Variation in the costs of delivering routine immunization services in Peru

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Objective Estimates of vaccination costs usually provide only point estimates at national level with no information on cost variation. In practice, however, such information is necessary for programme managers. This paper presents information on the variations in costs of delivering routine immunization services in three diverse districts of Peru: Ayacucho (a mountainous area), San Martin (a jungle area) and Lima (a coastal area).

Methods We consider the impact of variability on predictions of cost and reflect on the likely impact on expected cost–effectiveness ratios, policy decisions and future research practice. All costs are in 2002 prices in US$ and include the costs of providing vaccination services incurred by 19 government health facilities during the January–December 2002 financial year. Vaccine wastage rates have been estimated using stock records.

Findings The cost per fully vaccinated child ranged from US$ 16.63–24.52 in Ayacucho, US$ 21.79–36.69 in San Martin and US$ 9.58–20.31 in Lima. The volume of vaccines administered and wastage rates are determinants of the variation in costs of delivering routine immunization services.

Conclusion This study shows there is considerable variation in the costs of providing vaccines across geographical regions and different types of facilities. Information on how costs vary can be used as a basis from which to generalize to other settings and provide more accurate estimates for decision-makers who do not have disaggregated data on local costs. Future studies should include sufficiently large sample sizes and ensure that regions are carefully selected in order to maximize the interpretation of cost variation.

Keywords Immunization/economics; Immunization programs/economics; Vaccines/supply and distribution/administration and dosage; Child; Costs and cost analysis; Analysis of variance; Comparative study; Peru (*source: MeSH, NLM*).

Mots clés Immunisation/économie; Programmes de vaccination/économie; Vaccins/ressources et distribution/administration et posologie; Enfant; Coût et analyse coût; Analyse variance; Etude comparative; Pérou (*source: MeSH, INSERM*).

Palabras clave Inmunización/economía; Programas de inmunización/economía; Vacunas/provisión y distribución/administración y dosificación; Niño; Costos y análisis de costo; Análisis de varianza; Estudio comparativo; Perú (*fuente: DeCS, BIREME*).

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Voir page 681 le résumé en français. En la página 681 figura un resumen en español.

Introduction

In 1974, when the Expanded Programme on Immunization (EPI) was launched by WHO less than 5% of the world's children had been immunized during their first year of life against the six initial target diseases: diphtheria, tetanus, pertussis (whooping cough), poliomyelitis, measles and tuberculosis. However, vaccines were soon judged to be one of the most cost-effective ways of improving and maintaining children's health (*1*, *2*). The extensive promotion of vaccines resulted in a global coverage of fully vaccinated children of 80% by the mid-1990s (*3*). Yet this rate disguises considerable variation between and within countries.

While there has been some reporting of the cost of providing vaccination services (*4*), few studies have detailed the intra-country variation in these costs. Indeed, in applying cost-effectiveness analyses to health services, it is rare to see detailed cost analyses across facilities. Cost data can provide valuable information for national decision-makers and development partners. It can help EPI programme managers improve national budgeting and planning, identify cost inefficiencies (e.g. high wastage rates), and identify priorities by acting as an input to cost-effectiveness analyses. However, the representativeness of reported costs is frequently questionable because they are often based on national estimates of total expenditure or estimates from only a few facilities. Hence, variation in the expected costs (and benefits) at subnational levels is often not addressed. Therefore, as noted by the Immunization Financing Database team, "Further work is needed to better understand

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the sources of variation we find in the cost of immunization programmes. Understanding this variability will be extremely useful for future analyses" (*5*). In particular, it will be useful in helping governments and funding agencies to better understand which parameters vary within and between settings, how much variation in the parameters influences the resultant variation in the cost, and which parameters can, in general, be taken as constant across settings. The overall aim of this paper is to report and describe variations in the cost of delivering routine immunization services, by specific antigens, in three districts of Peru and to consider the implications for cost-effectiveness analyses.

