Determinants of Routine Immunization Costing in Benin and Ghana in 2011

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ABSTRACT

Background: Existing tools to evaluate costs do not always capture the heterogeneity of costs at the facility level. This study seeks to address this issue through an analysis of determinants of health facility immunization costs.

Methods: A statistical analysis on facility routine delivery and vaccine costs was conducted using ordinary least squares regression. Explanatory variables included the number of doses administered; proportion of time spent by facility staff on immunization; average staff wage; whether the health facility had enough staff; presence of cold chain equipment; distance to a vaccine collection point; and, facility ownership. Data were drawn from representative samples of primary care facilities in Benin and Ghana (46 and 50 facilities, respectively) collected as part of the EPIC studies.

Results: Weighted average RI immunization facility cost was US\$ 16,459 in Ghana and US\$ 14,994 in Benin. The regression found total doses administered to be positively and significantly associated with facility cost in both countries. A 10% increase in doses resulted in a 4% increase in cost in Ghana, and a 7.5% increase in Benin. In Ghana, the proportion of immunization time, presence of cold chain, and sufficiency of staff were positively and significantly associated with total cost. In Benin, facility cost was negatively and significantly related to distance to the vaccine collection point. In the pooled sample, facilities in capital cities were associated with significantly higher costs. Conclusions: This study provides evidence on the importance of the level of scale in determining facility immunization cost, as well as the role of availability of health workers and time they spend on immunization in Ghana and Benin. This type of analysis

21 can provide insights into the costs of scaling up immunization services, and can assist with
22 development of more efficient immunization strategies.

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24 Key words: Benin, cost, economics, Ghana, immunization, vaccine

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1. BACKGROUND

Like most Sub-Saharan African countries, Benin and Ghana have improved immunization performance during the past decade. According to the 2011 Ghana Multiple Indicators Cluster Survey, coverage of pentavalent vaccine (DTP-HepB-Hib) was 92.1%, while measles, yellow fever and neonatal tetanus immunization coverage were lower at 88.5%, 88.3% and 70.3%, respectively [1]. In Benin, a 2007 EPI Review found 81% administrative coverage for the pentavalent vaccine compared to 67% obtained through surveys [2]. Both countries have introduced new vaccines with GAVI support (pneumococcal, rotavirus or measles second dose).

Table 1: Routine childhood immunization vaccine schedule and age of administration in Benin and Ghana

Existing tools to assess routine immunization (RI) costs (such as the comprehensive multi-year plan) do not capture heterogeneity in facility costs. This is an important limitation as previous studies have demonstrated wide variation in facility cost that would contribute to national program costs and performance [3 ref: Walker]. The current manuscript seeks to address this issue by analyzing determinants of RI costs at facility level. Results from this type of analysis can support development of more targeted interventions to improve immunization program efficiency.

2. METHODS

2.1 Data collection

The current evaluation is based on a representative, stratified random sample of 50 facilities in Ghana and 46 facilities in Benin. In Ghana, districts were classified according to urban and rural location, number of pentavalent doses administered in 2011, and population density. Four rural districts (high and low number of doses administered by high and low population density) and two urban districts (high and low doses administered) were selected. Facility types included reproductive and child health (RCH) units of district hospitals; health centers (HC); community health planning and services facilities (CHPS); and clinics. CHPSs serve as first-line health facilities providing direct interventions as well as outreach services to mostly rural communities. Many CHPSs tend to require more manpower and fuel per vaccinated child than other health facilities. While costs may be higher, they tend to deliver fewer vaccine doses than other facilities, and have higher unit costs [4 ref Le Gargasson et al in this Supplement].

In Benin, eight districts were selected based on population density, pentavalent doses administered and geographic zone. Within the 14 total selected districts, immunization facilities associated with immunization programs were stratified by type (district hospital, health center, clinic, community health center); ownership (non-governmental or Government); and rural versus urban location. The average urban health facility covered a total population of approximately 20 to 40 thousand versus 8 to 15 thousand for the average rural health facility. Table 2 describes the sample of health facilities included in this analysis.

Table 2: Final sample selected by district and location in Ghana and Benin

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69 Forty percent of health facilities in the Ghana sample were CHPs, while an equivalent type
70 of health facility did not exist in the Benin sample (Appendix 1). This difference in health
71 structure composition and distribution limits direct comparison of costs between Ghana and
72 Benin. Benin had a higher average number of doses delivered per facility, and did not use
73 volunteers to conduct RI activities (Table 3 and 4).

