1 **Examining the cost of delivering routine immunization in Honduras**

2 Cara Bess Janusz^{a*}, Carlos Castañeda-Orjuela^b, Ida Molina Berenice^c,

3 Ana Gabriela Felix Garcia^a, Lourdes Mendoza^c, Iris Yolanda Díaz^c, Stephen C. Resch^d

4 a. Comprehensive family immunization unit, Pan American Health Organization, Washington, DC,
5 USA

6 b. Epidemiology and Public Health Evaluation Group. Universidad Nacional de Colombia, Bogota,
7 Colombia

8 c. Programa Ampliado de Inmunizaciones, Secretaría de Salud, Tegucigalpa, Honduras

9 d. Center for Decision Science, Harvard University, Boston, MA, USA

10

11 * Corresponding author: Pan American Health Organization, 525 23rd Street NW, Washington, DC,
12 USA; Tel.: 202-974-3744.

13 Email address: januszc@paho.org;

14

ABSTRACT

Background: Many countries have introduced new vaccines and expanded their immunization programs to protect additional risk groups, thus raising the cost of routine immunization delivery. Honduras recently adopted two new vaccines, and the country continues to broaden the reach of its program to adolescents and adults. In this article, we estimate and examine the economic cost of the Honduran routine immunization program for the year 2011.

Methods: The data were gathered from a probability sample of 71 health facilities delivering routine immunization, as well as 8 regional and 1 central office of the national immunization program. Data were collected on vaccinations delivered, staff time dedicated to the program, cold chain equipment and upkeep, vehicle use, infrastructure, and other recurrent and capital costs at each health facility and administrative office. Annualized economic costs were estimated from a modified societal perspective and reported in 2011 US dollars.

Results: With the addition of rotavirus and pneumococcal conjugate vaccines, the total cost for routine immunization delivery in Honduras for 2011 was US\$ 32.5 million. Vaccines and related supplies accounted for 23% of the costs. Labor, cold chain, and vehicles represented 54%, 4%, and 1%, respectively. At the facility level, the non-vaccine system costs per dose ranged widely, from US\$ 25.55 in facilities delivering fewer than 500 doses per year to US\$ 2.84 in facilities with volume exceeding 10,000 doses per year. Cost per dose was higher in rural facilities despite somewhat lower wage rates for health workers in these settings; this appears to be driven by lower demand for services per health worker in sparsely populated areas, rather than increased cost of outreach.

Conclusions: These more-precise estimates of the operational costs to deliver routine immunizations provide program managers with important information for mobilizing resources to help sustain the program and for improving annual planning and budgeting as well as longer-term resource allocation decisions.

Keywords:

Cost and Cost Analysis

Immunization

New vaccines

51 Honduras

52 Latin America

53

54

1. Introduction

Implementation of the Expanded Program on Immunization (EPI) in Latin America and the Caribbean (LAC) has been broadly successful. Vaccination has been responsible for much of the reduction in childhood mortality since the 1980s, and the LAC nations are on track to achieve Millennium Development Goal 4 [1]. At the beginnings of these EPI programs, the routine delivery of childhood vaccines, including Bacillus Calmette-Guérin (BCG), diphtheria-tetanus-pertussis (DTP), oral polio (OPV), and measles (M), cost no more than US\$ 20 per fully immunized child. Today, the cost of vaccines alone to complete the recommended schedules in most LAC countries far exceeds this cost [2]. There are newer, more expensive vaccines, including ones to prevent severe pneumonias, meningitis, and diarrheas in children, as well as the human papilloma virus (HPV) that causes cervical cancer in women. These new vaccines have demonstrated a favorable cost-effectiveness profile, but they often require a doubling or tripling of the budget envelope for their adoption into the routine program [3]. Additionally, the health system costs associated with delivering vaccines are likely increasing due to the infrastructure investments required to incorporate new vaccines and a broadening of the program to include population groups beyond children [4].

Concern about growing costs has triggered an interest in strengthening capacity to track and analyze immunization costs, cost-effectiveness, budget impact, expenditures, and outcomes in order to promote greater operational efficiency and sustainability. This trend has been especially true for countries that are approaching a transition away from donor support. Honduras is one of six LAC countries that receive new-vaccine subsidy support from Gavi, the Vaccine Alliance, which is a public-private partnership that works to increase access to new vaccines in the poorest nations of the world. In 2011, Gavi support subsidized 42% of the total cost of vaccines used in Honduras' national immunization program [5]. But, like all other LAC countries supported by Gavi (except Haiti), Honduras is “graduating” from Gavi eligibility due to economic growth and will soon face a higher, “graduated” cost

for the newly adopted vaccines. For Honduras and its Gavi graduating peers, understanding the cost of routine immunization in the context of Gavi graduation is critical for planning and program sustainability.