Methods

Selection of sites

We selected three districts from the 33 health regions in Peru to reflect the geographical diversity of the country (coast, jungle and mountains), differences in immunization schedules (the general schedule and specific for endemic hepatitis B and low-income zones), the availability of hospital cost-information systems, spread of disease (for example, the incidence of hepatitis B is greatest in the jungle area, in certain parts of the mountainous area, and in the coastal region, particularly in Lima, where the incidence depends on migration patterns to the capital) and finally, the interest and willingness of local authorities to collaborate. The three areas selected were Ayacucho (a mountainous area), Lima (a coastal area) and San Martin (a jungle area). Table 1 shows the current immunization schedules in Peru and the new national schedule, which is being introduced during 2004 and will harmonize schedules across the country. Within each of the selected districts we chose a stratified sample of health facilities to reflect the range of facilities delivering vaccines. The selection of these facilities was undertaken with the cooperation of officials from the Ministry of Health in each district; this was an attempt to identify facilities from which we could draw general conclusions. The number and type of facilities in which the costs were measured are given in Table 2.

Cost analysis

The costs borne by the government in providing routine immunization services were gathered for the January–December 2002 financial year. All costs are in 2002 prices in US$ and reflect those incurred by government providers. (The exchange rate used was US$ 1.00 = 3.66 soles.) In Peru, routine vaccination services are delivered via fixed sites at each level of care (Table 2). In seven facilities a cost-and-revenue information system was in place (the Sistema de Informacion de Costos y Ingresos). The objective of this system is to help health authorities assign financial resources efficiently (*6*). Where these systems were available, four types of cost centres were used: administration, general, intermediate, and final, of which EPI was one of several final cost centres. Specific EPI activity and data on resource use were collected from the cost-and-revenue information system and entered into Excel spreadsheets. The overhead costs attributable to the vaccination programmes (e.g. general hospital administration, laundry, cleaning) were estimated using step-down cost allocation methods. Where these systems were absent, similar data were collected using a series of resource-use forms from departments and service centres in each facility. The mean cost of vaccine delivery per dose was calculated in the following way:

- the cost of the vaccine and the syringe was assigned dire ctly to each vaccine;
- personnel, other goods, third party services, capital items (except the cold chain), infrastructure and overhead costs were distributed on the basis of the number of visits;
- the costs of the cold chain were distributed according to the number of vaccine doses administered.

The calculation of the number of visits took the following into account:

- for each dose of bacille Calmette–Guérin (BCG) given, we assumed that a dose of oral polio vaccine (OPV) was given to a newborn and that hepatitis B vaccine where applicable had also been given (Table 1);
- at the second, third and fourth visits we assumed that OPV, diphtheria–pertussis–tetanus (DPT) and *Haemophilus influenzae* type b vaccine (Hib), or the pentavalent vaccine where applicable, had also been given;
- the rest of the vaccines, such as yellow fever and measles, are administered in separate visits.

The weighted mean cost of vaccine delivery per dose was calculated using the number of vaccines administered as the weights. Also estimated and reported is the wastage rate, in which vaccine wastage is the proportion of vaccine supplied but not administered to children. This is calculated as:

vaccine wastage rate = ([doses supplied - doses administered] / doses supplied) x 100.

We have also estimated the cost per fully vaccinated child (FVC) as defined by the schedule — for example, a child in Lima who has received one dose of BCG, four doses of OPV, three doses of DPT, one dose of yellow fever vaccine and one dose of measles vaccine by his or her first birthday. Tests for statistical differences in the mean cost of vaccine delivery per dose and per FVC within and between facility types and districts were not performed because there was often only one facility costed per facility type in each selected district.

Results

Table 3 presents the mean number of doses administered, vaccine wastage rates, weighted mean cost per antigen and the cost per FVC by district and type of facility (web version only, available at: http://www.who.int/bulletin). We found that on average OPV is the most common type of vaccine provided by all facilities in all districts; this is followed by DPT. Doses of BCG and Hepatitis B vaccine are provided least regularly. Across the three districts, the health posts administer the lowest number of vaccines, while department hospitals and national hospitals provide the highest number of doses each year. Vaccine wastage rates were highly variable across facilities and districts. For example, the BCG wastage rate among health posts in Ayacucho was 47% compared with 88% among health posts in Lima. Similarly, the BCG wastage rate among health centres in Ayacucho was 54% and in Lima it was 68%. Wastage rates were highest for BCG and measles vaccines (which come in 10-dose or 20-dose vials) and lowest for the combination vaccine DPT–hepatitis B–Hib (which comes in a single-dose vial).