74

75 Data were collected using standardized, pre-tested questionnaires. Total RI facility economic
76 costs were estimated based on input quantities and prices as per a common methodological
77 approach developed for the EPIC studies and global costing guidelines [6,7]. Vaccines
78 administered were collected from facility monitoring records. Economic costs of inputs were
79 allocated to the different immunization activities (cf appendix 2 for definitions) based on factors
80 in the common approach. A fully immunized child (FIC) was defined as children receiving the
81 third dose of pentavalent (DTP-hepatitis B-Hib) vaccine derived from facility immunization
82 records. Weighted average costs were estimated using facility sampling weights.

83

84 In Ghana, the study protocol was submitted to the Ghana Health Service Ethical Review
85 Committee and the study was authorized in December 2012. In Benin, the study was exempted
86 from an Internal Review Board (IRB) process. Standard confidentiality procedures were
87 implemented to protect the identity of study informants including password-protected computer
88 entry.

2.2. Strategy for the treatment of joint cost

In most of the surveyed health facilities, resources were shared between different vaccination delivery strategies (facility-based or outreach), and between vaccination and other health services. For personnel, paid labor was estimated based on the percent of total working time spent on a range of immunization activities, such as record-keeping, vaccine administration, outreach, program management, among others. Vaccine costs were allocated to outreach or facility-based service delivery based on the number of doses administered within each strategy. For transportation and vehicle costs, the number of kilometers obtained from vehicle log books or estimated response was used to determine share of costs. Costs for overhead, utilities and communication were estimated based on the total facility or administration expenses for these items, multiplied the ratio of the number of patients receiving the third DTP dose and the sum of outpatient visits and inpatient admissions. In Ghana, the daily allowance for national immunization days was used to estimate volunteer labor costs.

2.3. Cost Determinants Model

According to economic theory, costs are a function of quantities, prices, quality, and other environmental factors [8-10]. For this study, facility immunization RI cost is represented in the following reduced form equation:

$$\log(CQ_i) = \beta_0 + \beta_1 * \log(Doses_i) + \beta_2 * \log(Time_i) + \beta_3 * \log(P_i) + \beta_4 * Z_i.$$

In this linear model, CQ_i is the total facility immunization cost (including vaccine cost); $Doses_i$ represents the total doses administered to RI (quantity measure); $Time_i$ reflects the proportion of time spent on immunization by facility staff; P_i is the average wage of staff (proxy price measure); and Z_i reflects other environmental and quality factors that could influence cost. One measure of quality was based on answer to the question “Do you have enough staff for routine immunization well ?” Other variables included type and ownership of the health facility, location of the facility, whether cold chain equipment was present in a facility, distance of the facility (km) to the nearest vaccine collection point, and existence of volunteers.

Variables in the regression equations were transformed into logs base 10. The coefficients on the explanatory variables can be interpreted as the effect a particular variable would have on total facility cost. Alternative model specifications were conducted for this analysis to examine the effects of different control variables in the regression. Ordinary Least Squares (OLS) regressions were conducted using STATA version 12 [11]. In addition to conducting separate regression analyses for each country, a pooled analysis was conducted. This analysis could assess whether relationships between the independent variables and facility cost hold with an improved sample size ($n=95$).

Post-estimation regression diagnostics were performed to examine the specification, robustness and sensitivity of the various models. A Breush-Pagan test for heterogeneity showed equality of variances. One important assumption for OLS was exogeneity of the output variable

(doses). The number of total doses administered was obtained from facility records for 2011. Costs were based on an analysis of inputs rather than government allocation of facility budgets which may influence the level of vaccine administration. For this study, doses delivered are therefore exogenous to facility cost for the period in question.

3. RESULTS

3.1. Statistical description of samples

Facility immunization costs were higher in urban than rural areas in Benin (Appendix 3a). Substantial variation occurred across regions and by facility type. These variations were reduced when vaccine costs were excluded. The distance between health facility and vaccine collection point was larger in rural facilities, and in hospitals. Higher costs were observed in facilities located in Central and Northern regions. Working time dedicated to vaccination was greater in urban areas and hospitals. The average wage was slightly lower in rural than urban areas.