In 2012-13, the Honduran Ministry of Health (MoH) undertook a study to estimate the costs of the routine immunization program for the year 2011. The study was carried out in collaboration with PAHO's ProVac Initiative, which is a capacity-building effort to strengthen evidence-based decision-making concerning immunization policy [6]. This study was part of the Bill and Melinda Gates Foundation's EPI Costing and Financial Flows (EPIc) project, a study of the cost and financing of national immunization programs in six countries. Research teams in the EPIc network developed common methodological guidance and actively worked to harmonize their studies with this guidance [7]. This article reports the total and unit costs of routine immunization delivery in Honduras in 2011 and describes these costs in the context of programmatic performance and efficiency. A companion article in this special supplement to *Vaccine* explores financing for immunization services in Honduras in the same year [8].

1.1. Routine immunization in Honduras

In Honduras, the recommended schedule of childhood vaccines includes the traditional ones of BCG, Hepatitis B (HepB) infant dose, OPV, DTP/HepB/Hib, and measles-mumps-rubella (MMR), plus two recent additions, pneumococcal conjugate vaccine (PCV) and rotavirus vaccine (RV). The national immunization program also includes vaccines for other populations and diseases, including Tetanus-diphtheria (Td), yellow fever, influenza, and booster doses of DTP (Table 1). Additionally, there are assessments underway to evaluate introducing the HPV vaccine as soon as 2015 [9].

Among countries of the Americas in the same income grouping, Honduras' immunization program is considered a success story. With the help of sustained vaccination coverage above 90 percent in targeted risk groups, mainly children under 5 years old, Honduras has been free of polio since 1981 and measles since 1989 [10]. Recently, Gavi recognized Honduras for its notable achievement of reaching

98% coverage of the target population with the rotavirus vaccine within two years of the vaccine's introduction into the routine schedule [11]. In 2011, Honduras reported that all children under the age of 2 years were fully vaccinated with all the recommended routine vaccines, with the exception of PCV13, which had been newly introduced in the middle of that year. However, population coverage of childhood vaccines in Honduras saw a slight downward trend after adjustments to the official denominator estimates in more recent years. When using municipal-level denominators that do not account for migration, coverage gaps appear to persist in vulnerable populations and difficult-to-access areas. Security problems in the country have compounded the problem of suboptimal coverage in some districts [12]. Nonetheless, the estimates available indicate coverage has been very high overall for many years [10].

The MoH delivers over 90 percent of all vaccinations in Honduras. The national immunization program has its central administrative offices in the capital, Tegucigalpa. Regional offices in each of Honduras' 20 sanitary regions oversee service delivery activities as well as organize and operate the supply chain. At the municipal level, one health facility is designated as the "lead" facility for EPI, and has some administrative role in managing immunization in the municipality's health facilities.

The vast majority of immunization service delivery occurs in three types of health facilities: (1) hospitals; (2) CESAMO [*Centro de Salud con Médico y Odontólogo*] health centers, which are typically found in more densely populated areas; and (3) CESAR [*Centro de Salud Rural*] health centers, which are mostly found in rural areas. Immunization in hospitals is limited to newborn application of BGG and hepatitis B doses (70 percent of all births occur in hospitals). Therefore, the bulk of immunization activity occurs in CESAMO and CESAR health centers.

2. Methods

The methods for this study were guided by the "common approach" methodology for the EPIc multi-country study [7], which aimed to harmonize approaches between the six study sites regarding the

sampling protocol, scope and categorization of costs, preferred data sources and assumptions, and study perspective. In Honduras, we retrospectively estimated the economic costs of the government-administered routine immunization program for 2011, from a societal perspective that valued the opportunity cost of all resources consumed in the delivery of immunization except patient time and expenses (e.g., for transportation to clinics).

The routine immunization program is defined as the routine activities to deliver vaccines to the recommended target populations in Honduras. These routine activities include health facility-based vaccination, outreach activities, and the annual periodic intensification of routine immunization (PIRI) through mass social mobilization (which overlaps with Vaccination Week in the Americas) [13]. The annual total number of doses applied in the routine program includes those applied in-facility and out-of-facility, but excludes doses applied to achieve a supplemental non-routine program goal, such as vaccination of adult risk groups with the pneumococcal polysaccharide vaccine supply that Honduras received as a donation in 2011. To facilitate comparison to other countries in the EPIC study, we also present the portion of program cost for delivering immunization to children up to 1 year of age (see Supplementary Appendix 1). All costs, other than for vaccines and syringes, were collected in the local currency, lempiras, and converted to 2011 US dollars, with the official exchange rate of 18.8915 lempiras to US\$ 1.00. Vaccines and syringe purchase records were already in US dollars. All capital costs were annualized, with a three percent discount rate [14].