The weighted mean costs of vaccine delivery per dose were systematically lower in the facilities in Ayacucho than in other districts, although there were a few exceptions: the cost per dose of Hib vaccine and hepatitis B vaccine was higher among health centres in Ayacucho vis-à-vis those situated in San Martin: US$ 6.24 (standard deviation (SD) = 0.49) for Hib

Table 1. **Immunization schedules in Peru**[a]

Age of child	Immunization schedules			
	2002			2004
	General immunization schedule (e.g. Lima)	Endemic hepatitis B areas (e.g. San Martin)	Low-income areas (e.g. Ayacucho)	National general immunization schedule
Birth	BCG,[b] OPV-0[c]	BCG, OPV-0, Hepatitis B vaccine	BCG, OPV-0	BCG, Hepatitis B vaccine
2 months	OPV-1, DPT-1[d]	OPV-1, pentavalent[e]	OPV-1, pentavalent	OPV-1, pentavalent
3 months	OPV-2, DPT-2	OPV-2, DPT-2, Hib-2[f]	OPV-2, pentavalent	OPV-2, DPT-2, Hib-2
4 months	OPV-3, DPT-3	OPV-3, pentavalent	OPV-3, pentavalent	OPV-3, pentavalent
9 months	Yellow fever vaccine	Yellow fever vaccine	Yellow fever vaccine	Yellow fever vaccine
12 months	Measles vaccine	Measles vaccine	Measles vaccine	Measles vaccine

Source: Ministry of Health, Peru.
[a] Numbers after vaccines refer to first, second or third dose given. OPV-0 refers to the neonatal dose.
[b] BCG = bacille Calmette–Guérin.
[c] OPV = oral polio vaccine.
[d] DPT = diphtheria–pertussis–tetanus vaccine.
[e] In each instance, pentavalent DPT–hepatitis B vaccine–Hib vaccine is supplied in two separate vials, one containing DPT and hepatitis B vaccine (liquid) and the other containing Hib vaccine (lyophilised). The vaccine is given by mixing the contents of the two vials and giving all the vaccines in the same syringe.
[f] Hib = *Haemophilus influenzae* type b vaccine.

and US$ 1.33 (SD = 0.08) for hepatitis B in Ayacucho compared with US$ 3.41 (SD = 0.05) and US$ 1.08 (SD = 0.16) respectively in San Martin. Similarly, the cost per dose of DPT was US$ 0.80 in provincial hospitals in Ayacucho compared with US$ 0.72 in provincial hospitals in San Martin. The cost per dose of BCG administered in health posts was US$ 0.61 (SD = 0.12) in Ayacucho and US$ 1.88 (SD = 0.27) in Lima. There are no health posts in San Martin. In health centres the cost was US$ 0.72 (SD = 0.07) in Ayacucho, US$ 0.79 (SD = 0.07) in San Martin and US$ 0.76 (SD = 0.16) in Lima. In the provincial hospitals in Ayacucho the cost was US$ 0.72 while in the provincial hospitals in San Martin it was US$ 1.38. There are no provincial hospitals in Lima. Among facilities in Ayacucho, there did not appear to be marked differences in costs between different types of facilities, e.g. the cost per dose of BCG was US$ 0.61 (SD = 0.12) in health posts, US$ 0.72 (SD = 0.07) in health centres and US$ 0.72 in the one provincial hospital. However the cost of providing the same vaccine in the department hospital is 2–3 times higher (US$ 1.50). As noted above, there is substantial variation across districts and facility types in the cost per dose of BCG administered: US$ 0.61–1.88. The cost per FVC ranged from US$ 16.63 to US$ 24.52 in Ayacucho, US$ 21.79 to US$ 36.69 in San Martin and US$ 9.58 to US$ 20.31 in Lima. This represents an overall range of US$ 9.58 to US$ 36.69.

Variation in the weighted mean cost of vaccine delivery per dose can be explained in part by the wastage rates and volume of output at each facility. In general we found a positive correlation between the mean cost of vaccine delivery per dose and wastage, and this relationship was significant at the 5% level for BCG, yellow fever vaccine, measles vaccine and Hib vaccine. Conversely, we found negative correlations between the mean cost of vaccine delivery per dose and output, although none of these was significant.

