TECHNICAL REPORT

Costing and Financing Analyses of Routine Immunization in Uganda

Teresa Guthrie, Charlotte Zikusooka, Brendan Kwesiga, Christabel Abewe, Stephen Lagony, Carl Schutte, Edmore Marinda, Kerrin Humphreys, Zipozihle Chuma Nombewu, Katlego Motlogelwa, Anthony Kinghorn

Prepared by Health Development for Africa

Final: 30 November 2014

Health & Development Africa

Mott MacDonald House
359 Rivonia Boulevard
Rivonia 2128
South Africa
T: +27-87-310-5000
F: +27-87-310-5198

Contact Person: Dr. Anthony Kinghorn
akinghorn@hda.co.za (+27) 83 273 4276

Contents

Acknowledgements

The study team would like to acknowledge the support of Uganda MOH staff at National, District and Facility level in providing guidance and data while dealing with many other demands on their time. In particular we are grateful for the roles played by Dr Robert Mayanja, Dr Jacinta Sabiti and all other members of UNEPI team in the MOH.

The study was made possible by the financial support of the Bill and Melinda Gates Foundation. Logan Brentzel and Damian Walker provided key technical and general leadership for this and other country studies. Members of the study Reference Group, drawn inter-alia from GAVI, WHO and UNICEF, also provided key advice at various stages in the study process.

The findings and conclusions contained within this report are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

List of tables

List of Figures

Appendix Tables and Figures

Acronyms

AFENET	African Field Epidemiology Network
BCG	Bacille Calmette-Guérin (tuberculosis vaccine)
cMYP	Comprehensive Multi Year Plan
DEA	Data Envelopment Analysis
DHO	District Health Officer
DHT	District Health Team
DTP	Diphtheria, Tetanus and Pertussis vaccine
DTP3	Third dose of DTP vaccine
DVS	District Vaccine Store
EPI	Expanded Program on Immunization
EVM	Effective Vaccine Management
FIC	Fully Immunized Child (defined as child who has received DTP3)
FOB	Free on board (the buyer pays for transportation of the goods)
FTE	Full-Time Equivalent
FS	Financing Sources
FSP	Financial Sustainability Plans
GAVI	Global Alliance for Vaccines and Immunization
GAVI-ISS	GAVI Immunization Service Support
GoU	Government of Uganda
GVAP	Global Vaccine Action Plan
HC	Health Center
HDA	Health & Development Africa
HepB	Hepatitis B vaccine
Hib	Haemophilus influenza b
HMIS	Health Management Information System
HNC	Healthnet Consult
HPAC	Health Policy Advisory Committee
HSSP	Health Sector Strategic Plan
JICA	Japan International Cooperation Agency
MNTE	Maternal Neonatal Tetanus Elimination
MOH	Ministry of Health
NGO	Non-Governmental Organisation
NHA	National Health Accounts
NMS	National Medical Stores
NUVI	New and underutilized vaccines
OPV	Oral Polio Vaccine
Penta	Pentavalent vaccine (DPT-HepB+Hib)
PCV	Pneumococcal Conjugate Vaccine
PHC	Primary Health Care
PIE	Post Introduction Evaluations
PPS	Probability proportional to size
RED	Reaching Every District approach
RI	Routine immunization
Rota	Rotavirus vaccine
SHA	System of Health Accounts
SIAs	Supplemental Immunization Activities

SOS	Sustainable Outreach Services
UCI	Universal Child Immunisation
UNICEF	United Nations Children's Fund
UNMHCP	Uganda National Minimum Health Care Package
UNEPI	Uganda National Expanded Program on Immunization
USAID	United States Agency for International Development
USG	United States Government
VHW	Village Health Workers
WHO	World Health Organisation

Executive Summary

I. Background and Rationale of the Study

In Uganda and other countries, accurate data on the costs of immunization with routine and new vaccines is needed to improve country level planning and financing for immunization, as well as to provide evidence to inform domestic and external resource mobilization. More specifically, enhanced cost information is required for better use of the comprehensive multi-year plan (cMYP), and the cMYP tool, which are used to plan and budget for the national immunization program, including estimates for the routine program, campaigns, and new vaccines.

The importance of information on costs and financial flows is increased by the introduction of high cost new vaccines. However, the number of studies examining routine immunization program costs and financing has fallen in recent years. Furthermore, the methodologies of various costing studies have often differed, making it more difficult to compare or apply results more widely. There has been a general assumption that unit costs for conventional immunization have been reduced due to lower vaccine costs, but this and other cost related assumptions need to be validated.

This study formed part of the multi-country EPIC initiative, supported by the Bill and Melinda Gates Foundation, GAVI and WHO. The EPIC studies aim to develop updated estimates of routine immunization program costs in six pilot countries, map their funding flows, cost introduction of new vaccines, and develop standardized methodologies to produce comparable results.

Uganda had a population of 34.5 million people in 2011, of which 88% lived in rural areas. The population growth rate of 3.6% is driven by a fertility rate of 6.9 births per woman. Infant mortality rate is estimated at 76 per 1,000 births, but varies between different areas of the country. Uganda is a low income country with a Gross National Income per capita of US$ 440 in 2012.

An estimated 72% of the population lived within 5kms of a health facility in 2010, an increase from 49% in 2000. Immunization coverage improved between 2000 and 2006, but showed some decline thereafter. Coverage with most vaccines has remained above 80% but with variations between districts. Uganda will implement PCV vaccine from the end of 2013 and intends to implement rotavirus immunization thereafter. The standard types of health facility in Uganda are Health Centres (HC) II, III and IV, and hospitals (general, regional and national). Access to quality health care, especially in rural areas, is impeded by limited infrastructure, availability of medicines and other health supplies, shortage of public sector human resources, low salaries, lack of accommodation at health facilities and other factors.

II. Methodology

The study followed the EPIC Common Approach developed for the multi-study initiative, based on the standard WHO approach to costing various components of the routine immunization program. The following methodologies were used.

i. *The costing of routine immunization services* used a bottom-up, ingredients-based, retrospective costing methodology which identified costs from the perspective of the health service provider, in 2011. The Uganda study applied a multi-stage, purposive and stratified random sampling approach. All 10 regions were represented and one or two districts per region were purposively sampled to represent a range of typical service contexts. 52 health facilities were randomly sampled from the strata of health facilities in these districts (general hospitals and HC II, III and IV). The study included government and NGO services as both provide immunization on behalf of the government in Uganda. Private for profit facilities were excluded as they were not expected to be able to provide comparable data and were not viewed as a major means of extending coverage.

   Routine immunization program costs were collected using structured interview schedules from all levels of the health system (facility, district and national). The costs included the value of inputs shared with other health programs, which mainly occurs at the district health office level. The ingredients approach identified the type of inputs, quantified the number of inputs, and multiplied them by unit prices and the proportion used for routine immunization. Facility and District level costs were weighted according to sampling weights. Any large variations in total facility costs and unit costs were identified and analyzed, to identify unique facility or service characteristics or other factors.

   Both economic and financial total program costs were calculated, broken down by line item and according to ten standard routine immunization activities. A series of unit costs were also generated, including total cost per dose, cost per infant in the target population, cost per DTP3 immunized child and cost per capita. In addition to total unit costs, the study estimated delivery unit costs (minus the vaccine and supplies costs), as well as the line item unit costs to provide a set of costing benchmarks.

ii. *The prospective costing of the planned implementation of PCV* applied an ingredients-based costing for 2013, also from the perspective of the service provider. Incremental costs were estimated, to represent only the additional (incremental) costs to the system due to PCV implementation. The costing had to be prospective as full implementation had not yet started at the time of the study. A proportion of salary costs per dose estimated in the main costing study were used to estimate human resource costs of PCV administration.

iii. *The productivity analysis and costs determinants analysis* applied scatterplot and regression analysis in STATA. Variables associated with the dependent productivity (output) or cost variable were included in the models where economic theory suggested a plausible reason for association. To investigate factors associated with productivity and cost, least square regression models were fitted, and log transformed (ln) data of independent and dependent variables was used in analyses. In order to assess the degree of linear relationship between variables, Pearson correlation coefficients were fitted. Where several independent variables were highly correlated (e.g. total doses and DPT3 children), only selected ones were included in each model. A number of other diagnostics were undertaken.

iv. *The financial mapping component* applied a simple mapping of all sources of funding for immunization in 2010 and 2011, and quantified their contributions.

Data was collected at the same time as costing study data at facility, district and national levels. They were coded according to the System of Health Accounts (SHA, 2011) classifications, with additional disaggregation applied to the health function code to increase detail of analysis for the immunization program. Findings were compared with financing sources projected in the Uganda cMYP.

Use and Limitations of results

This study applied a rigorous, standardized approach and collected critical costing data at facility and district levels. This should inherently improve on previous estimates which did not have key data to inform comprehensive cost estimates. The costing was based on a sample of facilities that ensured representation of a range of service contexts, regions and facility types. However, lack of available service data at national level did not allow for assessment of possible sample biases or alternative weighting approaches. The sample size was expected to be large enough for multiple regressions with up to five independent variables. The consistency of dependent variables' relationships with a limited number of independent variables suggests that conclusions of regressions are robust, even if some less strong associations may not have reached statistical significance due to the limited sample size. Samples of HCII and HCIII were also relatively large, and facility types with smaller samples (hospitals and HCIV) account for a relatively small proportion of facilities and immunizations.

Overall, the main findings of this study are not likely to be very sensitive to data and other limitations. They should be robust and adequately generalizable to other public settings in Uganda, to inform planning and budgeting of immunization services. Nevertheless, quality and availability of financial and programmatic data posed challenges at each level. There were particular limitations of immunization statistics in some facilities, vaccine and supplies data, and district level expenditure records. Informants' estimates of staff time use may also have some biases. Limited facility and national level immunization statistics affected aggregation for country level cost estimates. The data deficiencies do however have implications for ongoing ability to plan and manage services.

III. Results

a) Routine immunization program costs

Several main conclusions arose from the costing in relation to contributors to costs.

- The bulk of routine program costs (80%) were incurred at facility level (when including the vaccine costs at the facility level), followed by the national level (11.5%) and then district level (8.4%).
- HCII and HCIII each contributed an estimated 30% and 36% of all facility level immunization costs respectively, and they represent 60% and 32% of total facility numbers in the country respectively. HCIV represent 5% of facilities and 12% of costs, and hospitals 3% of facilities and 21% of costs.
- The total weighted average facility total spending on immunization by type ranged from US$ 4,309 for HC II, US$ 9,957 for HC III, US$ 21,160 for HCIV and US$ 52,793 for hospitals. However there is wide variation around these means.
- Vaccines and vaccines supplies (38% together) were the largest cost item in the total national immunization costs, followed by salaries at 31%. They also contributed the bulk of facility and outreach service costs, which are the

immunization activities with the highest costs. Transport was the next largest recurrent cost (5%).

- Outreach accounted for around 40% of immunizations and can have substantial extra costs of staff time and transport, particularly in remote populations, for which it is a particularly important delivery model.
- Program management costs amounted to a relatively high 19% of non-vaccine costs at facility level, and 5.5% of district and 29% national levels.
- Capital costs made up 18% of economic costs, with vehicles contributing the largest part (11%). The cold chain contributed only 2% to routine economic costs, although it is a critical operational necessity and fiscal costs of purchasing capital equipment may pose budget challenges.
- Differences between economic and financial costs were small. Hidden resource use by the immunization program is thus not a major issue for planning.

The total cost of the Ugandan routine immunization program (US$ 40 million in 2011) was higher than previous estimates, in large part due to more complete assessment of staff costs, and facility and district level operational costs. The estimated total immunization cost would have accounted for 18% of total resources for health and 24% of GOU expenditure on health from own revenue.

These figures have implications for sustainability of routine immunization services and new vaccines, and for funding decisions by partners. The cMYP for 2011 under-estimated personnel costs and vehicles as well as other district level expenditures, but also may have over-estimated vaccine costs or the coverage rate. Immunization unit costs were slightly higher than recent ones available for Uganda due to previous underestimation of staff and transport costs in particular.

The total unit cost per DTP3 child was US$ 33.64 and US$ 3.93 per dose, *including district and national level costs*. Excluding the vaccine costs, the national delivery unit costs per DTP3 child and per dose were US$ 22.66 and US$ 2.65 respectively. The unit costs are somewhat lower than unit costs reported by the EPIC studies in the other countries, primarily due to lower staff salaries.

At facility level (see Table below), the weighted total unit cost per DTP3 immunized child varied from US$ 31.25 in HCIII to US$ 34.25 in general hospitals, US$ 44.30 in HCIV, and up to US$ 52.42 in HCII. The average cost across all facility types per DTP3 child at facility level was US$ 44.17.

Overall system cost estimates are likely to mainly be affected by HCII, with the highest unit costs, and HCIII, which had the lowest unit costs, because they contribute 60% and 32% of facilities respectively. In addition, extension of immunization coverage seems most likely to be through HCII and III.

Traditional planning approaches based on average costs by facility type, for example, can potentially be improved by using these results. However they should ideally be modified to reflect service volumes and other determinants, as there is substantial variation around average unit costs (see below).

Weighted Facility Total Costs, Outputs and Unit Costs ($, 2011)

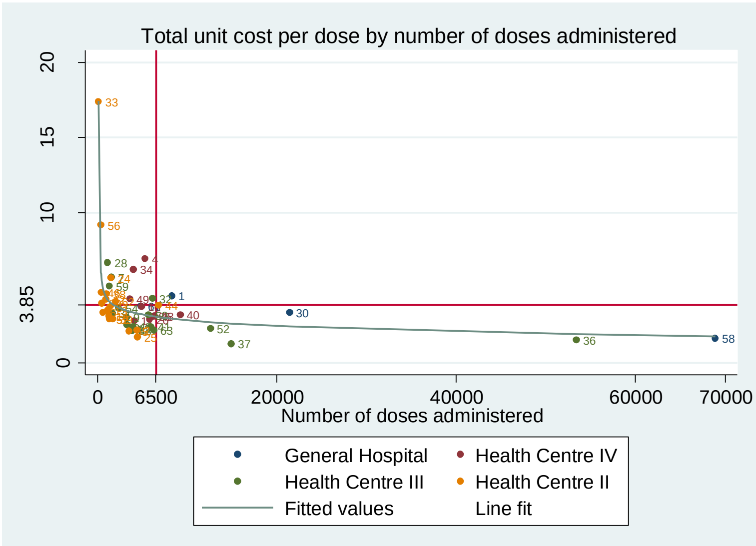
FACILITY STATS, OUTPUTS & UNIT COSTS	HC II (n=18)	HC III (n=18)	HC IV (n=9)	Gen Hosp.(n=4)	Total All Facilities
Outputs					
Total Child Doses	33 597	134 883	49 488	103 520	321 488
Total DTP3 Vaccinated Children	3 399	13 636	4 642	11 720	33 397
Infant population (< 1year)	13 040	20 360	11 037	44 535	88 972
Catchment population	266 996	467 833	256 670	1 035 694	2 027 193
W.Av total doses	1 191	3 655	5 231	20 501	2 895
W.Av DTP3 children	111	397	496	2 163	298
W.Av Infant pop (<1yr)	321	720	1 783	11 998	930
W.Av Catchment pop./ facility	7 450	16 532	41 455	279 028	21 549
Total Weighted Cost (US$)	4 309	9 957	21 160	53 793	8 772
W.Unit Costs (US$) (including vaccines & supplies)					
W.Cost per Dose	6,45	3,32	4,28	3,34	5,17
W.Cost per DTP3 Vaccinated child	52,42	31,25	44,30	34,25	44,17
W.Cost per child	16,84	24,65	18,07	15,65	19,52
W.Cost per capita (catchment pop)	0,73	1,07	0,78	0,67	0,84
Total Weighted Non-Wage Cost (US$)	2 706	7 155	12 613	37 875	5 922
W.Unit Costs (US$) Non-Wage (including vaccines & supplies, excluding salaries)					
W.Cost per Dose	2,54	2,39	2,52	2,27	2,48
W.Cost per DTP3 Vaccinated child	25,62	22,63	26,02	22,90	24,53
W.Cost per child	9,54	17,83	10,80	11,03	12,48
W.Cost per capita (catchment pop)	0,41	0,77	0,46	0,47	0,54
Total Delivery Cost (US$) (excluding va	2 827	5 425	14 828	28 185	5 181
W.Unit Delivery Costs (US$) (excluding vaccines & supplies)					
W.Cost per Dose	5,11	2,09	3,06	2,15	3,88
W.Cost per DTP3 Vaccinated child	39,28	19,96	30,86	22,23	31,69
W.Cost per child	11,39	13,04	12,21	10,45	11,96
W.Cost per capita (catchment pop)	0,49	0,57	0,53	0,45	0,52
Total Non_wage Delivery Cost (US$) ((	1 223	2 623	6 281	12 267	2 332
W.Unit Delivery Costs (US$) Non-Wage (excluding vaccines, supplies & salaries)					
W.Cost per Dose	1,20	1,16	1,31	1,07	1,19
W.Cost per DTP3 Vaccinated child	12,48	11,35	12,59	10,88	12,04
W.Cost per child	4,09	6,22	4,95	5,83	4,92
W.Cost per capita (catchment pop)	0,18	0,27	0,21	0,25	0,21

Facility performance **or** ***efficiency*** (indicated by unit costs per dose or per DPT3) was found to be associated with a number of factors. The figure below explores the relationship between unit costs per dose and total number of doses administered by the facility. The plot suggests a marked relationship between the two variables, with unit costs falling as service volumes increase. There is also notable clustering of different types of facility. There is however, wide variation within facilities of the same type and at the same levels of output, particularly at low immunization volumes.

Further statistical analysis found that, apart from being associated with the volume of immunizations provided, efficiency was also linked to the number of people attending facilities, the number of zones served, distance to vaccine collection point, and the type of facility.

HCIII tend to have lower unit costs, while HCIV appear less efficient, than others with the same immunization volumes. There was a consistent pattern of variables associated with efficiency. However, regression analyses could not readily explain large proportions of efficiency.

Total unit cost per dose by the number of doses administered (US$, 2011)



Costing of the planned introduction of PCV

The incremental costs for PCV in 2013 amounted to US$ 24 million for 90% coverage, or US$ 13.2 million at 45% coverage. Given that the actual roll out of PCV in Uganda has been delayed, these costs are likely to roll over into 2014. The introduction of PCV-10 represents a very large addition of as much as 61% to the routine immunization program expenditure in Uganda (at 90% coverage), or 33% extra at 45% coverage. Sustaining the on-going cost of PCV coverage may thus be a material challenge to Uganda and its partners.