Data were collected on resource use and costs at the central, regional, and municipal program administrative levels as well as at health facilities. Eight of the country's 20 sanitary regions were selected purposefully by the EPI to represent a range of settings in terms of the level of urbanization, socioeconomic status, and geography. Two of the selected regions are geographically small, but very populous metropolitan regions (Tegucigalpa and San Pedro Sula). The six other selected regions are more characteristic of the country as a whole. Within the 8 regions, we gathered data from each regional EPI office. In addition, using a multistage probabilistic design, we collected information from a sample of

31 rural (CESAR) facilities and 40 urban health facilities (CESAMOs and hospitals) participating in the routine delivery of public sector vaccinations.

First, from each of the six non-metropolitan regions, three municipalities were selected without replacement and with probability proportional to the size of population under 1 year old. Then, in each municipality, the facility designated as the “lead” facility for EPI in the municipality was selected, as was one non-lead CESAMO and one CESAR. The facilities were selected by simple random sampling within these three strata. Most lead facilities were CESAMOs, but in three cases the lead facility was a hospital. In some instances a municipality did not have a non-lead CESAMO or non-lead CESAR to select, and in these cases, a facility of the other type was selected instead. The probability of selection for each facility was calculated using a Monte Carlo simulation in which 10 million samples were drawn, and the probability of selection equaled the fraction of samples containing the facility. After separating the doses applied in the two metropolitan regions from the rest of the regions, characteristics of the selected vaccination delivery sites are similar to other facilities in the sampling frame that were not selected and other facilities outside of the frame, including the ratio of urban to rural sites and the mean number of doses applied by health facility type (Table 2).

2.1. Data collection

Survey instruments were developed, tested, and then administered at all 71 health facilities and eight regional offices selected in early 2013 (Supplementary Appendix 2). Data was entered in EpiInfo7 (U.S. Centers for Disease Control and Prevention, Atlanta, Georgia, USA) and exported to Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington, USA). Structured interviews were conducted with staff at the national immunization program offices in Tegucigalpa to capture costs at the central level, and then this information was analyzed in the ProVac COSTVAC tool, also developed in Microsoft Excel. COSTVAC was piloted previously in Colombia and Bolivia and is described elsewhere [15].

Surveys at all levels captured information on labor, cold chain, vehicles, travel and per diem allowances, buildings, and other recurrent and capital costs. When resources were shared between the routine immunization program and other health service delivery activities, only the proportions of each shared resource reported as used by the immunization program were valued. Additionally, data on vaccine, injection supplies, and other supplies and costs (including international freight and handling) were collected at the central office. A bottom-up costing approach was used for these commodities, in which the total number of vaccine doses delivered to patients was multiplied by the average price per dose paid for vaccines in 2011, including transaction costs (insurance and fees), excluding transfers (e.g., import duties), and accounting for reported vaccine-specific wastage rates. For the base case scenario, the unit price of Gavi-subsidized vaccines included both the portion of cost paid by Gavi and the portion paid by the Honduran government. The cost of syringes and supplies was similarly based on the number of vaccine doses delivered and unit prices, but, assuming 5% wastage. Because the vaccine doses and associated vaccination supplies such as syringes, cotton, bandages, and rubber gloves are typically imported and have well-documented standard costs, we categorized this group of resource use as its own category, “Vaccines and Supplies.” All other categories of resources required to deliver the immunization program are referred to as “system costs” (i.e., non-vaccine costs). These system-cost inputs (labor, equipment, vehicles, per diem and travel allowances, buildings, etc.) were apportioned across twelve principal immunization program planning components used to develop annual and multiannual plans in the Latin America and Caribbean region to understand the activity-based cost structure of the program (Box 1).

2.2. Data analysis

After a modest correction factor was applied to account for differences between the sampled and non-sampled municipalities, the inverse of the probabilities of selection was used as *analytical weights* in the data analysis. Total costs were derived by extrapolating the *weighted* average system cost per dose estimated for the sample, accounting for sample design, to all health facilities in Honduras. We excluded

the administrative costs identified at the two metropolitan regional offices (Tegucigalpa and San Pedro Sula), which were substantially higher than the costs in the other regions surveyed. We then averaged the administrative cost per dose identified at all other regional offices and applied this average to non-sampled regional offices in the country in order to estimate costs for this level. These extrapolated cost estimates were then summed with the central-level costs to construct an estimate of the total economic cost of the routine immunization program in Honduras for 2011.