Table 4 provides a breakdown of the weighted mean cost of vaccine delivery per dose by type of facility. The mean fixed cost per dose (comprising capital items and salaries, which are fixed in the short term) accounted for 15.64–41.10% of the total mean cost per dose. However, when overhead costs were excluded, this proportion increased to 24.72–54.78%. Overhead costs accounted for between 13.32% and 60.88% of the mean cost per dose at rural and national hospitals, respectively. With the exception of the national and department hospitals (where overhead and personnel costs are the greatest), vaccines account for the largest proportion of cost per dose (range: 15.71–57.65%).

Discussion

To decide whether investing in vaccination services is cost-effective requires an understanding of both the costs and consequences of current vaccination practices. It is important to understand whether and how costs vary. Understanding the factors that contribute to cost variations helps in estimating the impact of adopting global policies at the national level, and national policies at the district level; it also helps in determining the extent to which cost–effectiveness ratios can be generalized reliably. Importantly, what we learn about the sources of cost variations — that is, what drives cost — may be helpful in identifying ways to improve the efficiency of service delivery. This paper has focused on the “cost” in cost-effectiveness and, in particular, the need to describe variations in the cost of providing vaccination services.

We found that the mix of vaccines provided varied systematically across districts and facilities. There may be several reasons for this. First, for many years, there has been a worldwide initiative to eradicate polio. Therefore more people may be aware of the benefits of the polio vaccine and may, consequently, demand it more often than other vaccines. In addition, the schedule requires four doses, so it is perhaps not surprising that this is the most common vaccine administered. Similarly, it is not surprising that BCG was usually the vaccine that was provided least often, perhaps because it requires only one dose to confer protection.

Generally, strategies with the lowest average cost per FVC are thought preferable, although these costs represent specific sets of technological and operational factors that may not be replicable in different districts due to differences in, for example, geography. However, differences in how the cost per

Table 2. **Number of facilities in which data collection took place by area, Peru**

Type of facility	Area			
	Ayacucho	Lima (metropolitan)	Lima (local health authority)	San Martin
Health post	2 (260)[a]	NF[b]	4 (12)	NF
Health centre[c]	2 (42)	NF	2 (4)	4 (43)
Rural hospital (8–20 beds)	NF	NF	NF	1 (8)
Provincial hospital (about 50 beds)	1 (6)	NF	NF	1 (1)
Department hospital (about 150 beds)	1 (1)	0 (9)	NF	NF
National hospital (>250 beds)	NF	1 (11)	NF	NF

[a] Figures in parentheses are the number of facilities.
[b] NF = no facilities of that type exist in this area and deliver vaccines.
[c] Generally, rural hospitals provide no inpatient services except deliveries.

FVC is defined can lead to variations, e.g. different schedules mean that different vaccines are included in the definition (Table 1). We noted that the cost per FVC was lower among facilities located in Lima where the newer, more expensive vaccines against hepatitis B and *Haemophilus influenzae* type b have not yet been introduced. Furthermore, the Peruvian schedule includes the neonatal dose of OPV-0, and this does not accord with common global practice. Therefore Table 3 also presents the cost per FVC excluding OPV-0, which reduces the cost per FVC by US$ 0.57–1.59.

Importantly, we used the same costing methods in each of the facilities across each of the districts; this means we can exclude methodological inconsistencies as a potential source of variation in the mean cost of vaccine delivery per dose. However, we did note two other causes of variation in our costs: vaccine wastage and volume of output. Vaccine wastage is important because it may show programme errors. For example, it may highlight the fact that too many drops of OPV or more than the required volume of other vaccines is being used; it may point out failures in the cold chain; or it may show that vaccine forecasting is poor and vaccines are expiring before they can be used (*7*). There are also economic implications associated with wastage. If wastage can be reduced without affecting coverage, it can result in significant savings for programmes (*8*). Unfortunately we were unable to relate coverage rates to our sample of facilities due to inaccurate estimates of the catchment and target populations; had we been able to do so we might have shed light on the extent to which this is feasible in practice. However, our data did indicate a negative correlation between wastage and output, although this was significant at the 0.05 level only for BCG and measles vaccine. In addition, our data suggest that there are economies of scale attributed to vaccination clinics — that is, as the number of children vaccinated in each facility increases, the mean cost of vaccine delivery per dose falls. The main reason for this relationship is the large fixed-cost component per facility. Other causes of the variation may be the result of service delivery strategies, including the type and timing of the vaccines administered; the frequency of the sessions; and the level of integration of activities with other health programmes.