Further findings of the costing included the following:

- Reducing vaccine costs will be a key issue in enhancing programme sustainability, as vaccines and injection supplies contribute between 84% and 74% of total costs of introducing the new vaccine.
- Assessment of realistic initial coverage rates may be important to avoid to over-investment in initial vaccines stocks and unnecessary wastage and strain on existing cold chain and distribution. Improved facility-level records and aggregation of statistics to national level could greatly enhance forecasting.
- The estimated economic unit costs per PCV immunized child in the introduction period under the 90% coverage scenario are between $15.97 and $16.71, equivalent to around 50% of combined costs of all other vaccines per DPT3 child in the routine immunization. The economic costs per dose in the introductory period amount to $4.04 - $4.23, or 108% of the estimated $3.93 per dose for routine immunization. In lower coverage scenarios, unit costs are even higher.
- Service delivery costs (excluding vaccines and supplies) are also substantial. The fiscal service delivery costs ($10.02 per PCV immunized child) are likely to be markedly higher than the GAVI implementation grant of 80c per birth.
- The government contribution to NUVI has previously been under-estimated, particularly because substantial staff costs had not been included. The staff, cold chain and infrastructure are essential contributions for service delivery.

- Human resources requirements are substantial, but do not lead to incremental *fiscal* costs as new staff were reportedly not being employed. However, particularly when several new vaccines are introduced, additional capacity may be needed in order to avoid substantial opportunity costs, burdens on scarce management and service staff, and trade-offs in health personnel allocations.
- Cold chain capital *fiscal* costs before the introduction period were estimated at $5.6 million. A substantial part was NUVI-related, but some may have been to replace existing obsolete equipment. Requests for cold chain equipment funding should probably be judged on soundness as a broader immunization investment, rather than whether they are specific NUVI costs. Annualized economic costs of cold chain equipment for PCV would be relatively small (around US$ 222 000).

A large increase of funding is required for the roll-out of PCV – an additional 33% of funding would be required to achieve 45% coverage in the first year, or 61% additional to achieve 90% coverage, and increasing thereafter. Given this and the planned introduction of rotavirus vaccine in the following year, there could be a large funding gap that threatens the sustainability of NUVI options, unless there is careful forward planning with mobilization of both domestic and external funds.

b) Productivity and cost determinants

Scatter plots and multiple regressions identified more details of which factors are the most important predictors of total outputs (productivity) and costs of immunization at facility level. There was a high degree of consistency between the findings of models and the main conclusions are likely to be robust.

Analysis of total facility productivity (indicated by total doses or DPT3 immunized children) found a small set of variables that tended to be associated quite consistently with productivity, and could account for up to 75% of facilities' immunization volumes.

- Statistically significant associations between productivity and total facility attendance indicated that, when attendance increased 10%, immunisation outputs generally increased by around 5%.
- Other consistent and significant associations were with the number of zones served, urban location and facility type. Of note, the HCIII facility type *per se* is associated with higher outputs than HCIV and HCII.
- Productivity, when measured as *doses per immunization staff FTE*, fell with higher immunization staffing levels. Doses per staff FTE tended to be lower in HCII, indicating less productive use of staff than HCIII, HCIV and hospitals.
- There was little influence of other factors on productivity (e.g. numbers of staff and village health workers involved in immunization, poverty, remoteness and infrastructure).

The difficulty in identifying a range of significant factors which can explain a large proportion of efficiency and productivity may be because Uganda has a large number of small and rural facilities. These tend to have high variability in a range of factors, which could obscure associations that would be easier to identify when there are larger, less diverse facilities. Other associations may also have become statistically significant if the sample size had been larger.

The study considered a range of possible ***determinants of total facility immunization costs***, related to quantity, price, quality, capital investments and service context such as facility type and poverty. The following table illustrates some of the final models for the different total cost measures.

Key conclusions in relation to determinants of total costs included the following:

- Models with the above independent variables can predict a large proportion of facility costs.
- Results confirmed expectations and findings of previous studies, that vaccines and human resources are the main determinants of facility costs. Their costs are in turn strongly associated with service volumes: a 10% rise in DTP3 children was associated with a 4% rise in facility costs.
- Total costs are also significantly associated with: number of zones served, which may represent both service quantity and cost factors of servicing more zones; urban or peri-urban location; and facility type. HC IV, III and II had 46%, 63% and 66% lower cost respectively compared to hospital immunization services, independent of other factors.
- Delivery costs that *excluded vaccines and HR* were only significantly associated with patient volumes (number of DTP3 immunized children), peri-urban/rural location and road condition. Thus vaccine and HR costs do not seem to obscure major effects of other determinants.
- No other determinants of facility costs were consistently significant, although the limited sample size may have hidden some significant associations. Capital costs are not strong determinants of total costs.

Determinants of Weighted Total Cost, and Total Costs *excluding* Vaccines and Human Resource Costs

		Dependent Variable		
		Ln total cost	Ln total cost *without vaccines*	Ln total costs *without vaccines and salaries*
Variable		Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value
Ln DTP3		0.40 (0.07) **< 0.01**	0.10 (0.09) 0.28	0.56 (0.19) **< 0.01**
Ln # Staff involved in immunization		0.18 (0.12) 0.15	0.31 (0.17) 0.07	-0.15 (0.33) 0.65
Ln # Zones supported		0.05 (0.02) **0.03**	0.05 (0.04) 0.15	-0.06 (0.07) 0.36
Ln facility attendance size		0.04 (0.08) 0.56	0.01 (0.11) 0.92	-0.27 (0.22) 0.23
Ln poverty index		0.18 (0.06) **< 0.01**	0.23 (0.09) **0.01**	0.16 (0.17) 0.35
Ln Distance to collectn pt		0.03 (0.02) 0.15	0.03 (0.03) 0.25	0.07 (0.05) 0.21
Roads	Good/Fair	Reference (0)	Ref	Ref
	Poor/very poor	0.02 (0.09) 0.81	0.11 (0.12) 0.35	0.50 (0.23) **0.04**
Cold chain Energy:	Electricity	Ref	Ref	Ref
	Other[&]	-0.05 (0.17) 0.75	-0.12 (0.24) 0.61	0.09 (0.47) 0.85
Area	Rural	Ref	Ref	Ref
	Peri-urban	0.35 (0.10) **< 0.01**	0.46 (0.15) **< 0.01**	0.97 (0.29) **< 0.01**
	Urban	0.48 (0.21) **0.02**	0.47 (0.29) 0.11	0.13 (0.56) 0.82
Facility type	Hospital	Ref	Ref	Ref
	HC IV	-0.61 (0.33) 0.07	-0.69 (0.47) 0.15	0.23 (0.91) 0.90
	HC III	-0.99 (0.28) **< 0.01**	-1.34 (0.40) **< 0.01**	-0.71 (0.77) 0.36
	HC II	-1.08 (0.33) **< 0.01**	-1.56 (0.46) **< 0.01**	-0.99 (0.90) 0.28
Constant		7.04 (0.65) < 0.01	8.66 (0.92) < 0.01	7.40 (1.80) < 0.01
R – squared		0.93	0.85	0.75
F value		F(13, 35)=37.9 **< 0.01**	F(13, 35) =15.0 **< 0.01**	F(13, 35) = 8.1 **< 0.01**

The strong and recurring association of performance, productivity and facility costs with facility type was notable. This suggests that facility type captures a substantial amount of variation related to delivery context and models of different facility types (e.g. particular staffing, equipment and transport functions), that is not accounted for by attendance or other variables which can be easily identified individually. Of note, the proportion of immunization provided through outreach or facility-based services did not seem to be a strong influence on performance.

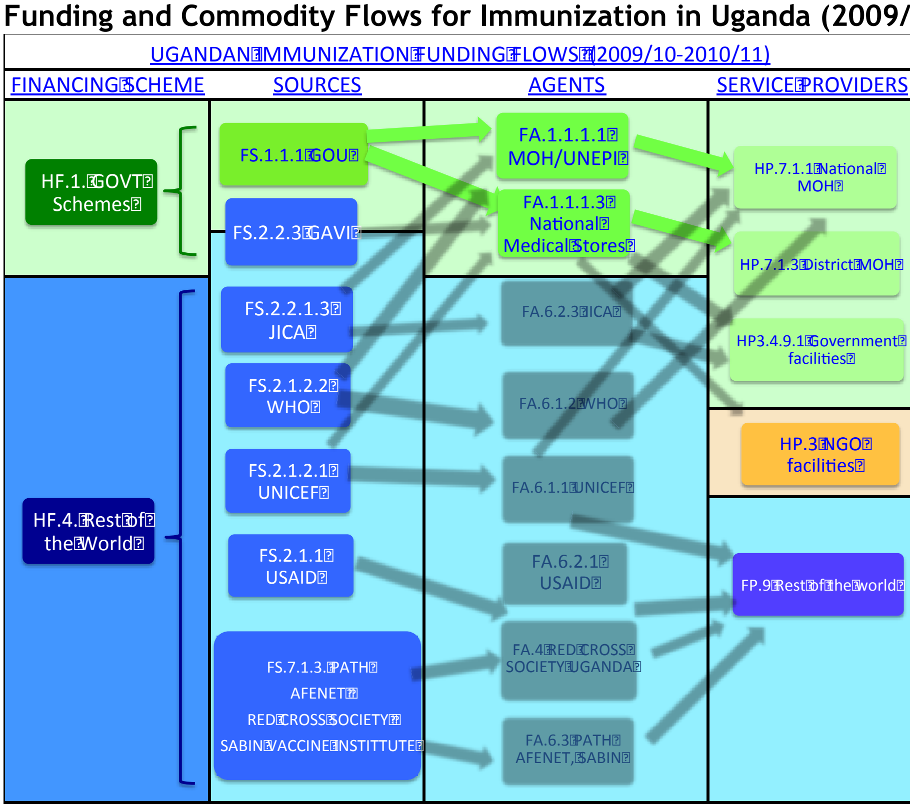
From a planning perspective the facility type, number of zones supported and expected total outpatient load of any new facility or program expansion should be carefully considered. Together they are able to predict a substantial proportion of the total facility immunization outputs, likely costs and immunization unit costs. However, particular local contexts will be important to consider in planning, given the variability between facilities' productivity, performance and costs.

Further investigation of causes of outliers and variations, and differences between facility types, would be useful to increase understanding of determinants of productive and efficiency, and thus inform programme management and planning.

c) *Financial mapping*

The mapping of resources for immunization was the most comprehensive in Uganda to date, and was able to draw on the costing study to produce more accurate information on items such as personnel, transport and various other district level costs. The project also developed an extension of the SHA coding system to provide more detail specific to immunization. The following figure illustrates the main funding flows mapped by the study.

Funding and Commodity Flows for Immunization in Uganda (2009/10-2010/11)



The mapping identified a total of US$24 million in 2009/10 and US$33 million in 2010/11. Comparing these resources with the study's total estimated national cost of US$40 million in 2011, there may have been an estimated overall financial gap of US$7 million in 2011, but in reality, most of this would have been absorbed by the MOH in routine service expenditure.

The results highlighted that the Uganda Government was in fact the largest funder of the routine EPI (42% in 2010/11), particularly through funding of personnel and other support functions at national, district and facility levels, which are difficult to estimate without a costing study. Similarly, it was difficult to track other (general operational) costs of overheads, administration and maintenance, as these were absorbed in the public primary health care grant. Other large cost drivers – vaccines, cold chain equipment, and transport (including vehicles) were mainly covered by development partners. Their contributions remain critical, particularly GAVI's contribution for vaccines (33% of expenditure in 2010/11). This raises issues around the long-term sustainability of the programme, if external funding for the EPI declines.

The mapping produced similar, though slightly larger estimates of overall resources to the cMYP's estimated financing sources in 2011 (US$ 1.2 million or 4% more). However, there were some substantial discrepancies in estimates for various activities, line items and their financing gaps.

Further mappings are likely to be valuable in coming years. Funding needs, flows and gaps are likely to be larger with introduction of PCV and Rotavirus vaccines, and programme efficiency and sustainability could be compromised without robust resource mobilisation and tracking. A useful option would be to establish a single system which can accurately capture all funding and contributions from partners and at the same time reconcile plans with government and partner reports of commitments, disbursements and actual expenditures. More detailed analyses would also be useful to explore financing related to programmatic areas, line items, sub-national funding flows and non-governmental providers.

IV. Conclusions and recommendations

This costing and financial mapping study of immunization services in Uganda has provided costing information for the routine immunization services that provides a much more solid basis for immunization planning, funding and management decisions. Similarly, more robust data has been generated in relation to the introduction of PCV, and resource mapping. The new information should enhance confidence in future cMYP and other planning estimates which have had previously had challenges in estimating costs and resource requirements.

Particularly important results are more robust estimates of human resource costs, and the related findings that both routine immunization unit costs and levels of GOU funding for immunization are substantially higher than previously estimated. More detailed understanding of patterns of costs and their determinants is also an important step forward. Innovations of the study include: application of a common methodology; statistical modeling to assess determinants of efficiency, productivity and costs with more rigour; and application of the SHA codes with greater disaggregation.

Overall, the findings of this study are thought to be adequately representative of public sector settings in Uganda to inform planning and budgeting for immunization services, despite some limitations mentioned above. However, some caution is needed in using results as benchmarks and for management and planning decisions. Firstly, a more comprehensive primary health care perspective is required in assessing efficiencies and options, as immunization services and costs cannot be managed in isolation. In addition, comparison of costs, unit costs and determinants with other countries may have risks. Finally, SIA's play a key role in immunization in Uganda but were not costed. Thus total resource requirements to achieve targets may be underestimated particularly at facility and district level.

Key recommendations

The following main recommendations are made, based on the findings of this study.

Costing, budgeting and financing

1 *Planners and managers should use the results from this study* to inform more accurate prediction and management of costs at the various levels of the system, for expanding coverage and new vaccine introduction. In general, cost estimates from this study can give useful guidance in planning at facility and higher levels However, specific local context and ingredients-based budgeting will be important to consider particularly for smaller facilities, as indicated by the high variation in facility level unit costs, productivity and total costs.

2 *cMYP assumptions should be updated* with the primary costing data presented here, and include the revised estimates of GoU contributions and costs, particularly for personnel.

3 *Consider potential to manage costs and efficiency of the main line items, activities and particular services* that are cost drivers or appear inefficient (e.g. HCIV, outreach).

4 *Revised estimates of resource needs, mapping of financing sources and estimates of the funding gap*, should be considered by government, GAVI and other partners to ensure long-term sustainability especially in relation to new vaccine introduction. The new estimates of government contributions and other costs may warrant review of co-funding requirements and implementation grants for NUVI.

5 *Consider implications of significant expansions of the immunization program, and new vaccines* (particularly more than one) for staff and management capacity. The study suggests that they may impose significant opportunity costs on the PHC system.

Management

6 Key *results should be disseminated to district and facility managers*, as part of a process to *support application of results* to improve planning and management.

7 *Systems should be reinforced* to strengthen the management and monitoring of key cost drivers and resources, including:
   - Vaccine stocks at all levels,
   - Use and maintenance of vehicles,

- Human resource capacity,
- Outreach costs, and;
- Wastage rates especially with expensive new vaccines.

Improving information

8 Uganda should continue efforts to *improve quality and national level availability of data on facility and district immunization output* and utilization. This will enhance programme management and estimation of immunization programme costs, and will help to assess the representativeness of sampled facilities.

9 *Further research on differences in facility costs and productivity* (especially with regards to facility types, outliers and key components such as outreach) would be useful to enhance sustainable and efficient programme planning and management. Research should consider immunization within the context of other PHC services. Ways to enhance capacity utilization in low volume settings or particular HC models could be explored to enhance efficiency.

10 *Review the current ledger account system and coding* to assess potential to improve financial information on immunization and general PHC services, to enhance service management, costing and finance tracking.

11 *Actual costs, of PCV and Rotavirus introduction, including possible hidden opportunity costs* in Uganda, should be monitored to validate the prospective costing.

12 Uganda and partners should consider further investigation to *assess functional implications and risks of differences in expected and actual funding flows*, as well as to identify potential bottlenecks, delays and needs for fund re-allocations.

13 Uganda should develop a *coordinated, single mechanism which accurately captures all contributions* received from partners, and at the same time reconciles government and donor reported figures. Enhanced resource needs estimates, financial tracking and gap analyses will be increasingly important given the scale of NUVI funding and potential for bottlenecks and limited sustainability.

1 Rationale, Purpose and Scope of the Study

The Global Vaccine Action Plan 2011-2020 (GVAP) galvanized renewed action for immunization, and particularly for the costing and financing of programs. Prior to that, the establishment of the GAVI Alliance in 1999, motivated countries to develop Financial Sustainability Plans (FSP) which aimed to ensure the financial sustainability of programs as more expensive, new vaccines became available. The FSP required countries to estimate their current and future costs and potential financing of the national immunization program. The successor to the FSP, the comprehensive multi-year plan (cMYP), includes a tool for planning and budgeting for the national immunization program, estimating the routine program as well as campaigns, shared program costs, and new vaccines.

An evaluation of 50 FSPs in 2008 revealed that the average cost per child was $17, and that governments were financing approximately 42% of immunization-specific costs.[1] Brenzel and Claquin (1994) had found earlier that the cost per child fully immunized against traditional vaccines such as tuberculosis, diphtheria, pertussis, tetanus, polio, and measles was around $20 on average, which was supported by subsequent country studies.[2] [3] [4] A subsequent analysis of 56 cMYPs for the period between 2004 and 2012 found the average cost per child to be $21 and the average cost per fully immunized child to be $28.[5] It was also found that the government contribution was higher than previous estimates, accounting for around 56% of total financing of routine immunization.

An increasing number of studies have focused on costs of new vaccines. Griffiths, et al (2009) estimated the cost of Hib vaccine introduction in Ethiopia as part of a Post-Introduction Evaluation (PIE) conducted with WHO.[6] Walker et al (2004) examined the costs of HepB introduction in Peru and Bangladesh, while Levin et al (2013) examined the introduction costs associated with Human Papiloma Virus (HPV) vaccine in Peru, Uganda and Viet Nam.[7] [8]

---

[1] Lydon et al, 2008

[2] Brenzel L and Claquin P. 1994. Immunization Programs and Their Costs, *Social Science and Medicine*, 39(4): 527-536.

[3] Kaddar M. Tanzi V. Dougherty L. 2000. Case Study on the Costs and Financing of Immunization Services in Côte d'Ivoire. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

[4] Levin A. Howlader S. Ram S. Siddiqui SM, Razul I, Routh S. 1999. Case Study on the Costs and Financing of Immunization Services in Bangladesh. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

[5] Brenzel L and Politi C. 2012. Historical Analysis of the Comprehensive Multi-Year Plans in GAVI-Eligible countries (2004 - 2015). Mimeograph. World Health Organization. http://www.who.int/immunization_financing/analysis/Historical_cMYP_Analysis_2012.pdf

[6] Griffiths U. Korczak VS. Ayalew D. Yigzaw A. 2009. Incremental system costs of introducing combined DTwP–hepatitis B–Hib vaccine into national immunization services in Ethiopia. Vaccine 27:1426–1432

[7] Walker D. Mosquiera NR. Penny ME, Lanata CF. Clark AD. Sanderson CFB. Fox-Rushby JA. 2004. Variation in the costs of delivery routine immunization services in Peru. Bulletin of the World Health Organization 82(9): 676-682.

Brenzel (2013) notes that the number of studies examining routine immunization program costs and financing has fallen.[9] There has been a general assumption that unit costs for conventional immunization have been reduced due to lower vaccine costs. However, better information is increasingly important in the context of competition for scarce financial and other resources, at the same time as new, more expensive vaccines are becoming available. Furthermore, the methodologies of various costing studies have often differed, making it more difficult to compare or apply results in a generalized way.