In Ghana, vaccine cost constituted a lower fraction of total facility immunization cost than in Benin. The variation between rural and urban areas, across regions and by facility type remained whether or not vaccine costs were included (Appendix 3b). Facility RI cost was greater in urban areas, and in hospitals. Higher costs also were observed in facilities located in the Northern region. The distance between the health facility and vaccine collection point was larger for rural than urban facilities. Urban facilities also showed greater proportions of working time dedicated to immunization perhaps related to the larger numbers of doses administered. The average wage

was slightly lower in rural than in urban areas, and increased from lower to higher- level health facilities (CHPS to hospitals).

Most facilities in both countries were government-owned (Table 4) and used public electricity. The largest differences between countries were user fees were only collected in facilities in Ghana,¹ and approximately one-third of facilities in Ghana did not have cold chain equipment. Table 3 shows the aggregated national RI cost based on weighted averages. The weighted average facility RI with and without vaccine in Ghana was US\$ 16,459 and US\$ 12,153, respectively. Costs for Benin were lower at US\$ 14,994 with vaccine costs, and US\$ 5,345 without vaccine costs. This confirms the previous observation that vaccine costs take a much higher share of immunization cost in Benin than Ghana. On average, Ghanaian facilities had fewer fully immunized children, total doses delivered, health staff dedicated to immunization, and immunization campaigns. However, wages were higher in Ghana which can partly explain the difference in the weighted average facility cost between the two countries.

¹ User fees were not for immunization services specifically but for other services in the health facility.

Table 3: Descriptive Analysis of the continuous regression variables for Benin and Ghana

Table 4: Descriptive Analysis of the categorical regression variables for Benin and Ghana

3.2. Regression models for total economic RI costs

The regression models had overall good explanatory power for the facility data in Ghana, and higher explanatory power for facilities in Benin. In both countries, total doses were positively and significantly associated with facility RI cost. A 10% increase in doses implies an increase of facility RI cost of 3.7% and 7.5% in Benin and Ghana, respectively. This relationship was maintained in the pooled analysis.

In Ghana, the proportion of time spent on vaccination, sufficiency of staff, and presence of cold chain equipment were significantly and positively associated with facility cost. An increase of 10% working time for vaccination will increase the facility cost by 5%. Immunization costs of the facilities having enough staff or cold chain equipment were on average 50% higher.

In Benin, distance in km to vaccine point was significantly and negatively associated with facility RI cost, such that a 10% increase in the distance to the vaccine point was associated with 1.3% decrease in facility RI cost. This result seems counter-intuitive, as one would expect distance to influence travel cost. However, another interpretation is that remote facilities have lower levels of inputs (and possibly lower quality of care) and hence, lower costs. The proportion of time and wages were not significantly associated with facility costs.

The pooled analysis confirmed the positive and significant relationship of facility cost with administered doses and proportion of working time. Facilities located in urban areas were significantly and positively associated with facility RI cost. Finally, RI facility costs were 44% higher in Ghana.

Table 5: Final linear regression model evaluating the association of different variables with facility immunization cost in Benin and Ghana.

4. DISCUSSION

Few statistical studies have looked at the determinants of routine immunization costs at facility level. For the Ghana analysis, the proportion of time spent was positively associated with total facility RI cost, though RI costs were not significantly associated with wage rates. In a setting where payment for human resources remains low, this suggests that productivity of human resource plays a more important role, at least for immunization program costs. The relationship with the proportion of time spent on routine immunization in Ghana is consistent with an earlier study, based on hours worked by village nurses [4].

In Ghana and Benin, facility immunization cost also was positively associated with the average number of total doses administered to RI. The relationship between the number of total doses administered and facility costs was found in another study conducted in India by Brenzel et al [4].

Walker et al. found considerable variations facility immunization costs in Peru according to region and facility type. Vaccine wastage also was reported as a predictor of immunization costs. However, information on wastage rates was incomplete or inconsistent in both Ghana and Benin and could not be evaluated in this study. The current study did not find significant effects of location and facility type independent of the effects of vaccine doses.

The study found a positive relationship between the quality of immunization services, represented by sufficient of staff and presence of cold chain equipment, and facility RI cost. The costing study reflected the actual state of service delivery in facilities and not a normative estimate of best practice. Therefore, it would be expected that facilities with more and better inputs would have a higher cost.