Total and incremental costs

New vaccines have entered the market during the past few years, and more are expected to be developed in the future. Governments have to decide whether to include new vaccines in their routine immunization schedule, which is publicly funded in most countries. In Peru, the process of harmonizing vaccination schedules across districts is taking place during 2004, and the government may decide to focus exclusively on estimating the incremental costs that this will entail. Guidelines have been developed to estimate these incremental costs. These look at the cost of adding the additional vaccine or vaccines to existing services (*9*). However, these guidelines do not attempt to provide cost estimates for existing services.

The decision to undertake an incremental or full cost analysis is part of a broader debate. A full cost analysis estimates the costs of all resources being used to run a project or programme, including basic infrastructure. In contrast, an incremental analysis accounts for only the major new inputs that are required by the new vaccine or vaccines. As such, an incremental analysis assumes that the organizational infrastructure already exists, and the analysis may therefore underestimate costs that are of a general administrative nature and are borne by the organization. Furthermore, it is also more difficult to generalize from an incremental cost analysis because it is often unclear to what extent the existing services and infrastructure are similar (or not) between settings. Finally, an incremental analysis may also fail to identify variation in the cost of providing additional services, such as vaccines, because there is no information on the underlying variation, which a full cost analysis provides. Nevertheless, the value of adopting incremental costing is that it relates to the more common policy question of whether to expand or reduce levels of provision (rather than to provide or not to provide), and it makes clearer the high price that is often associated with providing additional services. The value of costing existing services, which could be done to complement routine national coverage surveys, rather than costing only additional services, is that it is likely to improve knowledge about variation for different scales of production and in different settings. In particular, research on whether and how costs vary with the level of vaccination services would generate knowledge that could be used to inform decisions about whether to expand existing programmes. Valdmanis et al. (*10*) highlighted the fact that assumptions of constant returns to scale are unlikely to hold and so multiplying costs up or down in a linear way may drastically overestimate or underestimate costs. Finally, it allows the relationship between the costs and effects of providing existing services and new services to be questioned. This is most likely to be useful to those considering the relevance of setting or adopting global policy recommendations.

Table 4. **Weighted mean cost of vaccine delivery per dose and type of facility, in 2002 US$[a]**

Item	Health post		Health centre		Rural hospital		Provincial hospital		Department hospital		National hospital	
	Cost per dose	% of total cost	Cost per dose	% of total cost	Cost per dose	% of total cost	Cost per dose	% of total cost	Cost per dose	% of total cost	Cost per dose	% of total cost
Direct costs												
Capital items												
Infrastructure	0.00	0.23	0.01	0.56	0.03	0.94	0.01	0.83	0.02	1.04	0.01	0.50
Cold chain	0.00	0.23	0.01	0.79	0.06	1.89	0.00	0.27	0.00	0.00	0.01	0.50
Capital items (other than cold chain)	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00
Subtotal	0.01	0.46	0.02	1.44	0.09	2.83	0.02	1.27	0.03	1.57	0.02	1.01
Recurrent items												
Vaccines	0.59	39.83	0.87	57.65	1.39	43.81	1.03	58.49	0.60	31.08	0.31	15.71
Syringes	0.04	2.67	0.05	3.46	0.07	2.33	0.04	2.49	0.05	2.61	0.03	1.36
Personnel	0.46	31.20	0.28	18.73	1.17	36.73	0.33	18.79	0.76	39.54	0.29	14.63
Other recurrent costs	0.05	3.67	0.03	1.79	0.03	0.98	0.04	2.23	0.03	1.57	0.13	6.40
Subtotal	1.14	77.37	1.23	81.62	2.66	83.85	1.45	82.00	1.43	74.79	0.76	38.11
Total direct costs	1.15	77.83	1.25	83.06	2.75	86.68	1.47	83.27	1.46	76.36	0.78	39.12
Overhead costs	0.33	22.17	0.26	16.94	0.42	13.32	0.30	16.73	0.45	23.64	1.21	60.88
Total	**1.48**	**100.00**	**1.51**	**100.00**	**3.17**	**100.00**	**1.77**	**100.00**	**1.92**	**100.00**	**1.98**	**100.00**

[a] Due to rounding some items may appear to account for 0 cost.