In Uganda and other countries, accurate data on the delivery costs per dose or per child of routine and new vaccines is needed to enhance use of the cMYP tool and, more generally, to improve country level planning and financing, as well as providing evidence to inform domestic and external resource mobilization for immunization.

More accurate information on the costs and financial flows for new and routine vaccines programs, particularly from government sources, will be useful inputs into policy dialogue on sustainability and co-financing of new vaccines. Uganda's Post-Introduction Evaluations (PIEs), to be conducted six months after new vaccine introduction, will also be strengthened by better costing data.[10] In relation to Uganda and other countries, the information can be important in updating the GAVI Alliance policies on new vaccine introduction grants. Finally, estimates from the Uganda and other country studies can help inform the costing and financing projections that will be done for the Global Vaccine Action Plan (GVAP), as well as to input into work on resource tracking for the GVAP and at country level (Brenzel, 2013).

1.1 Purpose and Scope of the Study

The purpose of this study was to provide detailed estimates of routine immunization program costs in Uganda and estimate the future costs of introducing Pneumococcal Conjugate Vaccine (PCV) by the end of 2013. The exercise provides updated estimates of the delivery costs of routine immunization and new vaccine introduction, as well as identifying and analyzing the variability in facility unit costs and productivity.

The main questions addressed by this study are the following:

1. What are the delivery costs associated with the routine immunization program (costs per dose or per infant) at various levels of Uganda's health system?
2. What is the cost structure (cost by line item) of total facility costs, particularly cold chain recurrent and capital costs?
3. What would be the total estimated cost of the routine immunization program at various levels of the health system in Uganda for new vaccines (pentavalent, pneumococcal, or rotavirus)?
4. What is the cost of new vaccine introduction by major line item?

---

[8] Levin A. Howlader S. Ram S. Siddiqui SM. Razul I. Routh S. 1999. Case Study on the Costs and Financing of Immunization Services in Bangladesh. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

[9] Brenzel. 2013. Common Approach for the costing and financing of routine and new vaccines. Bill and Melinda Gates Foundation.

[10] http://whqlibdoc.who.int/hq/2010/WHO_IVB_10.03_eng.pdf

5. At facility level, how does productivity (doses/FTE[11] or other measure) of the routine program vary. What is the relationship between costs and output levels?
6. What are the facility total and unit costs, and what factors drive this variation?
7. How do the costs of vaccine introduction compare with budgets for it?
8. What are the main sources of financing of the routine immunization program and for new vaccine introduction, and what are the sources of financing of vaccines as compared to operating costs and capital investments?

The study sought to obtain data on expenditure and related characteristics of routine immunization at the facility (at different health care levels), district and national levels and aggregated these for the whole country.

This study was part of a multi-country initiative supported by the Bill and Melinda Gates Foundation, GAVI and WHO to develop updated estimates of routine immunization (RI) program costs in six pilot countries, map their funding flows, and to develop standardized methodologies to produce comparable results.

2 Background

2.1 Ugandan socio-economic status and health care system

Uganda is an East African country with a total land area of approximately 241,139 square kilometers, 18% of which is covered by water. The total population in 2011 was estimated at 34.5 million, of which the majority (88%) lived in rural areas. The annual population growth rate of 3.63% is fuelled by a high fertility rate of 6.9 births per woman, while the infant mortality rate is estimated at 76 per 1,000 births with variations between different areas of the country.[12] The number of under-one year olds in 2011 was estimated by the cMYP to be almost 1.5 million children. Uganda is classified as a low income country by GAVI, with a Gross National Income per capita of US$ 440 in 2012.

Uganda has a highly decentralized system of governance. Administratively, the country is sub-divided into 112 districts that are further divided into counties, sub-counties, parishes and villages (Local Councils).[13] The villages are the lowest administrative units in Uganda. Most parts of the country are accessible, with a fairly good network of roads, telephone, radio and TV as well as some availability of energy sources.

Uganda does not have a regional or provincial administrative tier in the health or other sectors. However, the Uganda Bureau of Statistics has divided the country into 10 regions for conducting national surveys (see Appendix 1). These 10 regions are commonly used as a frame of reference during planning, resource allocation and other decision-making by both government and development partners.

---

[11] Full Time Equivalent = total number of work *hours allocated to immunization* per week or month by all staff involved in immunization divided by standard number of total work *hours per staff member* per week or month in terms of their standard conditions of service.
[12] Uganda Demographic and Health Survey, 2002.
[13] Before the creation of a number of new districts that took place in 2010/11, there were 80 districts.

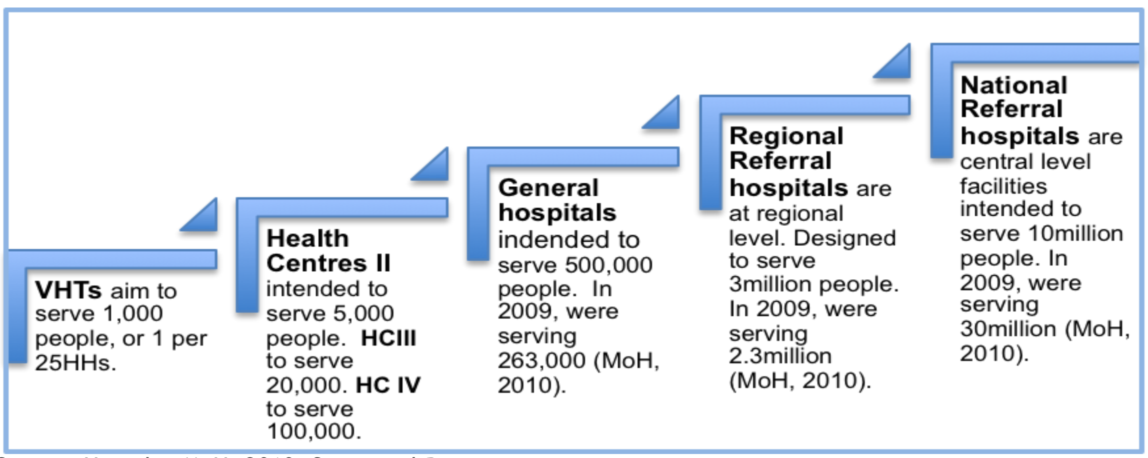
2.1.1 Health sector in Uganda

According to the Ministry of Health's statistics (MOH, 2010), the proportion of the population living within 5kms of a health facility was 72% in 2010, up from 49% in 2000. Access to health care facilities is impeded by limited infrastructure, availability of medicines and other health supplies, shortage of human resources in the public sector, low salaries, lack of accommodation at health facilities and other factors. These constrain access to quality service especially in the rural areas, where the majority of the population lives.

The Government of Uganda has developed a Health Sector Strategic Plan (HSSP) to improve the health care delivery system of which access to health services is a component. The HSSP II objective for the health infrastructure development was to ensure that 85% of the population lies within 5 km walking distance to access a well-equipped health facility regardless of level of facility.

The types of health facility in Uganda are: Health Centres (HC) II, III, IV; general hospitals, regional general hospitals and national general hospitals. The standard populations they are intended to serve are shown in the table below.

Figure 1: Ugandan National Health Facility Types and Catchment Populations



Source: Ugandan MoH. 2010. Statistical Report.

The numbers of each facility type throughout the country are shown in the table below. The majority of private and NGO facilities are relatively small, HCII services but immunization output data were not available centrally to allow for more detailed assessment of their significance in the delivery of immunization services.

Table 2-1: Health Facilities in Uganda by level and ownership (as 2011)

LEVEL OF FACILITY	GOVT	NGO	PRIVATE	TOTAL
HOSPITAL	63	64	20	**147**
HC IV	170	15	8	**193**
HC III	916	264	70	**1,250**
HC II	1,695	520	1,395	**3,610**
TOTAL	**2,844**	**863**	**1,493**	**5,200**

Source: MOH (2011) Statistical Report.

2.2 Routine immunization in Uganda

Programme performance

The Uganda UNEPI programme showed progressive improvement of routine immunization and surveillance indicators after 2000, but its performance subsequently stagnated.[14] Between 2000 and 2006, DPT3 coverage increasing from 56% in 2000 to 85% in 2006. Several investments into the program over the years, such as GAVI Immunization Service Support (GAVI-ISS), Sustainable Outreach Services (SOS) and the Reaching Every District (RED) approach, contributed to the successes attained. The impact of the immunization program was evident: the country remained polio free from 1996 to early 2009; morbidity due to measles declined by over 90% compared to 2000 with no confirmed deaths in 2004 and 2005; the number of meningitis cases due to Haemophilus Influenzae type b (Hib) declined by 95% at sentinel sites after introduction of Hib vaccine in 2002. The number of reported neonatal tetanus cases declined to less than 1/1,000 live birth nationally, and this led to Uganda being certified for Maternal Neonatal Tetanus Elimination (MNTE).

However challenges in routine immunization service delivery resulted in declining performance during 2007-2010. There has been variability in the performance of districts, with some achieving the set targets for routine immunization and surveillance, and many others not yet up to the required levels. Sustaining availability of current vaccines at health facilities, maintaining a high immunization coverage in a rapidly growing population, reaching all un-immunized children particularly with re-emergence of wild polio virus after 13 years, and maintaining a high quality and sensitive disease surveillance system at all levels are some of the challenges that the program faces.[14]

Over the 2012-16 period, the Uganda Expanded Programme for Immunization (EPI) plans to focus on the district level to improve routine immunization and surveillance performance; strengthen logistics management at all levels; and strengthen capacity of mid-level managers, operational level health workers and pre-service trainees to deliver quality immunization services. In addition to introducing pneumococcal, rotavirus vaccines and HPV vaccination, Uganda's Multi-year Plan aims to achieve and maintain polio free status, and maintain neonatal tetanus elimination and pre-elimination measles targets. An important part of the plan focuses on advocating for sustainable financing of the programme. The estimated costs for these planned activities, applying the cMYP tool, are presented in a later section, and are compared with the findings of this costing project.

Organization and management of Ugandan immunization services

The organization of immunization services in Uganda has several main features.[15] The Ugandan National Expanded Program on Immunization (UNEPI) is located in the Ministry of Health (MOH), but the management and delivery of the immunization services is decentralized to district, sub-district and facilities levels. The national level is responsible for developing policy, standards and priorities; building capacity;

[14] Ugandan EPI Multi-year Plan for 2012-2016
[15] Uganda EVA Assessment Report: Findings and Recommendations of the Assessment Team. 2011.

coordination and networking; resource mobilization; procurement of vaccines and equipment; and monitoring and technical support supervision to districts. The district and health sub-districts undertake the planning and management of service delivery; supervision of health units; in-service training; and ensure effective district and health facility reporting and monitoring systems.

At the *national level*, the Health Policy Advisory Committee (HPAC), chaired by the Permanent Secretary, is the coordinating body that advises both Government and partners on the implementation of the National Health Policy and Health Sector Strategic Plan (HSSP). The Committee provides overall policy advice and strategic coordination of the sector and oversees the management of annual health sector budget process. HPAC coordinates national and donor efforts for the immunization program. It is supported by eight technical committees of which Maternal Child Health technical working group discusses and reports on the immunization program. Administratively, UNEPI itself is located in the Department of National Communicable Disease Control in the Directorate of Clinical and Community Services of the MOH. UNEPI links with other MOH departments and divisions through Technical Working Groups, as well as Senior and Top Management committees. The UNEPI program is headed by the EPI manager who provides the day-to-day guidance for policy implementation and coordination.

At *district level*, the District Health Officer (DHO), as a head of the District Health Team (DHT), is responsible for the planning, implementation, supervision monitoring and evaluation of immunization services in both the public and private sectors. The EPI focal person at the district health office is responsible for the day-to-day running of EPI activities. The cold chain officer in the district manages the cold chain system in the district, including the district vaccine store (DVS).

Health facilities of all types are responsible for the actual delivery of immunization services as an integrated element in routine (daily) health services, either facility-based or through outreach activities; and for reporting and monitoring. Supplementary immunization activities (SIA's) such as intermittent campaigns also remain a relatively important means of achieving higher levels of coverage. There are also private and not-for-profit health facilities that provide some routine immunization (RI) services. The latter were included in the sampling since they deliver immunization services on behalf of the GoU, while the private for profits were omitted as per the Common Approach to ensure comparability with the other country studies.

All health facilities also offer mobile outreach immunization services in their neighbouring communities. Due to inadequate funding for logistics (and in some cases inadequate staff at health facilities), most outreach services are not provided on a regular basis. The functionality of outreaches varies greatly in different parts of the country, and between health facilities. Occasionally, supplemental immunization services are provided throughout the country (e.g. during the Child Health Weeks). In addition, mass immunization activities are conducted in some parts of, or throughout, the country, especially when there is an outbreak of diseases such as measles.

2.2.1 Current National immunization schedule and planned new vaccines

Currently, Uganda delivers the immunization schedule shown in Table 2-2. The DTP-HepB+Hib was introduced in Uganda in 2002, and the Government of Uganda is planning to introduce Pneumococcal vaccine in 2013, and Rotavirus in 2014.

Table 2-2: The Ugandan Immunization Schedule

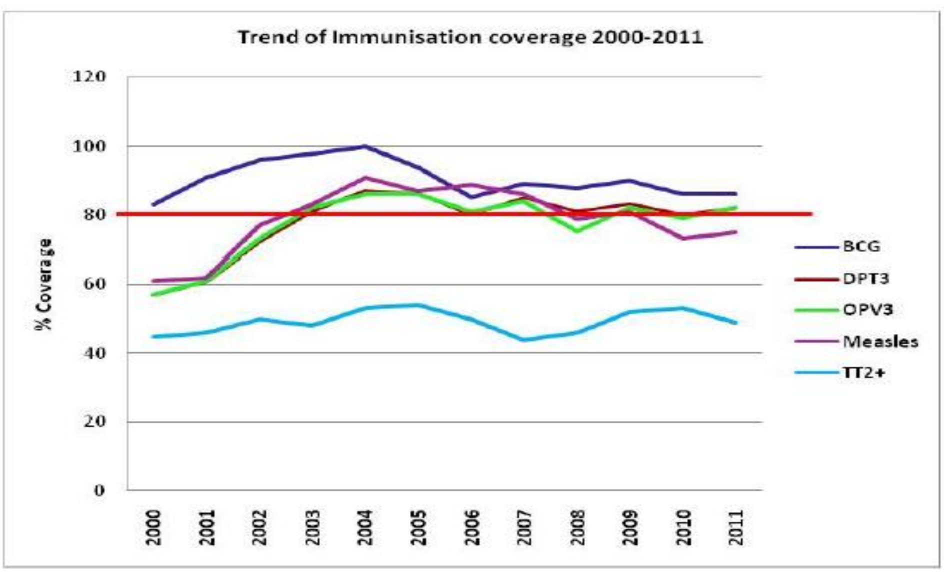
Vaccine/ Antigen	Dosage	Doses Required	Unit Price per Vial (US$, 2011)	Wastage rates*	Minimum Interval between Doses	Minimum Age to Start
BCG	0.05ml up to 11mths, 0.1ml from 11 mths	1	$ 2.12 (20 dose vial)	50%	None	At birth (or first contact)
DPT-Hep+Hib	0.5ml	3	$ 2.82 (20 dose vial)	5%	One month (4 weeks)	At 6 weeks (or first contact after that age)
Polio (OPV)	2 drops	0+3	$ 2.58 (20 dose vial)	50%	One month (4 weeks)	Birth or within first 2 weeks (Polio 0) and six weeks or first contact after 6 weeks (Polio 1)
Measles	0.5ml	1	$ 2.37 (10 dose vial)	50%	None	At 9 months (or first contact after that age)
Tetanus Toxoid	0.5ml	5	$ 1.20		First contact TT1; TT2 (4 wks after TT1); TT3 (6mths after TT2); TT4 (1 yr after TT3) & TT5 (1 yr after TT4)	First contact with a woman pregnant or of child bearing age (15-45 years)
PCV	0.5ml	3	US$ 3.5 per dose (2013)	5%	One month (4weeks)	At 6 weeks (or first contact after that age)

Source: Uganda EPI Workplan 2012-16. * WHO standard rates applied in study except for OPV (see text)

2.2.2 Coverage rates by vaccine

As described above, immunization coverage had improved between 2000 and 2006, but showed some decline thereafter (Figure 2). Current UNEPI statistics are comparable with the WHO best estimates for immunization coverage for Uganda in 2011, shown in the following table.[16]

Figure 2 Immunization Indicators for Uganda from 2000 to 2011



Source: UNEPI Multi-Year Work Plan (2012-16).

[16] TT is shown in this Figure, but cost and dosage numbers for TT were excluded from the costing study.

Table 2-3: WHO Best Estimates of Immunization Coverage for Uganda in 2011 (%)

Vaccine/ Antigen	BCG	DTP-3	Polio	MCV	HepB3	Hib3
WHO Best Estimate	86	82	82	75	82	82
Official	86	82	82	75	82	82
Administrative	86	82	82	75	82	82
Survey	N/A	N/A	N/A	N/A	N/A	N/A

Source: http://apps.who.int/immunization_monitoring/globalsummary/wucoveragecountrylist.html

2.3 Current knowledge on costs and financing of immunization in Uganda

Health financing in Uganda has been increasing over the last decade (Table 2-4). Per capita health spending increased from US$ 5.9 in 2000/01 to US$ 11.9 in 2009/10[17], but this decreased to US$ 10.29 in 2011/12.[18] These levels are however far below the US$ 47.9 that was estimated as required for the Uganda National Minimum Health Care Package (UNMHCP) in 2011/12.[19] Health expenditure by GoU increased from 7.5% of total government expenditure in 2000/01 to 9.6% in 2009/10, but decreased again to 8.3% in 2011/12.

Development assistance continues to play an important role in the funding of health care in general and immunization services.[20] However, much of this is 'off-budget' making it difficult for the MOH to track these expenditures or to co-ordinate efforts of the development partners, and to thereby ensure the national health priorities were being met. In 2011/12, the government's contribution to health was US$ 163 million, while the on-budget total funding for health constituted US$ 57 million, bringing the overall health budget to US$ 219 million.[21] Much of the off-budget support went towards HIV/AIDS, TB, malaria and blood transfusion safety.

The Ugandan National Health Accounts (NHA) for 2009/10 estimated a higher share from the GoU 14.4% of total health expenditure, 35.6% came from development partners, and the remaining 50% came from households, even though user fees had been removed from the lower health care facilities in 2001. A reported 28% of households had experienced catastrophic health care payments. Only a small proportion of the population in formal employment has access to private health insurance.[22] The NHA and other national level sources provide very limited information on expenditure and sources of finance for immunization specifically.

---

[17] Ministry of Financial Planning and Economic Development (MOFPED, 2009). MoH, 2010. Statistical Report: PER 2006, AHSPR 2008/9. Budget Out-Turn 2009/10.

[18] MOH. 2012/13. Annual Health Sector Performance Report. http://health.go.ug/docs/AHSPR_11_12.pdf

[19] HSLP Africa Ltd. 2008. Estimates of Costs of the Uganda National Minimum Health Care Package (UNMHCP).

[20] Uganda MoH Statistical Report of 2010.