Weighted average total facility-level system costs and weighted average facility-level system costs per dose were estimated for each type of health facility. System cost per dose was calculated at each level by dividing total immunization system costs at each level by total doses delivered in 2011.

We estimated the total cost per fully immunized child (FIC) by summing both the vaccine cost and system cost required to complete the recommended national schedule for 1-year-old children, which includes seven vaccines (14 doses in total). The estimate of vaccine and injection supply cost per FIC included transaction costs, injection supplies, and wastage for relevant vaccines. System cost per FIC was estimated for each vaccine by multiplying each recommended dose by the mean system cost per dose at each level of the program. Additional results specific to the cost of vaccinating children up to 1 year old were calculated to facilitate comparison between the study in Honduras and other EPIC country studies. All statistical analysis was conducted in STATA12.

3. Results

3.1. Total costs of routine immunization in Honduras

The total cost to deliver the routine immunization program in Honduras for 2011 was US\$ 32.5 million. Vaccines and other supplies represented a large share of the costs, amounting to 25%. However, labor was the largest cost category, accounting for about half of the total cost (Table 3). Excluding vaccine and injection supplies, about three quarters of the costs are incurred at the health facilities. Only 14% and 9% of system costs occur at the regional and central offices, respectively. About 55% of all

doses in the routine immunization program are delivered to children up to 1 year old. Analysis of program costs for this population is described in Supplementary Appendix 2.

Labor costs are substantial at all levels, but the activities supported by these costs range widely among the different program levels. Activities to support program management, including planning and coordination, supervision, monitoring and evaluation, and research, are consistently a large share of total labor across levels. In contrast, vaccine administration and social mobilization are more substantial at the facility level. At the regional offices, labor costs are mostly associated with program management, cold chain, and surveillance activities. Other labor costs that represent administrative and support activities, such as for drivers and secretaries, carry a larger share of the costs at the central level.

Expenses to support the launch of a new vaccination in April 2011, against pneumococcal disease, were also surveyed. Besides the cost of procuring the vaccine and needed supplies for the two new vaccine programs (around US\$ 4.8 million, assuming GAVI prices of US\$ 7 per PCV dose and US\$ 2.50 per rotavirus dose), nationwide trainings and revision of vaccination manuals represented the only other incremental costs identified for the 2011 study period. These costs totaled US\$ 142,300. The survey of costs at the facility level did not reveal any incremental costs solely related to incorporating the new vaccine.

Leading up to the introduction of rotavirus vaccine in 2009 and in anticipation of future PCV13 introduction, Honduras had invested substantially in the cold chain infrastructure to ensure adequate capacity for both rotavirus and PCV13. However, our study did not gather data on the cost of these investments, which occurred prior to the 2011 study period.

3.2. Unit costs and costs to fully vaccinate a child

In 2011, more than 4 million doses of vaccine were delivered to protect children, adolescents, and adults against 14 vaccine-preventable diseases. The mean system cost per dose to deliver the vaccines was US\$ 5.97, of which 78% occurred at the facility level. When accounting for the stratification by facility type in the sample design, the facility-level system cost per dose delivered ranges from US\$ 1.58 (95% CI: US\$ 1.23-1.92) in hospitals to US\$ 7.68 (95% CI: US\$ 4.16-11.21) in rural vaccination posts (Table 4). Regardless of facility type, facility-level system cost per dose was strongly (negatively) correlated with volume of doses delivered (Table 5). Facilities delivering fewer than 500 doses per year have the highest system cost per dose, at US\$ 25.55 per dose (95% CI: US\$ 21.48-29.61). In contrast, the facilities delivering 10,000 or more doses per year have the lowest system cost per dose, at US\$ 2.84 (95% CI: US\$ 2.03-3.66).

Focusing just on the cost of fully immunizing a child up to 1 year of age, we calculated that the cost per FIC was US\$ 132.24. Of this cost, US\$ 48.67 (37%) is for vaccine and injection supply and US\$ 83.57 (63%) is for system cost (Table 6). Since the total cost at regional and facility level accounts for the sample design, and is extrapolated based on facility volume, type, and location, the cost per dose represents a national average. Assuming the vaccine and delivery costs associated with the number of doses for completing the recommended schedule for the new rotavirus and pneumococcal conjugate vaccines, roughly 20% of the cost per FIC is associated with these vaccinations in 2011.

4. Discussion

Applying a rigorous methodology that included systematic data collection from a representative sample of health facilities and regional EPI offices, this study generated comprehensive, detailed, and precise estimates of resources actually used to deliver the national immunization program of Honduras. The study further benefited from the use of the COSTVAC tools developed by PAHO's ProVac Initiative

and collaboration with the community of immunization-costing experts convened for the large EPIproject. The results have direct utility for policymakers in Honduras as they carry out strategic planning for sustaining and improving the national immunization program. Additionally, the information adds another dimension to assessments of program performance, and provides useful baseline information for cost-effectiveness analysis and resource tracking over time.