Conclusions

This is the first paper to document the costs of the Peruvian national routine immunization programme. We have reported variations in the costs of providing vaccination services in three diverse districts of Peru. Indeed, this is one of the first papers since the 1980s to document the costs of a national immunization programme, and this is important given the resurgence of interest in investing in immunization programmes and in light of debates over whether it would be better to increase the coverage of existing vaccinations or introduce new vaccines. We conclude that the potential bias and inefficiencies involved in transferring data without resolving or understanding variations may not only introduce inefficient interventions or halt the provision of efficient interventions but may also harm a nation's health and welfare.

Alternatively, variation within and between settings may not exist or may not significantly affect conclusions. It is therefore vital that we continue to assess whether this is a serious concern and whether it leads to any systematic misallocation of resources in other settings. Therefore, more research needs to be performed that investigates the causes of variation in cost, effects and cost-effectiveness data within and between settings. Once this has been done, a priority must be to undertake more work that assesses the transferability or generalizability of existing and future evaluations within and between settings. The results will need to be explicitly tested in different settings. An investigation of how and why costs and effects vary within a study site would allow some judgement to be made about the impact of independent variables on cost, effects and cost-effectiveness in different settings. One might, for example, expect rising marginal costs and decreasing marginal effectiveness as interventions are extended through populations to combine to reduce cost-effectiveness. Thus, as Jamison (*11*) argues "favourable cost-effectiveness estimates can be real, but their margin of applicability may be limited". ■

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Conflicts of interest: none declared.

Résumé

Variation des coûts des services de vaccination systématique au Pérou

Objectif Les estimations des coûts de vaccination ne fournissent habituellement que des chiffres ponctuels à l'échelon national, sans information sur les variations subies par ces coûts. Dans la pratique cependant, de telles informations sont nécessaires aux gestionnaires de programmes. Le présent article apporte des informations sur les variations subies par les coûts des services de vaccination systématique de trois districts péruviens différents : Ayacucho (zone de montagnes), San Martin (zone de jungle) et Lima (région côtière).

Méthodes Nous examinons l'incidence de cette variabilité sur les prévisions en matière de coûts et présentons son impact probable sur les rapports coût-efficacité attendus, les décisions politiques et les travaux de recherche futurs. Tous les coûts sont exprimés en US$ 2002 et incluent les coûts d'administration des vaccins supportés par les services de vaccination de 19 établissements de santé publics au cours de l'exercice financier janvier–décembre 2002. Les taux de gaspillage des vaccins ont été estimés à partir des registres de stock.

Résultats Le coût par enfant entièrement vacciné va de US$ 16,63-24,52 à Ayacucho, de US$ 21,79-36,69 à San Martin et de US$ 9,58-20,31 à Lima. Le volume de vaccins administrés et les taux de gaspillage constituent des paramètres déterminants dans la variation des coûts des services de vaccination systématique.

Conclusion Cette étude montre qu'il existe des variations considérables dans les coûts d'administration des vaccins d'une région géographique à l'autre et d'un type d'établissement à l'autre. Les informations relatives au mode de variation des coûts sont utilisables comme base pour opérer des généralisations à d'autres situations et fournir des estimations plus exactes à l'intention des décideurs qui ne disposent pas de données désagrégées sur les coûts locaux. Les études futures devraient porter sur des échantillons de taille suffisante et s'assurer d'un choix judicieux des régions pour optimiser l'interprétation des variations de coût.

Resumen

Variación de los costos de la prestación de servicios de vacunación sistemática en el Perú

Objetivo Las estimaciones de los costos de la vacunación sólo suelen proporcionar datos puntuales referidos al ámbito nacional sin ninguna información sobre la variación de los costos. En la práctica, sin embargo, los gestores de programas necesitan ese tipo de datos. En este artículo se presenta información sobre la variación de los costos de la prestación de servicios de inmunización sistemática en tres distritos del Perú: Ayacucho (una zona montañosa), San Martin (una zona selvática) y Lima (una zona costera).

Métodos Examinamos la repercusión de la variabilidad en las predicciones del costo y evaluamos el impacto probable en las relaciones costo–eficacia previstas, las decisiones de política y las prácticas de investigación futuras. Todos los costos se expresan como precios de 2002 en US$ e incluyen los gastos en prestación de servicios de vacunación efectuados por 19 centros de salud públicos durante el ejercicio de enero a diciembre de 2002. Las tasas de desperdicio de vacunas se calcularon a partir de los registros de existencias.