[21] MOH. 2012/13. Annual Health Sector Performance Report. http://health.go.ug/docs/AHSPR_11_12.pdf

[22] MOH, 2010. Ugandan National Health Assessment (2008/09 & 20099/10). http://health.go.ug/docs/NHA_REPORT_FINAL_13.pdf

Table 2-4: Uganda Health financing trends over HSSPI and HSSPII (2000/01-2011/12)*

Year	GoU Funding (U Shs bns)	Donor Projects and GHIs (U Shs bns)	Total (U Shs bns)	Per capita public health exp (UGX)	Per capita public health exp (US $))	GoU health expenditure as % of total GOU expenditure
2000/01	124.23	114.77	239.00	10,349	5.9	7.5
2001/02	169.79	144.07	313.86	13,128	7.5	8.9
2002/03	195.96	141.96	337.92	13,654	7.3	9.4
2003/04	207.80	175.27	383.07	14,969	7.7	9.6
2004/05	219.56	146.74	366.30	13,843	8.0	9.7
2005/06	229.86	268.38	498.24	26,935	14.8	8.9
2006/07	242.63	139.23	381.86	13,518	7.8	9.3
2007/08	277.36	141.12	418.48	14,275	8.4	9.0
2008/09	375.46	253.00	628.46	20,810	10.4	8.3
2009/10	435.8	301.8	737.6	24,423	11.1	9.6
2010/11	569.56	90.44	660	20,765	9.4	8.9
2011/12	593.02	206.10	799.11	25,142	10.29	8.3

Source: MoH, 2012. Health Sector Performance Report. * Nominal – not adjusted for inflation

In the budget allocation process, UNEPI receives a budget from the MOH budget, with which it must undertake all the national level EPI activities and cover the EPI staff salaries. At the District and facility level, MOH funds for immunization are included in the primary health care (PHC) grant which is sent from national MOH to the DHOs, and which is based on an estimation of need in each district, taking into account population served, number and level of health facilities, and other indicators. This grant is spent by the DHO as required to deliver integrated primary health care services, of which immunization forms part.

Tracking of immunization finance at District level is difficult. Spending of the PHC grant on immunization services cannot be differentiated from other activities, as it is categorized with general health expenditures, such as maintenance of vehicles, fuel, per diems for the village health workers, overheads, gas and other supplies. Of note, some of the facilities and DHOs report that the PHC grant is insufficient to cover all key items, so vehicles often remained unused due to lack of fuel or poor maintenance.[23] Development partners also continue to fund their health projects directly (off-budget), or specific capital investments, rather than funding general health sector recurrent costs.

The Uganda EPI program anticipated its total costs for the five years (2012-2016) as US $399,588,047, with 60% of these costs being for vaccines and supplies. These estimates were derived by applying the cMYP tool. The EPI program intends to introduce new

[23] Informants indicated that contributing factors are lack of adjustment of PHC grant allocations to increasing need, limited overall public funds for health care and difficulty balancing competing priorities.

vaccines (PCV, Rota vaccine and HPV), construct new offices and stores at the national level, and conduct polio and measles supplementary immunization activities. All of these contributed significantly to the increased costs from 2012 to 2016. The EPI program foresaw a substantial funding gap, expected to be $87,470,768 by 2016, which is 23% of the total resource needs, excluding shared costs (UNEPI cMYP 2011).

The cMYP estimates of Uganda's total immunization costs (2011-2016) are summarised in Table 2-5 below. They suggest a unit cost of US$ 23.26 per fully vaccinated child in 2011, with subsequent large increases due to NUVI introduction. The 2011 estimate is lower than the $28 average cost per fully immunized child found in an analysis of 56 cMYPs for the period between 2004 and 2012 by Brenzel and Politi (2012).[5]

Table 2-5: cMYP estimated resource needs for the UNEPI Multi-Year Workplan (US$)

	Expenditure	Future Resource Requirements					
Programme Components	2011	2012	2013	2014	2015	2016	Total 2012 - 2016
Vaccine Supply and Logistics	18 566 288	21 487 248	46 233 197	74 797 435	75 100 955	77 376 444	294 995 279
Service Delivery	4 813 551	5 479 923	6 004 158	6 312 481	6 525 855	6 461 838	30 784 256
Advocacy & Communication	155 690	844 430	892 604	943 400	996 800	1 052 967	4 730 200
Monitoring & Dis. Surveillance	762 985	1 688 860	1 785 207	1 886 801	1 993 599	2 105 933	9 460 400
Programme Management	482 548	1 429 028	1 496 782	1 584 401	1 681 807	1 739 101	7 931 119
SIAs*	3 647 974	9 981 997	1 233 191	2 755 658	12 048 201	1 355 475	27 374 521
Shared Health Systems Costs	3 287 727	3 888 313	3 989 125	7 947 402	4 198 239	4 289 191	24 312 271
Grand Total	**31 716 763**	**44 799 799**	**61 634 264**	**96 227 578**	102 545 456	**94 380 950**	**399 588 047**
Cost/child	21,49	28,72	38,29	57,93	59,82	53,35	
Cost/dose	1,76	2,48	3,26	4,83	5,00	4,44	
Cost/DTP3	26,20	34,20	44,53	65,83	66,47	57,99	

Source: UNEPI, 2011. * Supplemental Immunization Activities

With regards to mapping of immunization funding specifically, there have been no previous, systematic efforts to identify and quantify the funding, except for the recent completion of the cMYP (Table 2-6).

Table 2-6: Ugandan cMYP Mapping of Anticipated Funding (2011-2016)

Funding Sources:	cMYP Finance Estimates 2011 (US$)
Central Government	8 437 918
District Local Government	3 587 818
UNICEF	3 423 584
PATH	653 617
WHO	1 584 167
GAVI	11 746 006
JICA	2 283 654
TOTAL	**31 716 763**

These cMYP estimates of available resources are compared in Section 7 with the financial mapping undertaken as part of this study.

3 Costing Analysis of Routine Immunization

3.1 Methodology

Key aspects of the methodology for the cost analysis are set out below. They were based on the Common Approach (Brenzel, 2013)[9] developed for the multi-country study, but adapted to address priorities identified by Ugandan partners and to tackle various data and practical limitations noted below.

Routine immunization is defined as those immunization services or activities that are conducted regularly as part of the national program. They include services delivered in health facilities, but also include outreach services provided in homes or in separate locations on scheduled days. Routine immunization differs from supplemental immunization activities (SIAs), such as campaigns and epidemic/outbreak response, which are more periodic in nature, for example yearly, or every few years. SIAs were excluded from this analysis.

3.1.1 Costing Perspective, Approach and Assumptions

The Common Approach, also based on the standard approach adapted from WHO (2002; 2008a; 2008b), applies a bottom-up, ingredients-based costing methodology which identified costs from the perspective of the health service provider. The study included both government and NGO service providers because the latter provide services on behalf of the government in Uganda. Private for profit facilities were excluded as they would not provide comparable data for immunization delivery in the other countries in the multi-country study, and as per the Common Approach. The costs to the patient in accessing the services, or their loss of productive time, were not estimated, and the societal broader costs or gains were also not estimated.

Costs were estimated retrospectively for 2011, and were captured in Ugandan Shillings (UGX) before converted to US$ (2011) using the annual average exchange rate, to control for short term fluctuations in exchange rates.

Routine immunization program costs were collected from all levels of the health system (facility, district and national). The costs included the value of inputs shared with other health programs, which mainly occurs at the district health office level. The ingredients approach identified the type of inputs, quantified the number of inputs, and multiplied by unit prices and the proportion used for routine immunization. A series of unit costs were generated from the exercise, including cost per capita, cost per dose, cost per infant in the target population, and cost per DTP3 immunized child. In addition to total unit costs, line item unit costs per dose and per child were generated to provide a set of costing benchmarks.

Facility and District level costs were weighted according to sampling weights. Any large variations in total facility costs and unit costs were identified and analysed, to identify unique facility or service characteristics or other factors. Costs were also attributed to ten standard immunization activities (see below).

Total routine immunization costs were compared and contrasted with the resource requirement estimates in the cMYP, and reports in the Joint Reporting Forms. As the Ugandan public sector budgets for the EPI program are mostly absorbed into the general human resource budget and the general primary health care (PHC) grants to districts, an accurate comparison with the public budgets could not be made. For similar reasons, actual government spending on immunization was difficult to trace.

Economic vs. financial costs

The study estimated both economic and financial costs. Economic costing reflects the true economic or opportunity costs of an intervention, and would thus include costs that may not have been paid for by the programme. However, the study identified no significant 'donated' resources, such as volunteer time. Village Health Workers receive small stipends, which were captured under salaries.

For the economic cost evaluation, all capital costs were annualized based with a 3% discount rate and estimates of useful life. "Useful Life" was defined as the average period for which an asset or property is expected to be usable for the purpose it was acquired. Further details of useful life estimates for equipment are provided in Appendix 3.

The financial costing reflects cash outflows or expenditure directly incurred by the program, as a more useful measure for assessing short to medium term resource and budgetary requirements. For the financial costing, capital asset costs were annualized without discounting, i.e. using a straight-line depreciation of assets.

Description of expenditure line items

The table below summarises the quantification method and the approach to valuation for each expenditure line item used for calculating and reporting costs in this study (US$, 2011 prices).

Table 3-1: Expenditure line items, resource quantification and valuation methods

Expenditure line item	Quantification method	Valuation method
Recurrent Costs – Immunization Specific		
Salaried labour	Quantification comprised the total time taken to provide immunization and related services. Immunization staff were required to allocate hours to various immunization activities over the period of a month. Where non-clinical staff directly supported the EPI, their time was included and quantified on the basis of hours allocated to EPI per month. Human resource costs of administrative staff were *not* allocated to the EPI, unless the facility respondents specifically mentioned and quantified their contribution.	Annual remuneration (obtained from public salary scales) was defined as the total cost to the employer (MOH) including benefits.
Village Health Worker time	In Uganda VHWs assist with immunization services, and are paid a stipend. Their input time was quantified in fieldwork interviews.	The Government stipend monthly rate was applied (UGX 3,000/ month).

Expenditure line item	Quantification method	Valuation method
Per diem and travel allowances	Per dia were quantified on the basis of days or nights spent away from the facility.	The standard Government rates for per diems were used.
Vaccine costs	Some facilities maintained accurate records of vaccines consumed and wasted. Wherever possible, these were used. Where facilities had poor vaccine records, the cost of vaccines was calculated on the basis of doses administered and WHO wastage factors. However, the wastage factor for OPV was also assumed to be 50% based on 2010 research on 20 dose vials and review of stock records in some districts.[24]	Unit costs for vaccines (FOB)[25] were obtained from the in-country UNICEF office.
Vaccine injection and safety supplies	Vaccine injection and safety supplies were poorly reported in facilities and so these were quantified on the basis of doses administered for the reason described above. A wastage factor of 5% was used in this calculation.	Unit costs for supplies were obtained from the in-country UNICEF country office.
Cold Chain energy costs	Most facilities had designated fridges for immunization, and kerosene or gas was used for the cold chain. In these instances interview data on procurement of gas or kerosene, was used to quantify consumption.	Prices for gas and kerosene are government controlled for all facilities. A standard price for electricity consumption was used.
Other supplies	Other supplies were any other expenditures which could not be included under other line items. Not many were reported.	Other supplies were valued based on actual expenditure reported.
Recurrent Costs - Shared		
Transport and fuel	Transport and fuel included bus and taxi fares (where used), as well as fuel consumed by vehicles. Bus and taxi fares were quantified in response to specific questions in the questionnaire. Fuel costs were based on estimated fuel consumption for different types of vehicles after allocation of kilometres travelled for the EPI. There were very few vehicles at facility level, and many at district level were no longer functioning, due to inadequate maintenance budgets.	Values for bus and taxi fares were provided by each facility. The price of diesel and petrol is controlled by government and the costs per litre are the same throughout Uganda.
Vehicle maintenance costs	Quantification was based on actual reported vehicle maintenance costs. Where these were not available an assumption was formulated in discussion with national management using actual service costs for similar vehicles to estimate an annual service unit cost. Service records and log books were poorly maintained.	Vehicle maintenance was valued at actual expenditure incurred or based on the maintenance costs for similar vehicles
Printing	Based on actual expenditure. No printing expenditure was reported at facility level.	Valued using actual expenditure reported at the national level.
Building overheads, Utilities, Communication	Building and grounds overhead costs, sundry utilities, maintenance and communication are costs incurred at district level, not facilities. Where possible actual expenditure was used to allocate costs to the EPI. (See 'District costs')	Overhead costs were based on allocation of reported actual expenditure at district level. Overheads were not included at facility level.
Training costs	Training costs were quantified based on days required to deliver the standard training module.	Actual expenditure incurred by EPI programme, only found at

[24] Vaccine Wastage Assessment, April 2010, Field assessment and observations from National stores and five selected states of India, UNICEF and National Rural Health Mission. This study examined wastage at 36 facilities. For OPV in a 20 dose vial the average wastage rate was calculated at 47%.
[25] Free on Board meaning that the purchaser is responsible for freight costs.

Expenditure line item	Quantification method	Valuation method
	They included venue hire, facilitation, per dia, travel costs and development and supply of all training materials. No facilities reported direct training costs.	national level.
Expenditure line items - Capital costs		
Cold chain equipment	Cold chain equipment was captured in the questionnaire.	Valuation of the equipment was based on the PQS list. The basic prices were increased by 20% to cover freight, in-country transport and installation at facilities.
Vehicles	Vehicles were captured in the questionnaire. Most facilities did not have vehicles, but some rural facilities had motor cycles.	Current vehicle replacement costs were obtained from dealers in Uganda and were deflated to 2011 prices.
Buildings	Space consumed was based on the measurement of facility space dedicated to the EPI (m^2).	Each m^2 was valued at $540, the standard MOH replacement cost of health facility type buildings.

Further details of 2011 unit prices are presented in Appendix 3.

Allocation to functional activities

Expenditure was allocated to ten standard immunization functional areas or activities, guided by the Common Approach (Brenzel, 2013), which provided a matrix that cross-tabulated the cost of each activity with the economic classification (production factors) of items used in the delivery of the activities. The breakdown of expenditure by activity was obtained through interviews with EPI staff at each facility. The framework for the interview schedule was developed and pilot tested to ensure applicability in Uganda.

Although the study was not designed as an activity based costing exercise, the allocation of costs to activities provides a valuable indicator of which activities consume most resources. Planners and management can use this analysis to guide their effort to improve operational efficiencies and productivity.

Table 3-2 provides an overview of functional activities and the expenditure items allocated to each activity.

Table 3-2: Overview of functional activities and allocation methods

Activity name	Expenditure items included in the activity	Allocation method
Routine facility-based service delivery	Time allocated by EPI staff, vaccines and injection supplies for facility immunizations, facility building costs and a portion of waste disposal costs.	Staff were asked to allocate their time to activities. Vaccine records in all the facilities did not provide a split between doses provided through facility-based or outreach delivery. Thus EPI staff were asked to estimate the portion of total immunizations provided at the facility or through outreach. This ratio differed by facility type (see table below), and was used to allocate vaccine costs, injection supplies and wastage between outreach and facility based service provision.
Record keeping / HMIS	This activity comprises only time allocated by staff.	Staff were asked to allocate their time to activities in the questionnaire.
Supervision	Staff time, and in certain instances transport and fuel costs, per diem and travel allowances.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with supervision.
Outreach services	Time allocated by EPI staff, vaccines and injection supplies for outreach immunizations and a portion of waste disposal costs.	Staff were asked to allocate their time to activities in interviews. Immunization staff were asked to estimate the portion of all immunizations carried out at the facility and during outreach activities. The ratio differed by facility type and was used to allocate vaccine costs, injection supplies and wastage between outreach and facility based service provision.
Social mobilisation	Staff time, and in certain instances transport and fuel costs, per diem and travel allowances. Village health worker costs are included in this activity.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with social mobilisation.
Cold chain maintenance	Cold chain maintenance includes staff time, operating costs (energy costs) and costs of any repairs.	Staff time as above. Energy costs for cold chain were specifically calculated. Repair costs were included where they were reported. No imputed maintenance cost was included if no repairs were reported.
Vaccine collection, distribution and storage	Staff time, transport and fuel costs, per diem and travel allowances. Capital costs of cold chain equipment were allocated to this activity.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with vaccine collection.
Program management	Staff time, cost of office equipment, per diem and travel allowances, and transport and fuel costs.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with program management.
Training	All facilities reported having no training. Only national level reported training costs.	Only national level reported costs included, since no facility reported any training.
Other	Any expenditure items which could not easily be allocated to the other defined activities. The total allocation to this activity in the Ugandan costing is immaterial.	In instances where the allocation is unclear the amount has been allocated to 'Other' in its entirety.

Facility records of immunization at all the facilities did not differentiate between immunizations done at the site as part of facility-based immunization, and those done through outreach activities. Thus allocations between facility-based and outreach services were estimated based on EPI nurses' estimates of the split. Table 3-3 shows the estimates provided, by facility type.

Table 3-3: Split between Routine and Outreach Immunization by Facility Type

	Routine	Outreach
Health Centre II	60%	40%
Health Centre III	60%	40%
Health Centre IV	65%	35%
Hospital	55%	45%

District level costs

In Uganda, the health budget allocations are transferred directly from national (central) level to the districts as lump sums intended for the general operational costs of the district health offices (DHOs). The expenditure records at the district level were weak and no detailed budgets existed, so it was not possible to collect details of the budget and sources of funding. It was also difficult to allocate certain shared costs to immunization, such as vehicle maintenance and fuel costs, as no detailed log books were maintained. The human resource costs of district staff directly involved in the EPI program were identified and included, but administrative and other supporting staff costs were not apportioned to immunization.

The total weighted cost per DHO was then attributed to the other 100 DHOs not included in the sample, in the aggregation process. The amounts could not be adjusted for output since these data were not available at the central level for all districts.[26]

3.1.2 Sampling

The study sample was drawn from public sector and non-governmental organization (NGO)/mission primary health care facilities and clinics, as well as some hospitals as they are also important providers of immunization services in Uganda. Private for profit facilities were excluded from the sample since the focus of the multi-country study was to compare public sector delivery costs. The sampling approach was informed by the Common Approach (Brenzel, 2013), but this had to be adjusted as Uganda did not have a national database which could identify the number of immunization doses provided at each facility, making it impossible to stratify high and low volume facilities. This also affected the aggregation approach, described in more detail below.

In order to be nationally representative, given the great diversity of socio-economic and cultural contexts in the country, stakeholders indicated that the sample should include facilities from all 10 regions. The sample was also stratified to provide representative data on costs of different levels of facility (health centres II, III, IV and general hospitals). As only Kampala and a few larger towns are considered urban, with the majority of the country labeled as rural, the level of the facility is considered by planners to be a more important indicator than urban or rural location of its size, catchment population and potential determinants of immunization costs.

[26] The data exist at the district level, but it was not feasible to obtain the records from all 112 districts.