The study had several limitations. First, the relatively small sample size per country may have led to bias in coefficient estimation. The pooled analysis resulted in a slightly higher effect of doses than in the Ghana sample alone, and a lower effect than the Benin sample alone. Second, factors other than input quantity and price will influence facility costs. While other variables were included in the various model specifications, variables such as corruption or staff training, which capture the behavior of health workers, were absent. Third, unit costs were not directly comparable between the two countries due to different types of facilities and health system structure. Some potentially important variables, such as vaccine wastage and vaccine stock-outs were not available to examine their impacts on facility RI cost.

Some of the tracing factors used in allocation of shared facility costs could potentially overestimate the true costs for routine immunization. In addition, use of the daily allowance for national immunization days to estimate volunteer labor costs may overestimate the latter when compared to local wages. When compared to potential financial costs, facilities where vaccines

represent a higher share of the economic costs are likely to have a lower financial cost / economic cost ratio (for example, district hospitals and Health Centres in Ghana).

Regarding policy implications, the recent expansion of CHPS facilities (located closer to rural populations) in Ghana led to additional operating costs at the service delivery level. However, from a household perspective, CHPS expansion should reduce travel and opportunity costs for users. The impact on total societal costs is unknown. Even if negative, there may be a social or ethical benefit in transferring costs from the rural poor to the local health system.

In conclusion, this study identifies factors associated with RI facility cost in two West African countries. These data should allow countries in the region to make some assessment of the impact of various strategies on overall costs. In terms of future research, these results also highlight the importance of full costing approaches in economic evaluations due to the significant contribution of human resource costs to total cost. The use of all resources (full costing) has been underestimated [5] or not considered in other studies. In addition, studies with a larger sample size might allow fuller evaluation of some potentially important variables.

Contributors:

CA conducted the statistical and regression analysis, developed the database and wrote the first draft of the manuscript. XX and JBLG provided input into statistical, regression analysis, conducted data analysis, interpretation and wrote parts of the manuscript. LK and FN provided input for data interpretation and discussion and reviewed the manuscript. AC recruited the core team, oversaw the project development and implementation, and reviewed the scientific study report and the article. BDG provided senior scientific support, supervised the scientific work and oversight to the project.

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Table 1: Routine childhood immunization vaccine schedule and age of administration in Benin and Ghana

	Ghana	Benin
<i>Traditional and underused vaccines (Routine immunization cost analysis)</i>		
Bacillus Calmette–Guérin (BCG)	Birth	Birth
Oral poliovirus (OPV)	Birth, 6, 10 and 14 weeks	Birth, 6 , 10 and 14 weeks
Diphtheria-tetanus-pertussis-hepatitis B- <i>Haemophilus influenzae</i> type b	6, 10 and 14 weeks	6, 10 and 14 weeks
Measles	9 months	9 months
Yellow-fever	9 months	9 months
<i>New vaccines (NUVI analysis)</i>		
Pneumococcal conjugate* (13-valent)	6 weeks, 10 weeks, 14 weeks (introduced April 2012)	6 weeks, 10 weeks, 14 weeks (introduced July 2011)
Rotavirus*	2, 6 and 10 weeks (introduced April 2012)	Not introduced
Measles second dose*	18 months (introduced February 2012)	Not introduced

**not included in facility routine immunization costs in 2011*

Table 2: Final sample selected by district and location in Ghana and Benin

District	Sampled urban facilities	% of total urban facilities sampled	Average population covered by one facility	Sampled rural facilities	% of total rural facilities sampled	Average population covered by one facility
	Urban			Rural		
Ghana						
Asante Akim South	2	100%	18 906	5	42%	9 431
Atwima Mponua	1	100%	122 398	5	55%	15 325
Bunkpurugu Yunyoo	1	100%	31 074	5	55%	6 958
Ga West	4	50%	16 011	4	44%	10 351
Kassena Nankana	2	100%	16 358	8	40%	4 075
Wa Municipal	1	100%	63 673	12	43%	6 123
Benin						
Akpro	2	25%	20082	3	50%	11402
Cotonou 2-3	5	100%	44239			
Cotonou 1-4	5	100%	35618			
Dassa Zoumé	2	25%	24035	4	100%	8041
Parakou N'Dali	1	40%	35955	3	25%	11260
Porto Novo	3	46%	23292	5	16%	12113
Savalou banté	1	22%	26624	4	100%	15602
Tchaourou	1	57%	27909	5	100%	14514

Table 3: Descriptive Analysis of the continuous regression variables for Benin and Ghana