Resultados El costo por niño totalmente vacunado se situó en los márgenes de US$ 16,63-24,52 en Ayacucho, US$ 21,79-36,69 en San Martin, y US$ 9,58-20,31 en Lima. El volumen de vacuna administrada y las tasas de desperdicio son los factores determinantes de la variación de los costos de la prestación de servicios de inmunización sistemática.

Conclusión Este estudio muestra que los costos de la administración de vacunas varían de forma considerable entre regiones geográficas y entre diferentes establecimientos. La información sobre el grado de variación de los costos puede servir de base para generalizar a otros entornos y ofrecer estimaciones más precisas a los decisores que no disponen de datos desglosados sobre los gastos locales. Es necesario que los estudios que se hagan en el futuro utilicen muestras suficientemente grandes y seleccionen las regiones con sumo cuidado para optimizar la interpretación de la variación de los costos.

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Table 3. **Mean number of doses administered, wastage and weighted mean cost per antigen and fully vaccinated child by district and type of facility, in 2002 US$**

Type of facility	Vaccine	Ayacucho: No. of doses administered	Ayacucho: Wastage (%)	Ayacucho: Cost per antigen	Lima: No. of doses administered	Lima: Wastage (%)	Lima: Cost per antigen	San Martin: No. of doses administered	San Martin: Wastage (%)	San Martin: Cost per antigen
Health post	BCG[a]	144.00 (154.15)[b]	47	0.61 (0.12)	14.50 (13.13)	88	1.88 (0.27)	NF[c]	NF	NF
	OPV[d]	479.50 (415.07)	30	0.57 (0.03)	325.00 (179.19)	31	1.36 (0.23)	NF	NF	NF
	DPT[e]	109.50 (136.47)	24	0.52 (0.02)	314.50 (187.71)	26	1.37 (0.24)	NF	NF	NF
	Yellow fever	169.50 (187.38)	23	1.55 (0.12)	NV[f]	NV	NV	NF	NF	NF
	Measles vaccine	269.50 (287.79)	34	0.93 (0.05)	97.50 (63.29)	77	2.91 (0.48)	NF	NF	NF
	Hib[g]	136.00 (171.12)	0	3.56 (0.02)	NV	NV	NV	NF	NF	NF
	Hepatitis B	5.00 (5.66)	6	1.62 (0.97)	NV	NV	NV	NF	NF	NF
	DPT–hepatitis B–Hib	222.00 (123.04)	0	3.76 (0.03)	NV	NV	NV	NF	NF	NF
	FVC[h]	–	–	16.63	–	–	14.32	NF	NF	NF
	FVC (excluding OPV-0)	–	–	16.06	–	–	12.96	NF	NF	NF
Health centre	BCG	348.00 (367.69)	54	0.72 (0.07)	671.50 (538.11)	68	0.76 (0.16)	620.75 (659.29)	54	0.79 (0.07)
	OPV	1304.00 (1279.86)	17	0.57 (0.06)	2583.00 (176.78)	29	0.68 (0.13)	1730.50 (1261.77)	32	0.72 (0.06)
	DPT	74 (53.74)	21	0.71 (0.01)	2329.50 (130.81)	15	0.71 (0.07)	396.25 (269.41)	40	0.71 (0.07)
	Yellow fever	179.00 (1.41)	16	1.74 (0.24)	488.50 (28.99)	54	2.62 (0.14)	562.50 (450.60)	40	2.33 (0.55)
	Measles	364.00 (376.18)	65	1.19 (0.14)	641.00 (73.54)	69	1.35 (0.26)	376.25 (240.03)	60	1.49 (0.17)
	Hib	355.50 (461.74)	24	6.24 (0.49)	NV	NV	NV	352.75 (238.39)	0	3.41 (0.05)
	Hepatitis B	106.50 (72.83)	12	1.33 (0.08)	NV	NV	NV	651.50 (668.11)	40	1.08 (0.16)
	DPT–hepatitis B–Hib	989.00 (1012.58)	0	3.83 (0.03)	NV	NV	NV	700.75 (452.75)	0	4.56 (0.07)
	FVC	–	–	17.42	–	–	9.58	–	–	21.79
	FVC (excluding OPV-0)	–	–	16.84	–	–	8.90	–	–	21.08
Rural hospital	BCG	NF	NF	NF	NF	NF	NF	187	55	1.54
	OPV	NF	NF	NF	NF	NF	NF	739	23	1.58
	DPT	NF	NF	NF	NF	NF	NF	181	58	1.51
	Yellow fever	NF	NF	NF	NF	NF	NF	248	78	6.57
	Measles	NF	NF	NF	NF	NF	NF	232	48	3.43
	Hib	NF	NF	NF	NF	NF	NF	173	0	4.09
	Hepatitis B	NF	NF	NF	NF	NF	NF	176	51	1.99
	DPT–hepatitis B–Hib	NF	NF	NF	NF	NF	NF	384	0	5.62
	FVC	NF	NF	NF	NF	NF	NF	–	–	36.69
	FVC (excluding OPV-0)	NF	NF	NF	NF	NF	NF	–	–	35.11
Provincial hospital	BCG	670	18	0.72	NF	NF	NF	60	81	1.38
	OPV	2186	32	0.74	NF	NF	NF	1048	25	0.81
	DPT	1446	21	0.80	NF	NF	NF	340	23	0.72
	Yellow fever	514	22	2.03	NF	NF	NF	1033	25	2.31
	Measles	573	33	1.27	NF	NF	NF	323	44	1.54
	Hib	–	–	–	NF	NF	NF	326	0	3.47
	Hepatitis B	329	12	1.51	NF	NF	NF	122	3	1.46
	DPT–hepatitis B–Hib	1442	2	3.99	NF	NF	NF	636	0	4.58
	FVC	–	–	18.96	NF	NF	NF	–	–	23.29
	FVC (excluding OPV-0)	–	–	18.21	NF	NF	NF	–	–	22.48