Sampling approach
The Uganda study applied a multi-stage, purposive and stratified random sampling approach. The stages were as follows.

i. Regional selection: all 10 regions were included in the sample - therefore a survey of all ten regions was applied.
ii. District selection: within each region, one or two districts were purposively selected to balance budget constraints with representation of different contexts in each region. Country stakeholders (UNEPI) guided the selection of the districts to ensure representation of the differing geographical, socio-economic and performance levels. District inclusion criteria included representation of rural or urban locations, rankings on the EVA performance league table (although not all districts were ranked), and hard to reach locations. Due to recent (2012) formation of a number of new districts, one new district was included in the sample. A stratified random sampling approach was used with the aim of being representative of all government and NGO health facilities in Uganda. The desired sample size calculation aimed to estimate a prevalence indicator that would achieve a desired precision, in line with the proposed method in the Common Approach. The sample size required for a proportion was used at the first stage, and a finite population correction factor used at the second stage, as set out below.

1. Stage One

$$n0 = \frac{Z2\ p\ q}{e2}$$

Where a normal distribution is assumed, and:
n0 = sample size
Z2 = area under the normal curve (1.96 for 95% CI)
p = estimated proportion of an indicator present in the population (assumed 0.5)
q = 1-p (0.5)
e2 = desired level of precision (assumed 10%)

The resulting sample size is = 96.

2. Stage Two (Finite correction for proportions)

As the population of facilities is relatively small, this allows for the sample size to be adjusted, because a given sample size provides proportionately more information for a small population.

$n = n0N/(n0 +(N-1))$ Where: n0 = initial sample size and N = population size

There were 3 707 public and NGO health facilities in Uganda at the time of the survey (N). Thus, a total of 94 facilities should ideally have been sampled for the study.

Due to budgetary constraints, 52 facilities were sampled from a total of 12 districts within the 10 regions. This represented 10.7% of the 112 districts in Uganda, and 1.35% of total health facilities in the country. However because of incomplete data, an effective sample size of 49 facilities was realized. This sample size would still give a precision of 0.14 for an indicator with an initial value of 0.5. Importantly, this sample size would also allow for regression models with about 5 independent variables, on the basis of the convention that 10 – 15 observations are required for any additional independent variable in fitting regression models.

Despite the assumption of normal distribution in Stage 1, it was expected that the distribution of costs would be skewed, with some facilities having very low costs. To compensate for this, the sampling and substitution approach aimed to ensure that rural and smaller facilities were adequately represented.

iii. Table 3-4 below reflects to profile of the selected districts.[27]
iv. Facility selection: stratified random sampling was applied within each selected district: facilities were stratified into types (levels: II, II, IV and general hospitals - public and NGO), and 1 or 2 facilities were randomly sampled within each strata within each sampled district.

Once in the field, a few of the sampled facilities were found to be non-functioning. Replacement facilities were purposively selected, based on the guidance of the EPI managers, in order to have similar characteristics of the sampled facility.

Sample size

A stratified random sampling approach was used with the aim of being representative of all government and NGO health facilities in Uganda. The desired sample size calculation aimed to estimate a prevalence indicator that would achieve a desired precision, in line with the proposed method in the Common Approach. The sample size required for a proportion was used at the first stage, and a finite population correction factor used at the second stage, as set out below.

1. Stage One

$$n_0 = \frac{Z^2\ p\ q}{e^2}$$

Where a normal distribution is assumed, and:
n_0 = sample size
Z^2 = area under the normal curve (1.96 for 95% CI)
p = estimated proportion of an indicator present in the population (assumed 0.5)
q = 1-p (0.5)
e^2 = desired level of precision (assumed 10%)

The resulting sample size is = 96.

2. Stage Two (Finite correction for proportions)

As the population of facilities is relatively small, this allows for the sample size to be adjusted, because a given sample size provides proportionately more information for a small population.

---

[27] One district had to be replaced because of an outbreak of the Marburg virus, and the replacement district was selected in the same region with similar characteristics to the original district.

$n = n_0N/(n_0 + (N-1))$ Where: n_0 = initial sample size and N = population size

There were 3 707 public and NGO health facilities in Uganda at the time of the survey (N). Thus, a total of 94 facilities should ideally have been sampled for the study.

Due to budgetary constraints, 52 facilities were sampled from a total of 12 districts within the 10 regions. This represented 10.7% of the 112 districts in Uganda, and 1.35% of total health facilities in the country. However because of incomplete data, an effective sample size of 49 facilities was realized. This sample size would still give a precision of 0.14 for an indicator with an initial value of 0.5. Importantly, this sample size would also allow for regression models with about 5 independent variables, on the basis of the convention that 10 – 15 observations are required for any additional independent variable in fitting regression models.

Despite the assumption of normal distribution in Stage 1, it was expected that the distribution of costs would be skewed, with some facilities having very low costs. To compensate for this, the sampling and substitution approach aimed to ensure that rural and smaller facilities were adequately represented.

Table 3-4: Profile of selected Districts

	Selected District	Region	Rural/Urban	League Table performance	Old / new district	Hard to reach area	Other
1	Adjumani	West Nile	Rural	97	Old	x	Previously war area; low socio-economic indicators
2	Buikwe	Central II	Rural	15	New		
3	Gulu	Mid Northern*	Rural /peri-urban	5	Old		Previously war area; high NGO presence
4	Hoima	Mid-Western	Rural		Old		
5	Kanungu	South Western	Rural /peri-urban		Old	x	Mountainous/ hilly region
6	Kampala	Kampala	Urban	1	Old		Capital city
7	Moroto	North East	Rural		Old	x	Mobile/ nomadic populations
8	Rakai	Central I	Rural		Old		High HIV prevalence
9	Tororo	Mid-Eastern	Rural /peri-urban		Old		Border with Kenya
10	Lira	Mid Northern*	Rural		Old		
11	Bushenyi	South Western	Rural		Old		
12	Iganga	East Central	Rural		Old		

* Very large region, very varied nature, so 2 districts selected from it

Details of Coverage and Representativeness

Hospital coverage: Four hospitals were randomly selected from the 38 hospitals in the 12 sampled districts. There were 127 hospitals in the whole country. Thus the selected 4 hospitals represented 3.94% of all (public and NGO) hospitals in the country.

Health Units coverage: Table 3-5 below provides a summary of the number of health facilities in the whole country, and the sample size for each level of care (excluding private for-profit facilities).

Table 3-5 Health care facility sampling frame and sample size

	Total Govt & NGO facilities	TOTAL finally included in sample	Sample % of Country Total
District offices	**112**	**12**	10.7%
Hospital	**127**	**4**	3.15%
Health Centre IV	**185**	**9**	4.9%
Health Centre III	**1,180**	**18**	1.53%
Health Centre II	**2,215**	**18**	0.81%
TOTAL Facilities	**3,707**	**49**	1.35%

Further information on the sampling frame and on each facility are provided in Appendix 2.

Determining probability sampling weights

The sampling weights for each facility's costs were calculated separately based on inverse probabilities of sampling at each sampling stage.

i. Since all regions were included, their probability of selection was equal and equated to 10/10 (1).
ii. A sample of n districts was selected from a total of N districts in a region, and their probability of selection was thus = n/N. Twelve districts were selected from a total of 112, thus n = 12, and N = 112 in this instance
iii. A facility m has the probability of being selected out of the number of similar health units in the same district (i) of m/Mi.

The overall probability of selection of a health unit in a district

= n/N x m/Mi

= nm/N x 1/Mi

Therefore, the weight of a sampled health unit was the reciprocal of its probability of being selected:

= N/nm x Mi

The weights for each district and each facility are provided in Appendix 2.

3.1.3 Data collection instruments and process

In order to facilitate the collection of routine immunization costing and qualitative data, an Excel data collection tool was developed, to be administered through face-to-face interviews. The tool was based on a generic version provided by the Common Approach (Brenzel, 2013). The first version of the tool was examined by in-country staff with local knowledge and several changes were made to facilitate the data collection in Uganda. The revised version was then used for training and pre-tested at four facilities (one of each: hospital, HCIV, HCIII, HCII) in Rakai district. After the pre-testing, a few amendments were made to the tool, followed by data collection at a further 48 health facilities. Data collection visits for most health facilities were spread over three to four days.

The data collection tool used for facilities was adapted slightly for use in data collection at district and national, to accommodate activities specific to the higher administrative levels. As described in a previous section, since facilities do not manage their budgets and expenditure, the 'budget and sources' component of the questionnaire for the facility could not be completed, and the data was obtained from the DHO. Collecting data from district and national offices took place over several months. The re-structuring of the UNEPI national program also contributed to a longer than anticipated data collection process.

HealthNet Consult (HNC), a Ugandan research group, managed the entire data collection and validation process. HNC researchers undertook the data collection, and were centrally involved in planning, development of the customised tool, training, cleaning, capturing and validation. The team consisted of a senior health economist, who acted as the team leader/supervisor, and four researchers who visited facilities and collected and captured the data. Researchers worked in teams of two that visited the facilities and interviewed staff. Researchers collected data using a hard copy questionnaire.

3.1.4 Data entry and analysis

The data collected from the facilities and districts was first captured in hard copy. Once these had been verified as complete, they were transferred to an Excel workbook with the same format, as soon as possible after data collection. The data in the workbooks was reviewed and cleaned (see data quality section below), and then re-captured into Excel Survey Sheets, for import into the Immunization Costing Tool and database developed by the Gates Foundation.[28] After further checking and correction of errors, the Costing Tool generated outputs aggregating all the data by type for easier analysis. This was done per facility, by cost component and by activity, and calculated the unit cost and other key indicators required for the regression analysis. The costing analysis was then undertaken manually in Excel. The results were compared to outputs of weighted cost analyses from STATA (version 12, College Station, TX) to check consistency.

3.1.5 Data quality and verification process

Implementation of a systematic quality assurance procedure helped to prevent unacceptable practices and to minimise errors in data collection and capture. Standard operating procedures for quality assurance (QA) were outlined before the beginning of the fieldwork and QA was an on-going procedure throughout the project. The approach to the development of QA procedures and the implementation of these procedures was as follows.

Identifying the potential causes of poor quality data

In order to identify possible risks and causes of poor data quality (missing, incorrectly

[28] Data could not be captured directly into the Gates Costing Tool and its Survey Sheets as these were not ready at the time of data collection.

captured or incorrectly coded data) the following questions were considered prior to and during data collection.

- Is there adequate supervision during fieldwork?
- Has the interviewer been trained adequately to know how to solicit and document the data collected accurately?
- Is the interviewer documenting all required information and completing the questionnaire correctly?
- If data is truly missing from the clinics is this being documented clearly?
- Is the same data being recorded consistently by different interviewers?
- Does the questionnaire have adequate instructions on how to record information?
- Are there clear coding instructions for missing/unknown/not applicable data?
- Are the interviewers/respondents finding the questionnaire to be user-friendly?
- Is the tool user-friendly with adequate coding information?
- How do we know whether the data in the Excel sheets have been accurately captured in the database?

Quality assurance procedures

The following steps were taken to mitigate the risk of poor data quality.

Data collection quality assurance

- Experienced senior researchers and skilled data collectors were recruited and trained to administer the questionnaire. The training used the questionnaire as the main training tool, took several days and involved some role-playing of possible data collection situations.
- The questionnaire was reviewed and revised in an iterative process involving senior researchers, data collectors and technical leads.
- A pre-test of the tool was conducted which assisted in further refining the tool and clarifying questions and data requirements.
- A survey control sheet was maintained to monitor progress of surveys.
- The process of capturing data into Excel workbooks without delay helped to highlight missing data or inconsistencies and address them while still in the field. All completed questionnaires (Excel version) were reviewed by the senior researcher and compared to the hard-copy questionnaire.
- All reviewed Excel version questionnaires were reviewed a second time by other team members using a structured checklist. In this way a trail of all queries and how they were resolved was created for each facility.
- Data collectors at Health and Development Africa (HDA) captured the approved Excel questionnaires into the database and costing tool. They identified any remaining inconsistencies or gaps, and the HNC team in Uganda addressed these promptly.

Data analysis quality assurance

- Costs generated by the tool were compared to a manual calculation estimate of costs by senior technical team members. A number of inconsistencies were identified which resulted in a thorough process of reviewing formula in the costing tool and correcting these where required.
- The same process also highlighted inconsistencies and outliers in captured data that were addressed, where inaccurate.

- The database and costing tool included a number of validation checks which prevented processing of data until all the errors are corrected.
- Costing results for all facilities were compared. Where unit costs and other values appeared to divert significantly from the average, the data were re-examined to ensure they had been accurately captured, or that outliers could be explained by facility characteristics.

Appendix 4 provides a summary representation of the quality assurance process.

3.1.6 Aggregation of costs

As data on the numbers of fully immunized children and number of doses for every facility were not available at the national level, it was not possible to extrapolate readily from the unit costs of sampled facilities to national level on the basis of numbers of fully immunized children or doses. Thus, the total cost for the country was extrapolated from the weighted average total costs for the facilities in each particular facility type (II, II, IV, hospital). These were calculated based on their inverse probability of being sampled and then applied to all the facilities of the same type in the country, to produce an estimated total cost for each stratum. Similarly, the weighted average total cost of the DHOs, based on inverse of their probability of being selected, was applied to all the non-sampled DHOs.[29]

To arrive at the total national cost of routine immunization, the estimated costs of the three different levels (central, district and facility) were summed.

Hence, ***total national cost** = Cost at* ***Central level*** *+ Costs at* ***district + Costs at health facility (HF) level***

The costs for each level were collected and calculated as follows:

A) Estimation of costs at Central level

Using an appropriate resource tracking tool, expenditure by donors and their implementing partners was obtained for 2011. Similarly, expenditure by government was obtained from government records and key informant interviews, particularly in relation to expenditures incurred by UNEPI, National Medical Stores and other relevant MOH departments.

---

[29] This methodology differed from the Common Approach methodology used in some other country studies. In those studies, for each sampled district, the weighted average facility costs by facility type was estimated and multiplied by the number of facilities in each district. These were added to the district level costs to produce weighted total district immunization costs, which were summed and then added to central would potentially introduce biases. For example some districts do not have any hospital and may produce district costs that are out of line with other districts, even those without hospitals. Also, selection of Kampala, Uganda's largest, and only predominantly "urban" district may have resulted in over-representation of urban costs. The relatively large samples of facilities, particularly those that provide the bulk of immunization (HCII and HCIII), were thus expected to provide more representative estimates of national costs than the sample of districts. There was particular caution about using the small sample of "districtised" costs due to absence of facility utilization and population data to allow assessment of whether the sampled districts adequately represented national utilization patterns.

Cost at Central level = *cost by* ***donors and partners*** + *cost by* ***govt entities at central level***

$$T_{central} = \sum_{k=1}^{n} d^k + \sum_{i=1}^{m} g^i$$

Where $T_{central}$ is the total cost at central level, d^k is expenditure of the d^{th} donor/partner and g^i is the expenditure of the g^{th} government entities at central level. Vaccine costs were included at the national level, and not double counted at the district and facility levels.

B) ***Estimation of Costs at District Health Offices***

Total expenditure of District Health Offices was estimated as follows:

Total Expenditure at District Health Offices level $T_{DHO} = \sum_{k=1}^{n} x^k a^k$

Where x^k is the weighted average expenditure by DHOs (obtained from the study, excluding the vaccine costs) in the k^{th} *region* and a^k is the total number of DHO offices in the k^{th} *region, n* is the total number of regions in the country

C) ***Estimation of Costs at Health facility level***

In the sampling, the health facilities were stratified by different levels of health care namely; general hospitals and Health Centres (II, II, IV). Therefore, using the weighted total costs of the sampled facilities, the estimation of the aggregated total expenditures for types of health facilities is achieved as follows:

Total Expenditure at Hospital level $T_{HOSP} = \sum_{k=1}^{n} h^k p^k$

Where h^k is the weighted hospital expenditure (obtained from the study, excluding vaccines and vaccine supplies) in the k^{th} *region* and p^k is the total number of hospitals in the k^{th} region, *n* is the total number of regions in the country.

Total Expenditure at Health Centre level $T_{HC}\ i = \sum_{k=1}^{n} c^k y^k$

Where i *is the level of care (Health Centre II... IV)* , c^k is the weighted expenditure at the health centre level (obtained from the study, excluding vaccines and vaccine supplies) in the k^{th} *region* and y^k is the total number of health centres i *in the* k^{th} *region, and n* is the total number of regions in the country.

District costs at health facility level; $T_{HF} = T_{HOSP} + T_{HCII} + T_{HCIII} + T_{HCIV_V}$

D) Total national cost

Total national cost; $T = T_{CENTRAL} + T_{DISTRICT} + T_{HF}$

3.1.7 Limitations of the approach

A number of methodological limitations should be considered when interpreting the results of the costing, although main conclusions are expected to be robust, except where noted otherwise. Some limitations are associated with the approach, but others result from the limitations of data from records at facilities, the structure of routine reporting systems, and potentially from the sampling. The most important of these limitations are as follows.

a) Sampling strategy

As facility and district immunization output data for all facilities were not available at the central level, this hindered the stratification of the sample of facilities to ensure that there was optimal representation of low and high volume services, and to check the representativeness of the selected sites. The need for purposive sampling of districts, as directed by the reference group in order to try to achieve representativeness within the regions, and to ensure feasibility of fieldwork may also have introduced some biases which could not be easily identified. The sample size could also have limited representation of important sub-groups of facilities or contexts. Of note, confidence intervals around regression coefficients (see below) tended to be wide due to high variability and possibly small sample sizes, indicating limited precision and power to detect statistically significant associations between some factors.

b) Aggregation method

The absence of output data (numbers of DTP3 vaccinated children and number of doses) for all facilities nationwide meant it was not feasible to aggregate unit costs to produce national programme cost estimates which were weighted according to outputs of different types of facility. Therefore the aggregation method described above was used, which involved weighting average facility costs by facility type using inverse sampling probabilities, and applying this to all facilities in the country, by their type. This aggregation approach is likely to have limitations, including that unit costs varied quite widely among facilities of the same type, so the weighted averages could have been over- or under-estimates. However, applying an average total cost by facility type did attempt to accommodate the variation between the facility sizes, and the weighted average unit cost per facility type is a useful indicator for policy makers and planners when estimating costs per facility type in Uganda.

When calculating the national aggregated unit cost for delivery of immunization, the lack of accurate statistics on DTP3 vaccinated children at national level again hampered the calculation, and thus the denominators were based on cMYP output estimates for 2011 (DTP3 children and doses). As an alternative option, the number of DTP3 children was estimated based on the coverage rate (82%) of the surviving infants (4.5% of the total population), and the number of doses calculated using the WHO coverage and wastage rates. This approach gave very similar outputs and therefore unit costs as when applying the cMYP outputs. Despite this, some unavoidable uncertainty remains around the national level unit costs.

c) Assumptions and data limitations

Costing estimates were based on a several assumptions which were considered to be reasonable given the available data, but which may have had limitations. Data available from facility records also showed anomalies in a number of cases, suggesting limited quality of routine data which could not be corrected. The most important limitations are likely to be the following.

- Staff costs, which are a relatively large proportion of total costs, were estimated based on staff time allocations to immunization activities, and between the different immunization activities. These relied on respondents' recall of the proportion of staff time devoted to the activities, rather than records or observations. This could have resulted in over- or under-estimation.