In addition to being useful for policymakers and stakeholders in Honduras, the study also generated three key insights that are beneficial more generally. First, the study contributes to a growing literature showing that the “system costs” of high-quality immunization programs, particularly labor costs for vaccine delivery, are significant, and should not simply be ignored. In many low- and middle-income settings, including Honduras, health sectors are rapidly expanding both the coverage and scope of services provided. However, the capacity of the health workforce is often a binding constraint on production. Greater awareness of the current use of scarce human resources by different activities of the health sector should aid efforts to align existing resources with health priorities and inform strategies to increase resources.

Second, this study shows that system costs of immunization programs at the facility level range widely, and that these costs are tightly correlated with the number of vaccine doses delivered. Similar findings on the range in unit costs in different health service settings have been reported for Peru [16] and for many other developing countries [17]. Additional studies are required to determine how much of the observed range at the facility level is unavoidable, and how much represents an opportunity to improve efficiency. However, this study suggests that achieving high coverage in sparsely populated areas will require more resources per dose delivered than in urban areas. The less densely populated areas may have somewhat lower wage levels, but they face fixed costs associated with ensuring that services are geographically accessible to populations in these areas. With an increasing number of municipalities registering DTP3 coverage rates below 80% in Honduras [12], more resources may be needed to achieve the goal of extending the benefits of immunization to all persons [18].

Third, this study is the first to estimate the economic cost of annual vaccination campaigns in conjunction with costing of a routine immunization program. In Honduras, as in many other LAC countries, these periodic campaigns mobilize a very large portion of workers in the health sector as well as government workers in other sectors, plus numerous volunteers, for a period of two to three weeks at a time. This massive community effort is responsible for delivering about 8% of the doses in Honduras, and it is believed to be critical to achieving high population coverage and maintaining the public perception of vaccination as an essential health intervention. Despite the important programmatic benefits that campaign activities provide for completing childhood schedules and other targeted goals, these annual drives are resource-intensive, and many of the resources consumed should be accounted for in the annual budgeting process. While our study does not measure the opportunity cost of these campaigns in terms of the health and other services foregone, it does value the time of all workers and volunteers (as well as other inputs) consumed during the campaigns. These factors should be taken into consideration for future planning efforts.

The study has several limitations. First, the study's design allows for standard statistical inference regarding the economic costs of vaccination in the eight regions surveyed. However, those regions were not selected at random. Therefore, our estimation of total national cost required the additional assumption that facilities in regions outside the sample frame are not systematically different from facilities of similar size and type in the sampled regions. Because of this, uncertainty in our estimates is somewhat greater than what is reflected in the reported confidence intervals. Secondly, labor cost at the facility level may have been overestimated due to a reporting bias. Although the interview method and interviewer training were designed to minimize this type of bias, we did not have a gold standard with which to validate the method or measure the bias, if present. Additionally, in most cases, the person in charge of immunization at the health facility reported her or his estimate of the fraction of the time each worker spent on immunization activities. Although they were encouraged to, and often did, solicit information from other health workers at the facility during the interview, it is reasonable to assume that the measure of health

worker time allocated to immunization is imprecise. Ideally, future studies would validate the method by comparing it to time-motion study or other more rigorous measurement methods. Third, the societal perspective of this study did not measure household costs associated with time and travel costs for vaccination. Fourth, our study was not able to allocate system costs to deliver specific vaccines, though it is possible that certain vaccine types require more or fewer resources. Finally, the correlates of total facility costs identified in this study are consistent with other published findings of facility-level cost drivers. However, having further information on the relationship between coverage (or other program performance measures) and total costs would help to refine recommendations on programmatic efficiencies.

We expect much of the information collected will be useful in routine budgeting as well as in strategic planning for new vaccine introduction, program quality improvement, and optimization of cost-efficiency. However, care must be taken in those efforts. Our estimates are from one historical year, and secular trends in unit costs and other contextual factors may necessitate updating or making adjustments to the results of this study for use in the future. Additionally, some of the costs we report have no corresponding financial transaction (e.g., volunteer time), and not all of the costs for immunization are accounted for in the immunization program's budget. Indeed, facility-level labor is a major input that is generally not included in the immunization budget. Finally, we did not estimate the marginal system cost of increasing coverage or the marginal system cost of adding a new vaccine to the routine immunization schedule. In the planning for marginal increases in scope or scale of the immunization program, we would not recommend naively assuming that additional doses would have system costs equal to the average system cost measured in this study. Nonetheless, in the context of planning for such increases, having the information from this study is far better than having no systematic, comprehensive information about resource use.

