos unitarios para utilizar en análisis económicos regionales, con ejemplos ilustrativos de un análisis de la vacuna conjugada infantil antineumocócica realizado en 10 países de América Latina y el Caribe en 2006. El objetivo del análisis fue obtener un conjunto consistente de costos unitarios de recursos empleados en el tratamiento de la enfermedad neumocócica, según una bien ponderada combinación de datos publicados, tasas de reembolso, datos de cobro y nuevos métodos de determinación de costos detallados. Los pasos previos al análisis abarcaron la determinación del grado de detalle requerido, la definición del intervalo de costos de interés y la selección de conceptos de medición apropiados. Se determinó el costo detallado de los ítems mediante la descomposición de los componentes del tratamiento. Para el análisis se utilizaron los costos promedio ponderados por la población. En este informe se describen los diferentes métodos de determinación del costo empleados en el estudio y los problemas conceptuales y prácticos encontrados para su aplicación. También se identifican los posibles retos para generalizar este enfoque a otros escenarios de determinación de costos con otras enfermedades.

Palabras clave: *Streptococcus pneumoniae;* costo de enfermedad; métodos; América Latina; Caribe.

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