- The lack of accurate vaccine stock records in some facilities prevented the calculation of accurate wastage rates, and so the WHO wastage rates had to be applied. This may have produced inaccurate estimation of vaccines and supplies costs in some facilities. A sensitivity analysis assessed the potential impact of this uncertainty.
- In some facilities, mainly the HCIIs, the reported numbers of children receiving DTP3 and Polio 3 were higher than those reportedly receiving DTP1 and Polio 1 respectively, which would not expected. This was probably due to weak reporting but, in some cases, outreach or supplemental activities might have captured more children for third doses. The potential impact of the over-reporting on a) aggregated national costs and b) total national unit costs was estimated to be limited to around 2.2%, given the contributions of the different facility types to the national EPI. Therefore the estimates of magnitude of overall immunization costs for Uganda are likely to remain robust. However, the effect may have been more significant on the facility level unit cost per DTP3 vaccinated child. For example, the apparent surplus of total DTP3 children was around 6.8% in HCII) and the higher denominator could potentially lead to under-estimation of the unit cost.
- Absence of detailed vehicle log books made it difficult to accurately assess both the total annual use of vehicles and the allocation of vehicles usage to immunization activities.
- Facility records did not separate immunizations performed at a facility from those done through outreach. Therefore to allocate vaccine and other costs between these two activities, it was necessary to use staff estimates of the split. This may have caused an under- or over-estimation of one or the other mode of delivery.
- District Health Offices' spending on immunization was difficult to extract from the other spending of the primary health grants. Therefore a share of the DHO overhead spending was attributed to immunization activities, based on the allocative factors described in the methodology section above.
- The bottom-up approach to estimating costs, rather than a step-down allocation of total facility expenditures over a full range of services, may have over- or under-estimated the portion of higher level costs for immunization as no detailed view of all other aspects of service delivery at district or facility level was obtained.

3.1.8 Ethical issues

Research and Ethics permission was obtained from the Uganda National College for Science and Technology (10 December 2012), and permission to access the health facilities was obtained from the MOH and UNEPI to conduct the study and to access the service delivery sites. Since this study did not entail interviewing any clients of immunization services, accessing their records, or obtaining other sensitive information from informants, no substantial ethical challenges were identified.

3.2 Results – facility level total and unit costs

3.2.1 Facility level costs

3.2.1.1 Total economic costs

The weighted total economic costs of routine immunization across all facility types are summarized in Table 3-6 by line item.

The weighted average total facility immunization cost across all facilities was US$ 8 772. The two largest shares of the total recurrent costs were for vaccines (39% on average across all the facilities), and then salaries at 32%, with the remaining recurrent costs being relatively small: cold chain energy costs (3.7%), vehicle maintenance and fuel (3.3%) and vaccine injections and supplies (1.8%). Of the 16.4% of total economic costs contributed by capital items, the largest proportion went to vehicles (9.3% of the total), followed by building costs (5.1%), with cold chain equipment contributing only 1.8%. The variation between the facility types is shown in the following section.

Table 3-6: Weighted Average Routine Immunization Economic Costs by Line Item for all sampled facilities (US$, %, 2011)

TOTAL FACILITY COSTS (US$) BY LINE ITEM	W.Av. & for Total Facilities	(Range)	W.Av.% for total Facilities
Sample (n):	49		
Line Items			
Salaried Labor	2 849	(461-28014)	32,5%
Volunteer Labor	-		0,0%
Per Diem & Travel Allowances	144	(0-1132)	1,6%
Vaccines	3 435	(212-89946)	39,2%
Vaccine Injection & Supplies	156	(0-3801)	1,8%
Other Supplies	133	(127-316)	1,5%
Transport/Fuel	153	(0-1703)	1,7%
Vehicle Maintenance	141	(0-3805)	1,6%
Cold Chain Energy Costs	325	(0-8011)	3,7%
Printing	-		0,0%
Building overhead, Utilities, Comms.	-		0,0%
Other recurrent	-		0,0%
Subtotal recurrent	*7 337*		*83,6%*
Cold Chain Equipment	159	(0-509)	1,8%
Vehicles	816	(0-14968)	9,3%
Lab equipment	-		0,0%
Other Equipment	10	(0-1216)	0,1%
Other capital	-		0,0%
Building	450	(14-4708)	5,1%
Subtotal capital	*1 435*		*16,4%*
Total Facility Immunization Cost	**8 772**		**100,0%**
	(1,912-112,753)		

3.2.1.2 Weighted cost profile - line items and activities

The table and figures below show that the weighted average total economic cost per facility range from US$ 4,309 in HC II, US$ 9,957 in HC III, US$ 21,160 in HC IV to US$ 53,793 in the general hospitals. Because the majority of districts and facilities in Uganda are labeled as rural, with only Kampala and a few larger towns labeled as urban and peri-urban, the costing data are presented here according to the facility type, rather than by urban or rural location. (See Appendix 1 for location of facilities).

The level of the health centre (HC) relates primarily to the size of their catchment area, with HC IV having a larger catchment area than HC II and III, but usually less than the general hospitals. The differences in average total costs of the different facility types are thus largely consistent with their expected utilization levels. The catchment areas hospitals also may have populations that use other facilities for immunization services, or may receive patients (referred or self-referred) who reside in catchment areas of other facilities. This may affect some facilities' costs and utilization levels in relation to their official catchment populations.

Somewhat higher total costs in hospitals would be expected due to their larger outputs – a weighted average of 20,501 doses per hospital per year compared to 1,191 per HCII per year.

Recurrent costs, ranged from 82.4% in HC IV to 89% in general hospitals, and formed 83.6% of total costs on average. Interestingly the HC IV had the highest proportion of costs for salaries per facility (40.4%), and the least for vaccines (28.6%). Hospitals had the highest proportion for vaccines (45.6%). The HC IV sites had proportionally larger vehicle costs than other facility types (16.2%), as the HC IV had more vehicles than the lower level facilities, at the time of the study.

The weighted outputs for each facility type and their unit costs are presented in the later section on unit costs.

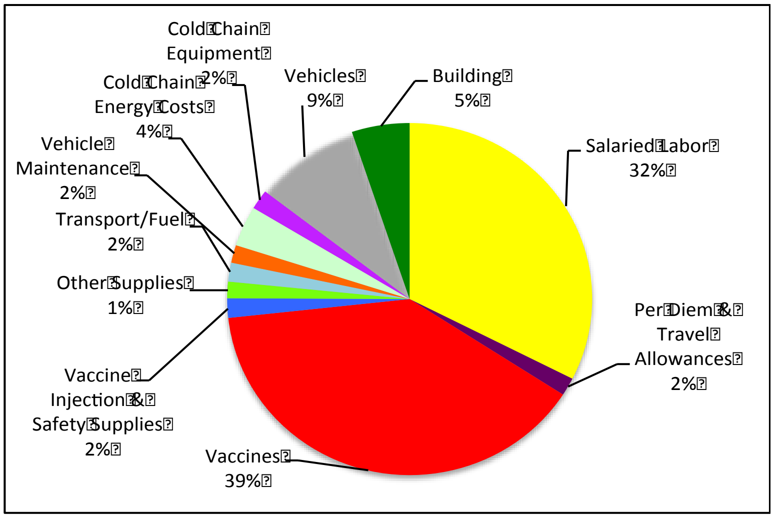
The following table presents the economic costs, where all the capital costs were annualized based with a 3% discount rate and estimates of useful life. There were no other volunteer inputs that had to be quantified. The financial costing reflects cash outflows or expenditure directly incurred by the program, as a more useful measure for assessing short to medium term resource and budgetary requirements. For the financial costing, capital asset costs were annualized without discounting, i.e. using a straight-line depreciation of assets. Thus the variation in the capital costs between the economic and financial costs was not large, with a decrease of 2% across all facilities' capital costs, and overall a decrease of 0.3% in total costs across all facilities.

Table 3-7: Weighted Average Immunization Economic Costs by Facility Type and Line item (2011, US$)

TOTAL FACILITY COSTS (US$) BY LINE ITEM	HC II W.Av Cost & (Range)	HC III W.Av Cost & (Range)	HC IV W.Av Cost & (Range)	Gen. Hosp. W.Av Cost & (Range)	W.Av. & (Range) for Total Facilities	% Share HC II	% Share HC III	% Share HC IV	% Share Gen. Hosp	W.Av.% for total Facilities
Sample (n):	18	18	9	4	49					
Line Items										
Salaried Labor	1 604	2 802	8 547	15 918	2 849	37,2%	28,1%	40,4%	29,6%	32,5%
	(461-10859)	(1080-9713)	(5172-11782)	(5074-28013)	(461-28014)					
Volunteer Labor	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Per Diem & Travel Allowances	90	181	324	429	144	2,1%	1,8%	1,5%	0,8%	1,6%
	(0-252)	(0-419)	(52-624)	(126-1132)	(0-1132)					
Vaccines	1 415	4 338	6 053	24 510	3 435	32,8%	43,6%	28,6%	45,6%	39,2%
	(212-8297)	(1487-67059)	(3670-10989)	(5514-89946)	(212-89946)					
Vaccine Injection & Supplies	67	194	279	1 098	156	1,5%	1,9%	1,3%	2,0%	1,8%
	(0-353)	(66-2873)	(187-530)	(250-3801)	(0-3801)					
Other Supplies	127	127	127	316	133	2,9%	1,3%	0,6%	0,6%	1,5%
	(127-127)	(127-127)	(127-127)	(316-316)	(127-316)					
Transport/Fuel	64	227	759	21	153	1,5%	2,3%	3,6%	0,0%	1,7%
	(0-419)	(0-1397)	(0-1703)	(0-153)	(0-1703)					
Vehicle Maintenance	67	75	336	1 778	141	1,5%	0,8%	1,6%	3,3%	1,6%
	(0-629)	(0-912)	(0-2194)	(198-3805)	(0-3805)					
Cold Chain Energy Costs	117	289	566	3 825	325	2,7%	2,9%	2,7%	7,1%	3,7%
	(0-472)	(0-872)	(0-943)	(472-8011)	(0-8011)					
Printing	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Building overhead, Utilities, Comms.	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Other recurrent	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Subtotal recurrent	*3 550*	*8 233*	*16 990*	*47 894*	*7 337*	*82,4%*	*82,7%*	*80,3%*	*89,0%*	*83,6%*
Cold Chain Equipment	133	181	238	253	159	3,1%	1,8%	1,1%	0,5%	1,8%
	(0-415)	(135-509)	(152-413)	(149-313)	(0-509)					
Vehicles	413	678	3 438	5 135	816	9,6%	6,8%	16,2%	9,5%	9,3%
	(0-5677)	(0-5241)	(0-14968)	(1673-9062)	(0-14968)					
Lab equipment	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Other Equipment	1	26	5	6	10	0,0%	0,3%	0,0%	0,0%	0,1%
	(0-66)	(0-1216)	(0-51)	(0-98)	(0-1216)					
Other capital	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Building	213	839	488	505	450	4,9%	8,4%	2,3%	0,9%	5,1%
	(14-1119)	(62-4708)	(224-864)	(118-864)	(14-4708)					
Subtotal capital	*759*	*1 724*	*4 170*	*5 899*	*1 435*	*17,6%*	*17,3%*	*19,7%*	*11,0%*	*16,4%*
Total Facility Immunization Cost	**4 309**	**9 957**	**21 160**	**53 793**	**8 772**	**100,0 %**	**100,0 %**	**100,0 %**	**100,0 %**	**100,0%**
	(1912-26017)	(5374-81694)	(11579-36952)	(18333-112753)	(1912-112753)					

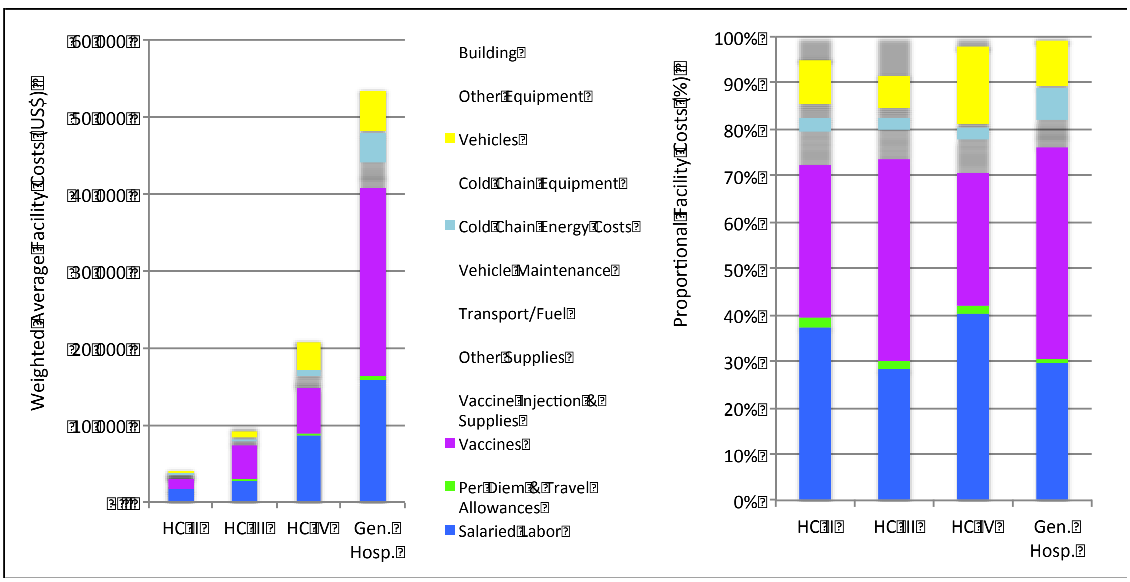
Note. Output data and unit costs are presented in the Unit Cost section below.

Figure 3: Proportional Share of Total Facility Costs by Line-item (2011, %)



The following figures present the facility costs graphically, in weighted numerical amounts and as proportions of their total costs.

Figure 4: Weighted Average and Proportional Line item Immunization Economic Costs per Facility Type (US$, %, 2011)



The following table shows the weighted average costs per facility type, by immunization activity.

Table 3-8: Weighted Average Immunization Economic Costs by Activity and Facility Type (US$, 2011)

TOTAL FACILITY COSTS BY ACTIVITY (US$)	HC II W.Av Cost & (Range)	HC III W.Av Cost & (Range)	HC IV W.Av Cost & (Range)	Gen. Hosp. W.Av Cost & (Range)	W.Av. & (Range) for All Facilities	% Share HC II	% Share HC III	% Share HC IV	% Share Gen. Hosp	Av.% for all HC
Sample (n):	18	18	9	4	49					
Activity										
Cold Chain Maintenance	264	426	930	4 431	531	6,1%	4,3%	4,4%	8,2%	6,0%
	(59-3078)	(112-1454)	(65-1183)	(873-8363)	(59-8363)					
NUVI	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Other	-	-	-	-	-	0,0%	0,0%	0,0%	0,0%	0,0%
Outreach Service Delivery	1 072	2 806	5 704	17 887	2 453	24,9%	28,2%	27,0%	33,3%	28,0%
	(0-5458)	(1259-29666)	(3051-7607)	(5527-45980)	(0-45980)					
Program Management	517	934	1 986	2 643	805	12,0%	9,4%	9,4%	4,9%	9,2%
	(170-1439)	(292-2892)	(174-7171)	(755-4626)	(170-7171)					
Record-Keeping & HMIS	110	248	556	754	201	2,6%	2,5%	2,6%	1,4%	2,3%
	(24-484)	(38-1425)	(0-2204)	(320-1179)	(0-2204)					
Routine Facility-based Serv-Del.	1 629	4 301	7 862	23 363	3 578	37,8%	43,2%	37,2%	43,4%	40,8%
	(790-12987)	(2051-44850)	(4741-11388)	(6210-55705)	(790-55705)					
Social Mobilization & Advocacy	74	248	476	377	164	1,7%	2,5%	2,3%	0,7%	1,9%
	(7-170)	(0-862)	(125-1122)	(178-1956)	(0-1956)					
Supervision	112	204	870	1 504	229	2,6%	2,0%	4,1%	2,8%	2,6%
	(0-587)	(18-1634)	(328-1970)	(369-2630)	(0-2630)					
Surveillance	73	145	556	138	124	1,7%	1,5%	2,6%	0,3%	1,4%
	(0-275)	(0-1164)	(0-1085)	(0-944)	(0-1164)					
Training	10	19	39	6	14	0,2%	0,2%	0,2%	0,0%	0,2%
	(0-45)	(0-102)	(0-750)	(0-130)	(0-750)					
Vaccine Collection, Distribution & Storage.	447	627	2 181	2 689	672	10,4%	6,3%	10,3%	5,0%	7,7%
	(115-2039)	(170-2368)	(446-5270)	(1802-3655)	(115-5270)					
Total Facility Immunization Cost	**4 309**	**9 957**	**21 160**	**53 793**	**8 772**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**
	(1912-26017)	(5374-81694)	(11579-36952)	(18333-112753)	(1912-112753)					

NB. The output data and unit costs are presented in the Unit Cost section below.

Figure 5 below shows that, on average, the largest proportion of costs arose from routine facility-based immunization activities (40.8%), followed by outreach activities (28%). Program management accounted for 9.2%, followed by vaccine collection, distribution and storage (7.7%) and cold chain maintenance (6%). Costs of other activities are small – only 2.6% for supervision and nil for NUVI as Uganda had not rolled out PCV by 2011. The proportions were similar across all the facility types, but there was a higher proportion for outreach activities in hospitals (33%) as opposed to 25% in the HC II (Figure 6).