Characteristics (in average)	Ghana		Benin		p-value
	Weighted Mean	Std. Err.	Weighted Mean	Std. Err.	
A. Immunization cost by facility, including vaccine costs (USD)	16,459.38	1,624.02	14,993.99	1,563.07	P<0.0001
B. Immunization cost by facility, excluding vaccine costs (USD)	12,153.01	1,041.89	5,344.62	425.76	P<0.0001
C. Proportion of staff time for routine immunization (%)	34.67	2.74	40.07	3.74	P<0.0001
D. Routine doses administered in 2011	3,244.52	411.47	8,120.86	882.37	P<0.0001
E. Total number of staff per facility	12.20	1.97	15.52	2.41	P<0.0001
F. Number of campaigns in 2011	2.21	0.31	4.09	0.09	P<0.0001
G. Average wage of staff per facility	432.55	10.94	126.09	7.48	P<0.0001
H. Distance in Km to the vaccine collection point	-	-	15.17	18.4	

Table 4: Descriptive Analysis of the categorical regression variables for Benin and Ghana

Variable	Ghana	Benin	p-value
Government-owned	95%	91%	0.422
Existence of cold chain equipment in the facility	68%	100%	p <0.0001
Collection of user fees	54%	0%	p <0.0001
Use of volunteer labor for immunization	84%	0%	p <0.0001
Whether facility manager felt he had enough staff to perform routine immunization well	65%	46%	0.099

Table 5: Results of the regression analysis of facility RI cost in Benin and Ghana

Variable	Ghana			Benin			Two countries
	(M1)	(M2)	(M3)	(M1)	(M1)	(M2)	(M1)
	N= 48; df. = 42; R ² -adj. = 0.412	N= 48; df. = 42; R ² -adj. = 0.512	N = 48; df. = 36; R ² -adj. = 0.472	N = 45; df. = 39; R ² -adj. = 0.868	N = 43; df + 37; R ² -adj. = 0.902	N = 43; df. = 34; R ² -adj. = 0.898	N = 93; df. = 84; R ² -adj. = 0.507
A. Total doses administered to RI (entered into the model as a log value)	0.359** (3.26)	0.366*** (4.95)	0.418*** (3.98)	0.690*** (13.64)	0.754*** (15.67)	0.752*** (14.09)	0.512*** (8.12)
B. Dedication proportion of vaccinating personnel time (entered into the model as a log value)	0.503** (2.76)	0.493** (2.99)	0.562** (3.20)	0.106 (1.40)	-0.0377 (-0.50)	-0.0492 (-0.70)	0.438*** (4.78)
C. Average monthly wage per facility (USD) - of staff involved in RI (entered into the model as a log value)	0.477 (1.21)	0.129 (0.32)	-0.141 (-0.25)	0.00353 (0.04)	0.0190 (0.29)	0.0250 (0.35)	-0.0156 (-0.09)
D. Enough staff to perform routine immunization well? (Yes = 1/ No =0)	0.657*** (3.57)	0.510*** (3.61)	0.496** (3.06)	-0.0577 (-0.98)	-0.0747 (-1.45)	-0.0802 (-1.53)	0.203 [†] (1.98)
E. Region (Greater Accra in Ghana/Cotonou in Benin=1; Others =0)			-0.187 (-0.70)			-0.0523 (-0.46)	0.318* (2.27)
F. Health Facility (CHPS in Ghana/Health Center in Benin =1/Others ==0)	-0.0484 (-0.23)		-0.104 (-0.55)	0.0390 (0.41)		0.0855 (0.86)	-0.118 (-0.97)
G. Ownership (Govt. =1/ CHAG/NGOs =0)			-0.153 (-0.56)				
H. Urban = 1 /Rural = 0			-0.0459 (-0.19)			-0.0147 (-0.15)	-0.0221 (-0.16)
I. User fees (Yes = 1/No = 0)			0.0149 (0.09)				
J. Cold chain equipment in facility (Yes = 1/No = 0)		0.481** (3.13)	0.480** (2.77)				
K. Existence of Volunteers supporting immunization (Yes = 1/No = 0)			0.284 (1.22)				
L. Distance in Km to the vaccine collection point (entered into the model as a log value)					-0.128*** (-5.48)	-0.129*** (-3.78)	
M. Dummy for country (1=Ghana, 0=Benin)							0.436 [†] (1.74)

t statistics in parentheses

[†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$