(Table 3, cont.)

Type of facility	Vaccine	Ayacucho: No. of doses adminis-tered	Ayacucho: Wast-age (%)	Ayacucho: Cost per antigen	Lima: No. of doses adminis-tered	Lima: Wast-age (%)	Lima: Cost per antigen	San Martin: No. of doses adminis-tered	San Martin: Wast-age (%)	San Martin: Cost per antigen
Depart-ment hospital	BCG	1087	52	1.50	NF	NF	NF	NF	NF	NF
	OPV	2159	32	1.20	NF	NF	NF	NF	NF	NF
	DPT	1301	21	1.12	NF	NF	NF	NF	NF	NF
	Yellow fever	1246	32	2.92	NF	NF	NF	NF	NF	NF
	Measles	716	48	2.23	NF	NF	NF	NF	NF	NF
	Hepatitis B	18	12	2.40	NF	NF	NF	NF	NF	NF
	DPT–hepatitis B–Hib	611	0	4.36	NF	NF	NF	NF	NF	NF
	FVC	–	–	24.52	NF	NF	NF	NF	NF	NF
	FVC (excluding OPV-0)	–	–	23.32	NF	NF	NF	NF	NF	NF
National hospital	BCG	NF	NF	NF	652	50	1.85	NF	NF	NF
	OPV	NF	NF	NF	5064	30	1.59	NF	NF	NF
	DPT	NF	NF	NF	4745	30	1.66	NF	NF	NF
	Yellow fever	NF	NF	NF	951	30	3.82	NF	NF	NF
	Measles	NF	NF	NF	1398	30	3.27	NF	NF	NF
	FVC	NF	NF	NF	–	–	20.31	NF	NF	NF
	FVC (excluding OPV-0)	NF	NF	NF	–	–	18.71	NF	NF	NF

[a] BCG = bacille Calmette–Guérin.
[b] Figures in parentheses are standard deviations.
[c] NF = no facilities of this type exist in this area and deliver vaccines.
[d] OPV = oral polio vaccine.
[e] DPT = diphtheria–pertussis–tetanus vaccine.
[f] NV = no vaccines of this type are delivered in this type of facility in this area.
[g] Hib = *Haemophilus influenzae* type b vaccine.
[h] FVC = fully vaccinated child as defined by the schedule (see Table 1). Because the cost per FVC has been inferred from the data, there is no data on the number and wastage of FVC, hence the dashes.