Figure 5: Proportional Share of Total Facility Costs by Activity (2011, %)

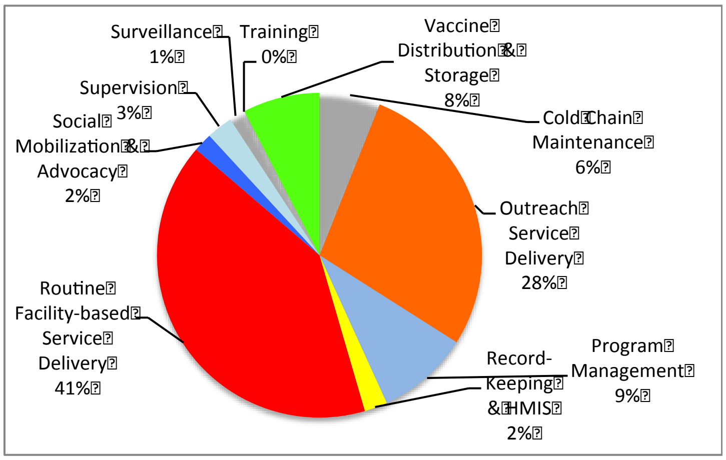
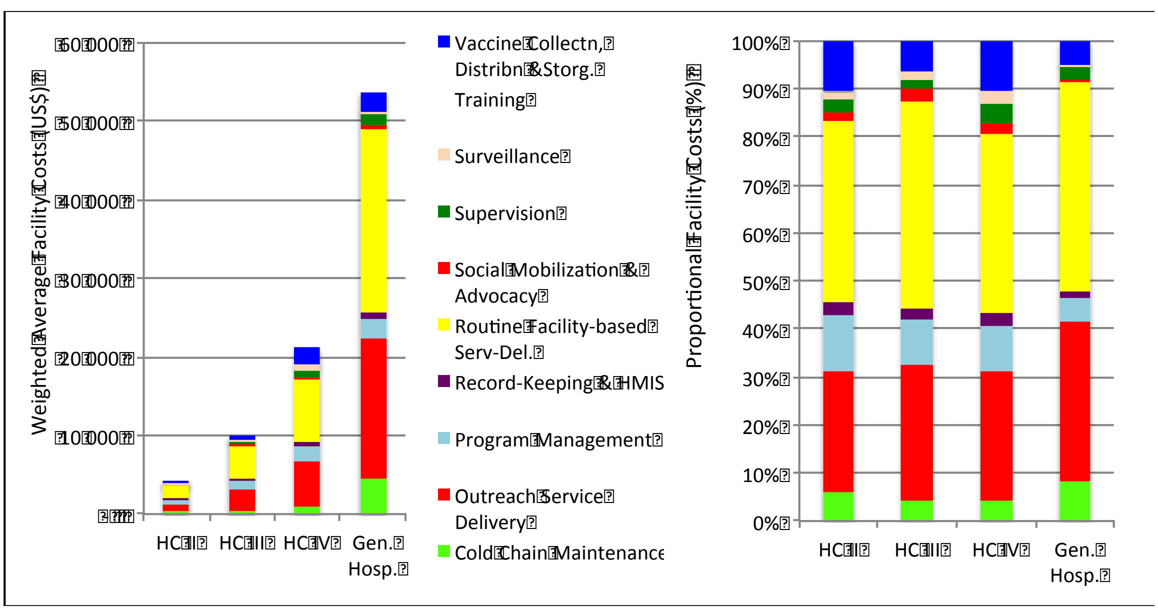


Figure 6: Percentage Contribution of Specific Immunisation activities to weighted Average Economic Costs ($, %, 2011)



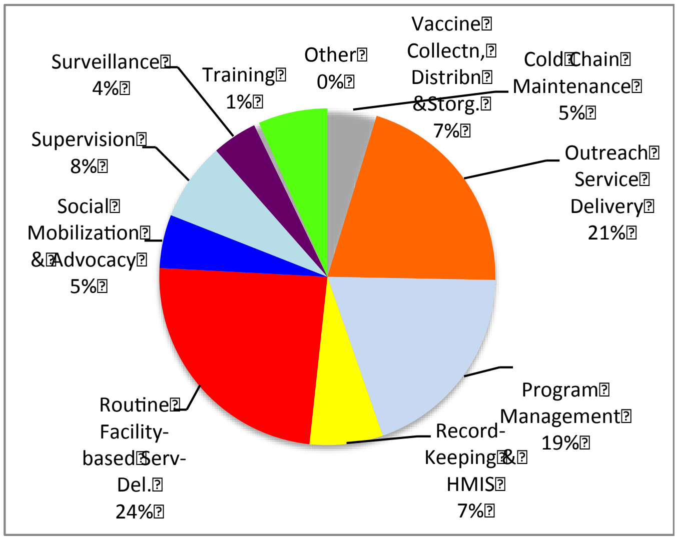
3.2.1.3 Salaries and Full-Time Equivalents

Estimates of salary costs for various program activities are shown in the tables and figures below. The proportion of costs contributed by outreach and facility-based service delivery are lower than for the total cost shares to these activities as the costs of vaccines in particular are removed. Staff intensive activities such as management, supervision and record keeping have larger portions of the salary costs than their share in the total facility costs.

Table 3-9: Weighted Average Salary Costs by Activity by Facility Type (US$, 2011)

SALARY SPENDING BY ACTIVITY (US$)	**HC II W.Av Cost (range)**	**HC II %**	**HC III W.Av Cost (range)**	**HC III %**	**HC IV W.Av Cost (range)**	**HC IV %**	**GH W.Av Cost (range)**	**GH %**	**W.Av for All Facilities**	% for all facs
Sample (n):	18		18		9		4			
Activity										
Cold Chain Maintenance	86 (0-2781)	5%	137 (40-621)	5%	363 (337-871)	4%	606 (352-1864)	4%	135 (0-2781)	5%
NUVI	-	0%	-	0%	-	0%	-	0%	-	0%
Other	-	0%	-	0%	-	0%	-	0%	-	0%
Outreach Service Delivery	266 (0-751)	17%	529 (137-1432)	19%	2 168 (500-3251)	25%	4 202 (999-7583)	26%	586 (0-7583)	21%
Program Management	397 (0-997)	25%	728 (82-2618)	26%	869 (174-2880)	10%	912 (210-1918)	6%	551 (0-2881)	19%
Record-Keeping & HMIS	110 (24-484)	7%	248 (38-1425)	9%	556 (0-2204)	7%	754 (320-1179)	5%	201 (0-2204)	7%
Routine Facility-based Serv-Del.	345 (85-6095)	21%	445 (116-1671)	16%	2 054 (885-3746)	24%	6 865 (713-14837)	43%	687 (85-14837)	24%
Social Mobilization & Advocacy	74 (7-170)	5%	195 (0-752)	7%	476 (125-1122)	6%	377 (178-1956)	2%	146 (0-1956)	5%
Supervision	112 (0-587)	7%	200 (18-1634)	7%	698 (328-1970)	8%	1 361 (369-2333)	9%	214 (0-2333)	8%
Surveillance	73 (0-275)	5%	145 (0-1164)	5%	556 (0-1085)	7%	138 (0-944)	1%	124 (0-1161)	4%
Training	10 (0-45)	1%	19 (0-102)	1%	39 (0-750)	0%	6 (0-130)	0%	14 (0-750)	1%
Vaccine Collectn, Distribn &Storg.	130 (24-460)	8%	156 (0-829)	6%	766 (33-1584)	9%	695 (329-1282)	4%	190 (0-1581)	7%
Total Salary Cost per facility	**1 604**	**100**	**2 802**	**100**	**8 547**	**100**	**15 918**	**100**	**2 849**	**100,0**

Figure 7: Proportional Economic Costs of Salary by Activity (%, 2011)



The largest proportion of salary costs went towards routine facility-based immunization activities (24%), followed by outreach activities (21%), program management (19%), supervision (8%), vaccine storage and distribution (7%) and record-keeping (7%). The other activities contributed 5% or less, with training accounting for only 1%.

With regards to the time spent on the various activities, the largest proportion of the full time equivalent (FTE) of staff time went to program management (25%), followed by routine facility–based immunization (23%) and outreach immunization activities (20%). In terms of total FTEs by facility, the HC II had 1.42 FTE working on immunization, HC III had 1.82, HC IV 4.34 and general hospitals had 7.5. The average across all facilities was 1.91 FTEs working on immunization. See the table below for further detail.

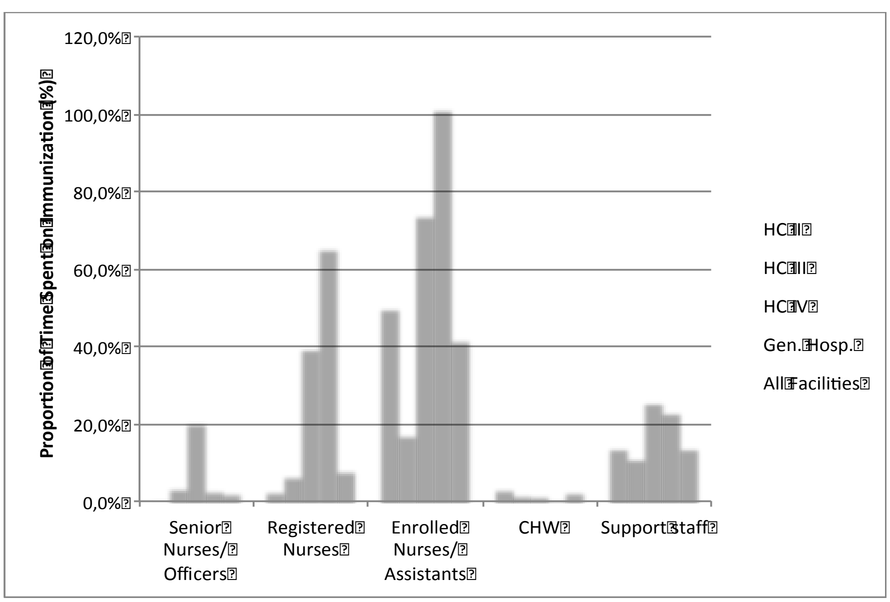
The Table 3-10 and following figure show the proportion of staff time spent on immunization, by staff type. The physicians and doctors spent the least amount of the time (0.2%), followed by the senior nursing staff (2.4%). The registered nurses spent on average 8.1% across all the facilities but this varied between facility types, with the registered nurses in the hospitals spending 65% of their time on immunization. It was the enrolled nurses and nursing assistants who spent the largest portion of their time on immunization (42% across all the facilities), but again with wide variation: 100% in the general hospitals and 17% in the HC II facilities.

When dividing by the number of doses per FTE, and estimating the time taken for each dose, there are again large variations between the facilities. Excluding the CHW time, the staff in the HC II spent 130 minutes per dose, the HC III staff spent 54 minutes per dose, the HC III staff spent 90 minutes per dose and the hospital staff spent 40 minutes per dose administered. This may allude to greater staff efficiencies in the hospitals with the very high outputs, but could also be due to the weak records of numbers of DTP3 immunized children and the stock records of doses consumed (as explained in the methodology section).

Table 3-10 : Total staff time spent on immunization by staff type

Share of Facility Staff Time Spent on Immunisation BY STAFF TYPE (5)	HC II W.Av (range)	HC III W.Av range)	HC IV W.Av (range)	GH W.Av (range)	W.Av for All Facilities (range)
Sample (n):	18	18	9	4	49
Total FTEs (excluding CHW)	1,42	1,82	4,34	7,50	1,91
Total FTEs (including CHW)	1,48	1,83	4,36	7,51	1,95
Doses/FTE (excluding CHW)	840	2 008	1 205	2 735	1 516
Doses/FTE (including CHW)	805	1 996	1 199	2 731	1 485
Time spent per dose delivered (excl CHW)	130	54	91	40	72
Time spent per dose delivered (incl CHW)	136	55	91	40	74
Share of time spent by Physicians / Superintendent / Doctor (U2)	0,0% -	0,0% -	0,0% -	5,0% (0-0.092)	0,2% (0-0.092)
Share of time spent by Senior Nursing staff (Principal NO & Senior Medical NO) (U3+U4)	0,0%	3,6% (0-0.28)	20,4% (0-0.51)	2,9% (0-0.22)	2,4% (0-0.51)
Share of time spent by Registered Nurses/ Nursing Officers (U5+U6)	2,7% (0-0.46)	6,7% (0-0.74)	39,6% (0-0.92)	65,4% (0-1.49)	8,1% (0-1.49)
Share of time spent by Enrolled Nurses / Nursing Assistants (U7+U8 med)	50% (0-0.6)	17% (0-2.6)	74% (0-0.92)	101% (0-1.6)	42% (0-2.6)
Share of time spent by Community Health Workers	3,3% (0-0.18)	1,9% (0-0.18)	1,7% (0-0.08)	0,4% (0-0.3)	2,6% (0-0.18)
Share of time spent by Support staff (incl cleaners, porters, security guards, drivers) (U8 other)	14,0% (0-0.53)	11,3% (0-0.36)	25,7% (0-0.99)	23,2% (0-0.46)	14,0% (0-0.99)

Figure 8 : Proportional Staff Time Spent on Immunization by Staff Type and Facility Type (2011, %)



The following table provides the full time equivalent staff for each of the immunization activities. Strangely the program management took a large portion of the total FTE (25% across all facilities), followed by routine facility-based immunization (23%) and outreach immunization (20%).

Table 3-11: Total FTEs by type of facility and activity (weighted averages and range)

FTE (per month per facility per facility) BY ACTIVITY	HC II W.Av (range)	HC II %	HC III W.Av (range)	HC III %	HC IV W.Av (range)	HC IV %	Gen. Hosp. W.Av (range)	GH %	W.Av for All Facilities (range)	% for all facilities
No. of Facilities (n):	18		18		9		4		49	
Cold Chain Maintenance	0,07 (0-1.04)	5%	0,08 (0.03-0.42)	4%	0,22 (0-0.64)	5%	0,35 (0.12-1.38)	5%	0,09 (0-1.38)	5%
NUVI	-	0%	-	0%	-	0%	-	0%	-	0%
Outreach Service Delivery	0,23 (0-0.46)	16%	0,34 (0.11-0.95)	19%	1,11 (0.37-1.86)	26%	2,05 (0.56-3.3)	27%	0,37 (0-3.3)	20%
Program Management	0,42 (0-1.14)	29%	0,59 (0.05-2.1)	33%	0,43 (0.06-2.97)	10%	0,41 (0.03-0.8)	5%	0,48 (0-2.97)	25%
Record-Keeping & HMIS	0,09 (0.01-0.23)	6%	0,15 (0.02-1.1)	8%	0,31 (0-1.59)	7%	0,33 (0.2-0.48)	4%	0,13 (0-1.59)	7%
Routine Facility-based Serv-Del.	0,31 (0.05-2.33)	22%	0,28 (0.07-1.19)	15%	1,03 (0.37-1.92)	24%	3,15 (0.35-6.58)	42%	0,43 (0.05-6.58)	23%
Social Mobilization & Advocacy	0,05 (0-0.14)	3%	0,07 (0-0.42)	4%	0,18 (0-0.7)	4%	0,12 (0-0.67)	2%	0,07 (0-0.7)	3%
Supervision	0,07 (0-0.21)	5%	0,09 (0.01-0.5)	5%	0,26 (0.07-1.04)	6%	0,48 (0.08-0.9)	6%	0,10 (0-1.04)	5%
Surveillance	0,05 (0-0.17)	4%	0,08 (0-0.76)	5%	0,27 (0-0.65)	6%	0,05 (0-0.28)	1%	0,07 (0-0.76)	4%
Training	0,01 (0-0.03)	1%	0,02 (0-0.09)	1%	0,02 (0-0.43)	1%	0,002 (0-0.05)	0%	0,01 (0-0.43)	1%
Vaccine Collectn, Distribn &Storg.	0,12 (0.01-0.37)	8%	0,12 (0-0.57)	6%	0,50 (0.02-0.86)	12%	0,55 (0.22-1.04)	7%	0,15 (0-1.04)	8%
Total Facility FTEs	**1,42** (0-2.33)	**100**	**1,82** (0-2.1)	**100**	**4,34** (0-2.97)	**100**	**7,50** (0-6.58)	**100**	**1,91** (0-6.58)	**100%**

3.2.1.4 Unit costs and line item benchmarks

The tables and figures below indicate that the ***total weighted unit cost*** (including the salaries and vaccine costs) per DTP3 immunized child was US$ 52 in HC II, US$ 31 in HC III, US$ 44 in HC IV and US$ 34 in general hospitals, with an average of US$ 44 across all facilities.

When the salary costs are removed, the ***non-wage cost per DTP3*** child reduced to US$ 26 in HC II, US$ 23 in HC III, US$ 26 in HC IV and US$ 23 in general hospitals, with an average of US$ 24 across all facilities.

When vaccine costs are excluded, the ***service delivery unit cost*** per DTP3 child was US$ 39 in HC II, US$ 20 in HC III, US$ 31 in HC IV and US$ 22 in general hospitals, with an average of US$ 31 across all facilities.

When salaries and the vaccine costs are excluded, the ***non-wage service delivery unit cost*** per DTP3 child was US$ 12 in HC II, US$ 11 in HC III, US$ 12 in HC IV and US$ 11 in general hospitals, with an average of US$ 12 across all facilities.

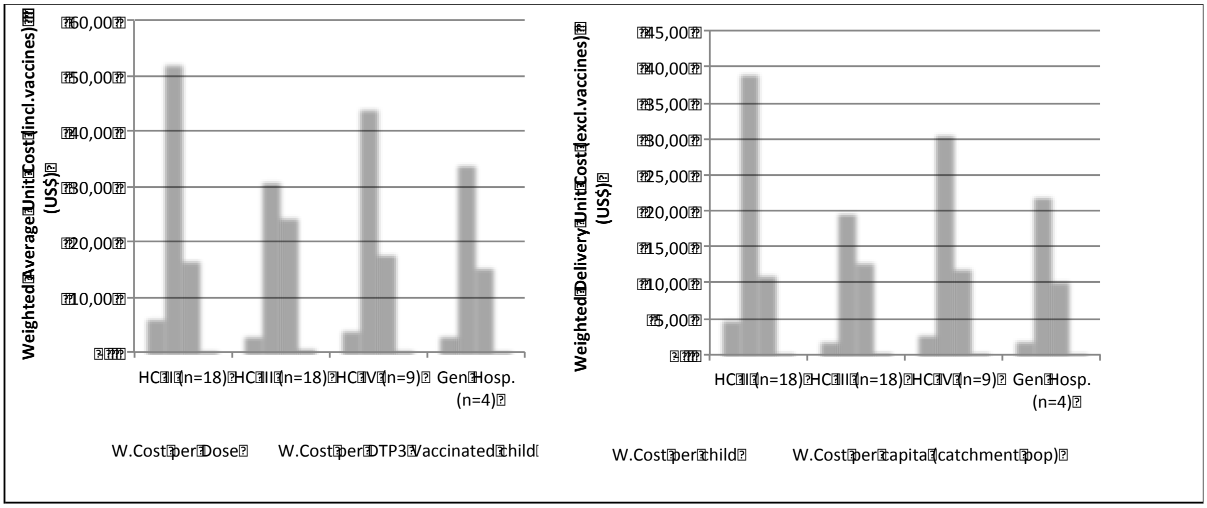
The cost per dose, per infant and per capita in the catchment population are also shown below. The determinants of these variations and related productivity issues are explored in later sections.