5. CONCLUSIONS

344

345
346
347
348
349
350
351

352

353
354
355
356
357
358
359

360
361
362

363

364

365

366

367

The study shows that even with the addition of new, more expensive vaccines to the routine schedule, system costs account for the majority of the resources used in the delivery of Honduras’ national immunization program. System costs per dose delivered range widely among facilities, with the costs being most strongly correlated with the number of doses delivered. The study contributes key information to enable better mobilization and management of resources for immunization. Integrating the type of costing data collected in this study with other program performance measures will enable more accurate resource planning and identification of opportunities to improve cost efficiency.

ACKNOWLEDGEMENTS

We would like to extend our deepest thanks to the top notch data collector team that visited all 71 health facilities and eight regional offices. The team of public health professionals that serve in management at the national and regional levels in Honduras dedicated a substantial amount of time for interviews and data gathering, and for this we are ever grateful. We also are indebted to the other EPIc country teams and EPIc steering committee members for their constructive feedback and reviews of the data and technical reports. And, finally, we would like to thank Logan Brenzel and Damian Walker for their support and guidance in this process. This study was kindly financed by the Bill and Melinda Gates Foundation.

Contributors: CJ, IMB, CC, GF & SR designed and implemented the study. LM, ID, IMB, GF & CC supported data collection. All authors contributed to data analysis and write up. All authors approved final manuscript for publication.

REFERENCES

- [1] Andrus JK, Crouch AA, Fitzsimmons J, Vicari A, Tambini G. Immunization and the Millennium Development Goals: progress and challenges in Latin America and the Caribbean. *Health Aff (Millwood)*. 2008 Mar-Apr;27(2):487-93. doi: 10.1377/hlthaff.27.2.487.
- [2] Brenzel L, Claquin P. Immunization programs and their costs. *Soc Sci Med*. 1994 Aug;39(4):527-36.
- [3] Lydon P, Levine R, Makinen M, Brenzel L, Mitchell V, Milstien JB, et al. Introducing new vaccines in the poorest countries: What did we learn from the GAVI experience with financial sustainability?, *Vaccine*. 2008 Dec 2;26(51):6706-16. doi: 10.1016/j.vaccine.2008.10.015.
- [4] Lydon P, Gandhi G, Vandelaer J, Okwo-Bele JM. Health system cost of delivering routine vaccination in low- and middle-income countries: what is needed over the next decade. *Bull World Health Organ*. 2014 May 1;92(5):382-4. doi: 10.2471/BLT.13.130146. Epub 2014 Feb 7.
- [5] Valdez W, Janusz C, Molina Berenice I, Mendoza L, Diaz IY, Resch S. Tracking financial flows for immunization in Honduras. *Vaccine*. Forthcoming.
- [6] Andrus JK, Toscano C, Lewis, Oliveira L, Roper AM, Dávila M, Fitzsimmons JW. A model for enhancing evidence-based capacity to make informed policy decisions on the introduction of new vaccines in the Americas: PAHO's ProVac Initiative. *Public Health Rep*. 2007 Nov-Dec;122(6):811-6.
- [7] Brenzel L, MORE, et al. Costs and financing of routine immunization: approach and findings of a multi- country study (EPIC). *Vaccine*. Forthcoming.
- [8] Valdez W, Janusz CB, and Resch S. Tracking financial flows for immunization in Honduras. *Vaccine*, this issue. Doi: .
- [9] Molina Berenice I, MORE, et al. Study of the cost-effectiveness of the introduction of the human papillomavirus vaccine in Honduras. *Vaccine*. Forthcoming.
- [10] WHO/UNICEF. Joint Reporting Form. Available at: http://www.who.int/immunization_monitoring/data/en/. Accessed October 2013 .
- [11] GAVI Alliance. GAVI awards countries and advocates for accelerating access to life-saving vaccines [press release]. Available at: <http://www.gavi.org/News/Press-releases/2012/GAVI-awards-countries-and-advocates-for-accelerating-access-to-life-saving-vaccines/>. Accessed February 2014.

396 [12] Honduras Expanded Programme on Immunization, Secretary of Health, 2010. Multi-year plan of the
397 Expanded Program on Immunization in Honduras. [13] REF for line 143

398 [14] World Health Organization. WHO guide for standardization of economic evaluations of
399 immunization programmes. Geneva: WHO; 2008.

400 [15] Castañeda-Orjuela C, Romero M, Arce P, Resch S, Janusz CB, Toscano CM, et al. Using
401 standardized tools to improve immunization costing data for program planning: the cost of the Colombian
402 Expanded Program of Immunization. *Vaccine*. 2013 Jul 2;31 Suppl 3:C72-9. doi:
403 10.1016/j.vaccine.2013.05.038.

404 [16] Walker D, Mosqueira NR, Penny ME, Lanata CF, Clark AD, Sanderson CF, et al. Variation in the
405 costs of delivering routine immunization services in Peru. *Bull World Health Organ*. 2004 Sep;82(9):676-
406 82.

407 [17] Bishai D, Mcquestion M, Chaudhry R, Wigton A. The cost of scaling up vaccination in the world's
408 poorest countries. *Health Aff (Millwood)*. 2006 Mar-Apr;25(2):348-56.

409 [18] World Health Organization. Global vaccine action plan 2011-2020. Geneva: WHO: 2013.

410 [19] Pan American Health Organization. Immunization in the Americas 2013 Summary. Washington,
411 D.C.: PAHO; 2013.

412 [20] Pan American Health Organization, Revolving Fund. Vaccine prices for year 2014. Available at:
413 http://www.paho.org/hq/index.php?option=com_content&view=article&id=1864&Itemid=4135.
414 Accessed February 2014.

415

Table 1.
Recommended vaccination schedule in Honduras for children, adolescents, and risk groups, with relevant costing data.

Vaccine	Doses recommended (number primary doses + booster)	Target group schedule (month)	Price per dose (US\$, 2011)	Wastage (%)
BCG	1	0	\$0.10	68%
Hepatitis B (HepB)	1	0	\$0.23	0%
Oral polio (OPV)	3+1	2, 4, 6, 18	\$0.21	18%
Pentavalent (DTP+HepB+Hib)	3	2,4,6	\$3.19	1%
Pneumococcal conjugate, 13-valent (PCV13)	3+1	2, 4, 6, 18	\$7.00 ^a	7%
Rotavirus	2	2, 4	\$2.50 ^a	2%
Diphtheria-tetanus-pertussis (DTP)	2	18, 48	\$0.18	19%
Measles-mumps-rubella (MMR)	1	18	\$1.60	3%
Tetanus-diphtheria (Td)	1	Risk groups	\$0.08	24%
Yellow fever (YF)	1	Risk groups	\$0.67	40%
Influenza	1	Risk groups	\$3.60	21%
Inactivated polio (IPV)	NR ^b	Risk groups	\$5.50	-

^a GAVI prices; all other prices are referenced from PAHO Revolving Fund.

^bNot reported

9

10 **Table 2**

11 Characteristics of sampled and non-sampled administrative offices and health facilities administering the
 12 routine immunization program in Honduras.

13

Characteristic	Sample	Frame	Nationwide
Number of central office	1	1	1
Number of regional offices	8	8	20
<i>by type: non-metropolitan</i>	6	6	18
<i>by type: metropolitan</i>	2	2	2
Number of health facilities	71	784	1535
<i>by type: CESAMO</i>	37	211	412
<i>by type: CESAR</i>	31	526	1020
<i>by type: hospital</i>	3	14	30
<i>By type: other</i>	0	31	73
Total population under 1 year old	63,632	102,709	177, 733
Total doses applied	541,862	2450891	4,104,310
	<i>Metro</i>	<i>Non-metro</i>	
<i>mean doses applied by type: CESAMO</i>	15,104	4792	6822
<i>mean doses applied by type: CESAR</i>	1926	1089	1160
<i>mean doses applied by time: hospital</i>	20,133	20,646	24,390
Fraction of total doses applied during PIRI	0.0988	0.0972	0.0927
Fraction of total doses applied to children under 1 year old	0.6149	0.6416	0.6498

14

15 *PIRI = periodic intensification of routine immunization.

16

17

18

19 **Table 3**

20 Total cost of the routine immunization program in Honduras (2011 US dollars, in thousands).

21

CAPITAL COSTS				
Category	Facility	Regional	Central	All Levels
Vaccine and supplies	\$0	\$0	\$0	\$0
Labor	\$0	\$0	\$0	\$0
Volunteers	\$0	\$0	\$0	\$0
Cold chain	\$625	\$176	\$12	\$813
Vehicles	\$53	\$44	\$65	\$162
Buildings	\$613	\$104	\$17	\$734
Other	\$28	\$10	\$103	\$141
TOTAL	\$1319	\$334	\$197	\$1850
RECURRENT COSTS				
Category	Facility	Regional	Central	All Levels
Vaccine and supplies ^a	\$0	\$0	\$7990	\$7990
Labor	\$15,404	\$1800	\$449	\$17,653
Volunteers	\$713	\$0	\$0	\$713
Cold chain	\$357	\$70	\$30	\$457
Vehicles	\$60	\$71	\$21	\$152
Buildings	\$220	\$0	\$6	\$226
Other	\$1021	\$1046	\$1381	\$3448
TOTAL	\$17,775	\$2987	\$9877	\$30,639
TOTAL COSTS				
Category	Facility	Regional	Central	TOTAL
Vaccine and supplies ^a	\$0	\$0	\$7990	\$7990 (25%)

Labor	\$15,404	\$1800	\$449	\$17,653 (54%)
Volunteers	\$713	\$0	\$0	\$713 (2%)
Cold chain	\$982	\$246	\$42	\$1270 (4%)
Vehicles	\$113	\$115	\$86	\$314 (1%)
Buildings	\$833	\$104	\$23	\$960 (3%)
Other	\$1049	\$1056	\$1484	\$3589 (11%)
TOTAL	\$19,094	\$3321	\$10,074	\$32,486 (100%)

22

23 ^a Note: Total vaccine costs reflect the following assumptions: (1) PCV13 and rotavirus price per dose consider
24 GAVI-manufacturer price agreements of US\$ 7.00 per dose and US\$ 2.50 per dose, respectively, and (2) vaccine
25 and supply costs for PPV23 (2011 donation) were excluded.

26

27

28

29 **Table 4**

30 Weighted average delivery cost per dose, by facility type (2011 US dollars).

31

Facility type	Obs.	Mean	SE	95% CI LB	95 CI% UB
CESAMO	37	\$4.56	\$0.60	\$3.34	\$5.77
CESAR	31	\$7.68	\$1.75	\$4.16	\$11.21
HOSPITAL	3	\$1.58	\$0.17	\$1.23	\$1.92

32

33

34

35 **Table 5**

36 Weighted average delivery cost per dose, by facility output category (2011 US dollars).

37

Facility size (no. of doses)	Obs.	Mean	SE	95% CI LB	95% CI UB
Huge (≥10,000)	16	\$2.84	\$0.40	\$2.03	\$3.66
Large (5000-9999)	4	\$4.63	\$1.67	\$1.28	\$7.97
Medium (1500-4999)	20	\$5.05	\$0.85	\$3.34	\$6.75
Small (500-1499)	27	\$9.28	\$0.83	\$7.61	\$10.96
Tiny (<500)	4	\$25.55	\$2.02	\$21.48	\$29.61

38

39

Table 6
Cost per fully immunized child (FIC) at age of 1 year in Honduras (2011 US dollars).

Vaccine	Doses/U1 FIC	Cost/Dose	Total Cost
BCG	1	\$0.10	\$0.10
Hepatitis B	1	\$0.23	\$0.23
Oral polio	3	\$0.21	\$0.63
Pentavalent	3	\$3.19	\$9.57
Rotavirus	2	\$2.50	\$5.00
PCV 13	3	\$7.00	\$21.00
MMR	1	\$1.60	\$1.60
Vaccine only	14		\$38.13
with CIF, Syringe, Sbox & Oth supply			\$46.01
with waste	17.11		\$48.67
All other resources employed for delivery (labor, cold chain, infrastructure, etc.) by dose			
Central administration		\$0.51	\$7.12
Regional administration		\$0.81	\$11.33
Facility delivery		\$4.65	\$65.13
Total for delivery			\$83.57
Total Economic cost per fully immunized child			\$132.24

Box 1

Definitions of EPI planning and budgeting components in PAHO Region

EPI Component	Cost definition
Political priority, advocacy and legal basis	Time and resources dedicated to advocacy and policy, including developing legal frameworks for immunization.
Planning and coordination	Time and resources dedicated to managing, planning, and budgeting and coordinating at all levels of the program.
Vaccines and supplies	Includes all vaccines and safe injection supplies.
Cold chain	Time and resources dedicated to installing, maintaining and using the cold chain, which encompasses vaccine storage and distribution.
Training	Time and resources developing, administering and/or participating in training and continuous learning opportunities.
Social mobilization	Time and resources dedicated to community level mobilization to raise awareness about vaccination, including television spots, information and education campaigns, and importantly resources dedicated to support the Jornadas Nacionales de Vacunación.
Other operating costs	Time and resources dedicated to other recurrent and capital costs of the immunization program, for example printing and office furniture.
Monitoring and supervision	Time and resources dedicated to local level staff to perform supervision visits and meetings in order to monitor coverage and other performance indicators.
Surveillance, vaccine safety and laboratories	Time and resources dedicated to epidemiological investigation of Adverse Events Following Immunization (AEFI) and VPD outbreaks.
Information systems	Time and resources dedicated to record keeping and reporting data between programmatic levels.
Research	Time and resources dedicated to operational research.
Evaluation	Time and resources dedicated to evaluating program performance at sub-national and national level.