Table 3-12: Weighted Immunization Outputs & Unit Costs by Facility Type (2011, US$)*

FACILITY STATS, OUTPUTS & UNIT COSTS	HC II (n=18)	HC III (n=18)	HC IV (n=9)	Gen Hosp.(n=4)	Total All Facilities
W.Av total doses	1 191	3 655	5 231	20 501	2 895
W.Av DTP3 children	111	397	496	2 163	298
W.Av Infant pop (<1yr)	321	720	1 783	11 998	930
W.Av Catchment pop./ facility	7 450	16 532	41 455	279 028	21 549
Total Weighted Cost (US$)	4 309	9 957	21 160	53 793	8 772
W.Unit Costs (US$) (including salaries, vaccines & supplies)					
W.Cost per Dose	6,45	3,32	4,28	3,34	5,17
W.Cost per DTP3 Vaccinated child	52,42	31,25	44,30	34,25	44,17
W.Cost per child	16,84	24,65	18,07	15,65	19,52
W.Cost per capita (catchment pop)	0,73	1,07	0,78	0,67	0,84
Total Weighted Non-Wage Cost (US$)	2 706	7 155	12 613	37 875	5 922
W.Unit Costs (US$) Non-Wage (including vaccines & supplies, excluding salaries)					
W.Cost per Dose	2,54	2,39	2,52	2,27	2,48
W.Cost per DTP3 Vaccinated child	25,62	22,63	26,02	22,90	24,53
W.Cost per child	9,54	17,83	10,80	11,03	12,48
W.Cost per capita (catchment pop)	0,41	0,77	0,46	0,47	0,54
Total Delivery Cost (US$) (excluding va	2 827	5 425	14 828	28 185	5 181
W.Unit Delivery Costs (US$) (excluding vaccines & supplies)					
W.Cost per Dose	5,11	2,09	3,06	2,15	3,88
W.Cost per DTP3 Vaccinated child	39,28	19,96	30,86	22,23	31,69
W.Cost per child	11,39	13,04	12,21	10,45	11,96
W.Cost per capita (catchment pop)	0,49	0,57	0,53	0,45	0,52
Total Non_wage Delivery Cost (US$) ((	1 223	2 623	6 281	12 267	2 332
W.Unit Delivery Costs (US$) Non-Wage (excluding vaccines, supplies & salaries)					
W.Cost per Dose	1,20	1,16	1,31	1,07	1,19
W.Cost per DTP3 Vaccinated child	12,48	11,35	12,59	10,88	12,04
W.Cost per child	4,09	6,22	4,95	5,83	4,92
W.Cost per capita (catchment pop)	0,18	0,27	0,21	0,25	0,21

The total weighted cost per dose including vaccines varied from US$ 3.34 in the hospitals to US$ 6.45 in HC II, with a US$ 5.17 average across all facilities. Excluding vaccine cost, the lowest delivery per dose cost was US$ 2.09 in HC III and the highest was US$ 5.11 in HC II, with an average of US$ 3.88.

Figure 9: Weighted unit costs by facility type with & without vaccines (US$ 2011)



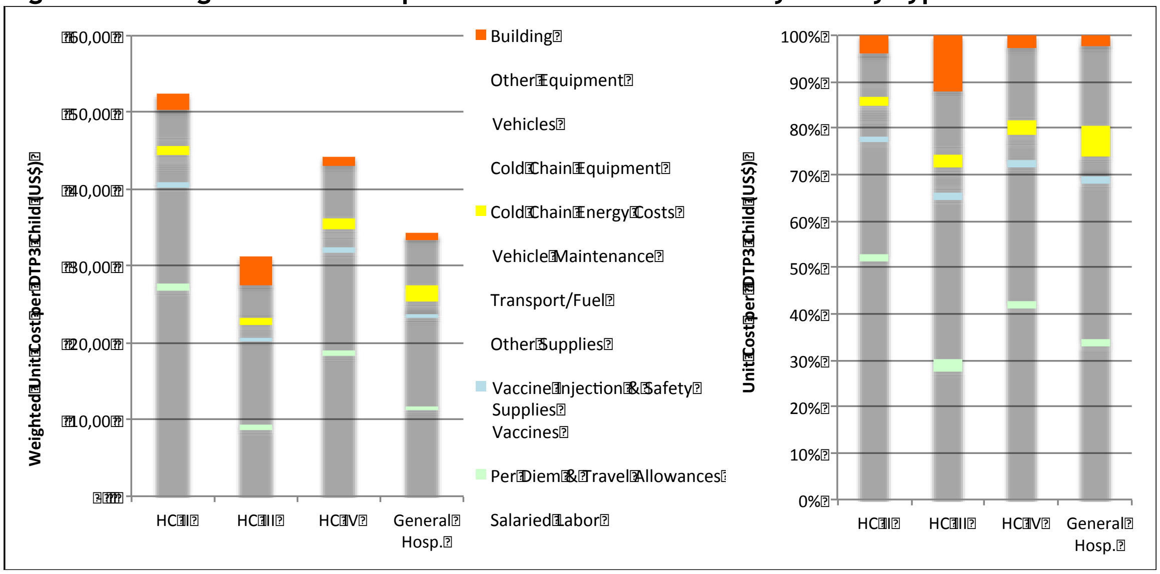
The composition of the DTP 3 unit cost by line item is shown below. Overall, the largest cost was for salaried labour (44.5%), followed by vaccines (27%), and vehicles (8.3%). The recurrent costs made up 83%, while capital costs contributed 17%. Of note, HC II had higher staff costs, while HC IV had higher capital costs due to the higher costs of vehicles which were found in HC IVs.

Table 3-13: Weighted Unit Cost per DTP3 child by Line Item and Facility Type

TOTAL FACILITY UNIT COSTS (US$) PER DTP3 CHILD	**HC II** Weighted Unit Cost (DTP3)	**HC III** Weighted Unit Cost (DTP3)	**HC IV** Weighted Unit Cost (DTP3)	**General Hosp.** Weighted Unit Cost (DTP3)	**Across All HC** Weighted Unit Cost (DTP3)	% Distribution for all Facilities (per DTP3 child)
No. of Facilities (n):	18	18	9	4		
Weighted number of Total DTP3 chln	111	397	496	2 163	298	
Expenditure Line Items						
Salaried Labor	26,80	8,61	18,27	11,34	19,64	44,5%
Volunteer Labor	-	-	-	-	-	0,0%
Per Diem & Travel Allowances	0,96	0,79	0,63	0,45	0,87	2,0%
Vaccines	12,56	10,80	12,85	11,49	11,93	27,0%
Vaccine Injection & Safety Supplies	0,58	0,49	0,59	0,53	0,55	1,2%
Other Supplies	2,13	0,46	0,27	0,34	1,40	3,2%
Transport/Fuel	0,95	0,87	1,53	0,00	0,92	2,1%
Vehicle Maintenance	0,56	0,30	0,64	1,13	0,49	1,1%
Cold Chain Energy Costs	1,00	0,86	1,33	2,24	1,01	2,3%
Printing	-	-	-	-	-	0,0%
Building overhead, Utilities, Comms.	-	-	-	-	-	0,0%
Other recurrent	-	-	-	-	-	0,0%
Subtotal recurrent	*45,53*	*23,17*	*36,11*	*27,52*	*36,82*	*83%*
Cold Chain Equipment	1,43	0,72	0,49	0,23	1,10	2,5%
Vehicles	3,32	3,59	6,53	5,73	3,65	8,3%
Lab equipment	-	-	-	-	-	0,0%
Other Equipment	0,01	0,05	0,01	0,01	0,02	0,0%
Other capital	-	-	-	-	-	0,0%
Building	2,13	3,72	1,16	0,76	2,58	5,8%
Subtotal capital	*6,89*	*8,08*	*8,19*	*6,72*	*7,35*	*17%*
Facility Immunization Cost/DTP3 child (US$)	**52,42**	**31,25**	**44,30**	**34,25**	**44,17**	**100,0%**
Facility Cost Non-Wage/ DTP3 child (US$)	25,62	22,63	26,02	22,90	24,53	
Facility Delivery Cost per DTP3 child (excl. vaccines) (US$)	39,28	19,96	30,86	22,23	31,69	
Facility Delivery Non-Wage Cost per DTP3 child (excl. vacc&sals)	12,48	11,35	12,59	10,88	12,04	

Bearing in mind the expected economies of scale as the facility size and their DTP3 output figures increased, there would appear to be logical trend of decreasing DTP3 unit costs from the HC II down to the hospitals. However, the HC III are clearly the outlier, perhaps due to their lower staff and vehicle costs, compared to HC II and HC IV respectively.

Figure 10: Weighted unit cost per DTP3 child immunized by facility type and line item



The following table and figure present the unit cost per dose breakdown.

Table 3-14: Weighted Unit Cost per Dose by Line Item and Facility Types (US$, 2011)

FACILITY UNIT COSTS (US$) PER DOSE	HC II Weighted Unit Cost/dose	HC III Weighted Unit Cost/dose	HC IV Weighted Unit Cost/dose	General Hosp. Weighted Unit Cost/dose	Across All HC Weighted Unit Cost/dose	Av.% Distribution for all HC types (per dose)
No. of Facilities (n):	18	18	9	4		
Weighted number of Doses	1 191	3 655	5 231	20 501	2 895	
Expenditure Line Items						
Salaried Labor	3,30	0,92	1,76	1,11	2,30	44,5%
Volunteer Labor	-	-	-	-	-	0,0%
Per Diem & Travel Allowances	0,12	0,08	0,06	0,04	0,10	2,0%
Vaccines	1,55	1,15	1,24	1,12	1,40	27,0%
Vaccine Injection & Safety Supplies	0,07	0,05	0,06	0,05	0,06	1,2%
Other Supplies	0,26	0,05	0,03	0,03	0,16	3,2%
Transport/Fuel	0,12	0,09	0,15	0,00	0,11	2,1%
Vehicle Maintenance	0,07	0,03	0,06	0,11	0,06	1,1%
Cold Chain Energy Costs	0,12	0,09	0,13	0,22	0,12	2,3%
Subtotal recurrent	*5,61*	*2,46*	*3,49*	*2,68*	*3,56*	*83,4%*
Cold Chain Equipment	0,18	0,08	0,05	0,02	0,13	2,5%
Vehicles	0,41	0,38	0,63	0,56	0,43	8,3%
Lab equipment	-	-	-	-	-	0,0%
Other Equipment	0,00	0,01	0,00	0,00	0,00	0,0%
Other capital	-	-	-	-	-	0,0%
Building	0,26	0,39	0,11	0,07	0,30	5,8%
Subtotal capital	*0,85*	*0,86*	*0,79*	*0,66*	*0,79*	*16,6%*
Facility Immunization Cost / Dose (US$)	**6,45**	**3,32**	**4,28**	**3,34**	**5,17**	**100,0%**
Facility Cost Non-Wage/ dose (US$)	2,54	2,39	2,52	2,27	2,48	
Facility Delivery Cost per dose (excluding vaccines) (U	5,11	2,09	3,06	2,15	3,88	
Facility Delivery Non-Wage Cost per dose (excl. vacc&sals)	1,20	1,16	1,31	1,07	1,19	

Further detailed Tables and Figures for various unit costs can be found in Appendix 8.

a. Variation in unit costs between facilities and facility types

The Ugandan weighted unit costs per dose and per DTP3 immunized child showed variations between facilities and facility types. When scatter plots were used to graph relationships between unit costs and different variables, the strongest relationship appeared to be with service volumes. The figure below shows the relationship between total unit costs per dose and the total number of doses administered.

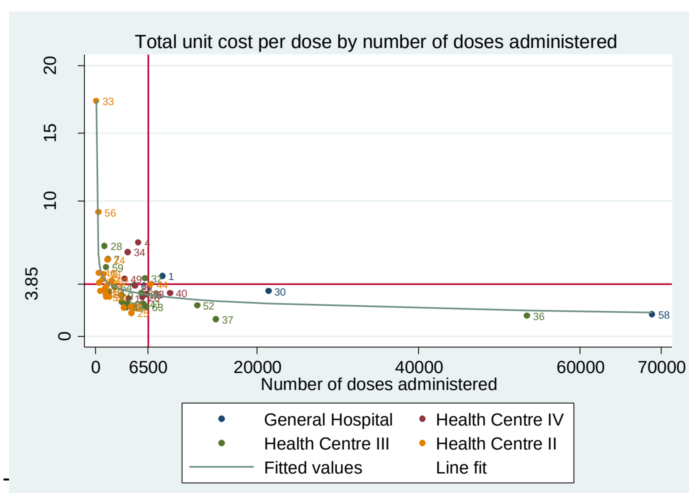
Each point on the graph represents a sampled facility with a unique identifier number (see Appendix 1 Table 1.3 for identifiers). Facilities are colour-coded by facility type. The cost curves are linear fractional polynomial predictions, using untransformed and ln-transformed variables. The reference lines are placed on the mean of the variable.

The ln-transformed graph shows a clearer relationship between increasing numbers of doses and reducing cost per dose than does the untransformed data. In the untransformed plot there is an indication of a steeper curve among facilities with lower outputs. There is some clustering of different facility types. Hospitals with their very high output numbers tend to have lower unit costs. The HC II appear to be the least efficient, which would be expected due to their much lower catchment populations and attendance.

This is particularly noticeable in four outliers. [30] High unit costs in Kidoko and Pachara (HCII # 33 and # 56) were due to the very low output volumes.[31] The two facilities with lowest unit costs – Kiswa (#36, in Kampala) and Rakai hospital (#58) – both had very high output numbers.[32]

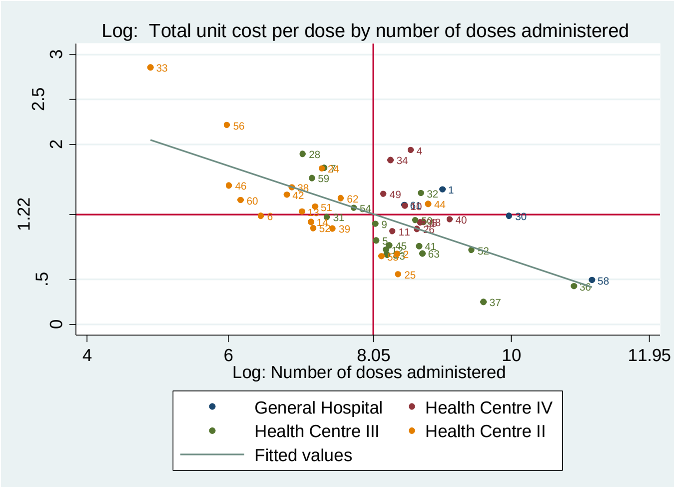
Figure 11: Total unit cost per dose by the number of doses administered (US$, 2011)

i) Non-transformed



[30] In further graphing of untransformed variables, these four facilities were excluded in order to better show the relationships for other facilities. They were however included in ln-transformed graphs.
[31] Kidoko only provided immunization once a month, with a total of 25 DTP3 children and 73 doses administered. Pachara had 55 DTP3 children, 185 doses, and is considered to be a hard-to-reach location.
[32] Kiswa had 5,416 DTP3 immunized children and 23,570 doses administered. Rakai hospital had 8,602 DTP3 children and 32,241 doses.

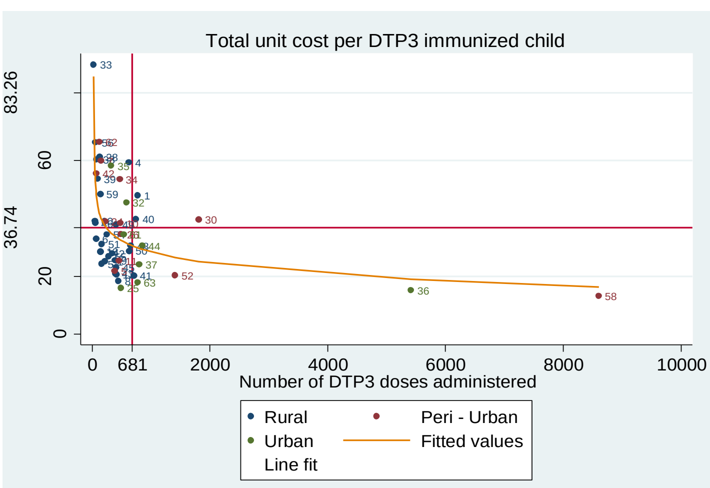
ii) Ln-transformed



The unit cost per DTP3 immunized child also suggested a decrease as the volume of children vaccinated increased. Once outliers were included, the non-linear untransformed plot gave the impression of a steeper curve among facilities with lower outputs, and flatter one among facilities above a threshold of around 1000 DPT3 per annum, but this may be exaggerated by the high volume and high unit cost outliers.

Figure 12 shows unit costs per DPT3 immunized child by location of facility. No association of unit costs with rural, urban or peri-urban sites is obvious. When the three high output outlier facilities are removed, some decline in unit costs with increasing outputs is still apparent, but there is wide variation around the predicted cost line. The lack of a clear association between unit costs and urban, peri-urban or rural location also persists.

Figure 12: Total unit cost per DPT3 child vs. number of children immunized with DPT3



Further variations and characteristics affecting underlying outputs and costs of facilities are explored in Sections 5 and 6. Annex 8 includes further scatter plots and regression analysis to identify factors associated with unit costs at facility level.

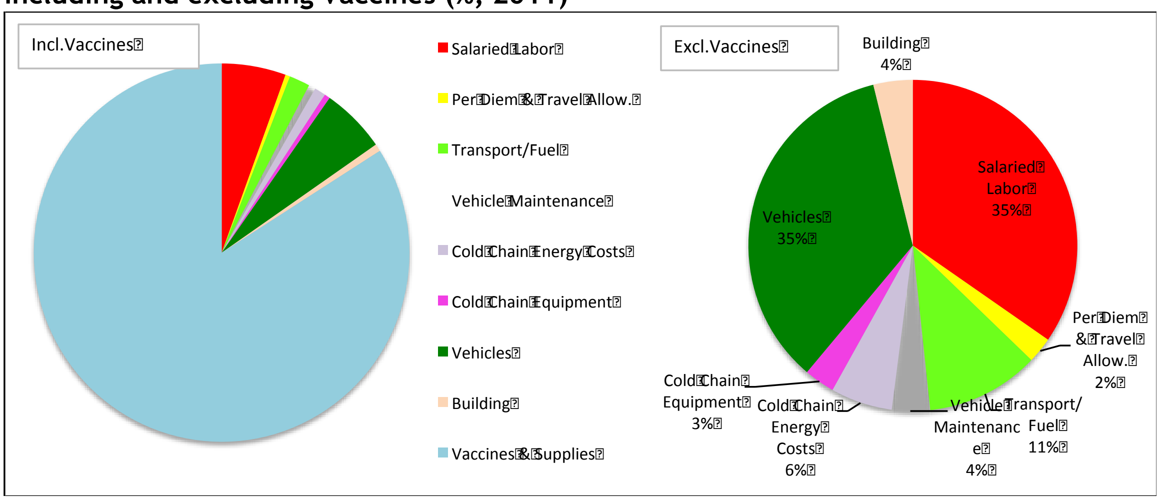
3.2.1 Results – costs at district level

The district level costs for administering the immunization program and supporting the facilities service delivery were obtained from the District Health Offices (DHOs) in 12 districts. These were weighted based on the inverse of their probability of being in the sample. The tables and figures below provide the total DHO economic costs for routine immunization, weighted, per line item (cost category), and by activity.

Table 3-15 and Figure 13 below indicate the DHO level costs by line item. The largest cost category was vaccines (84%), with the remaining line items taking very small portions: vehicles (5.6%), salaries (5.5%), and transport and fuel costs (1.8%).[33] Vehicle maintenance and cold chain costs contributed around 0.6% and 1% respectively. Recurrent items accounted for 93% of costs, while capital made up 6.7%, the former due to costs of the vaccines. The figure also shows the changed distribution by line item after removing the vaccine costs.

The total weighted economic costs at DHO level ranged from US$ 61,650 in Moroto, to US$ 600,508 in Kampala, which had district populations of 390 000 and 1.7 million respectively. Kampala may also have been responsible for the purchase of vaccines for facilities, especially hospitals, outside of their geographic area. After removing the vaccines, the DHO costs were lowest in Buikwe at US$ 13,783 and highest in Gulu (US$ 74,925), with a weighted average of US 29,923 across all facilities.

Figure 13: Proportion of District Health Office Weighted Economic Costs by line item, including and excluding Vaccines (%, 2011)



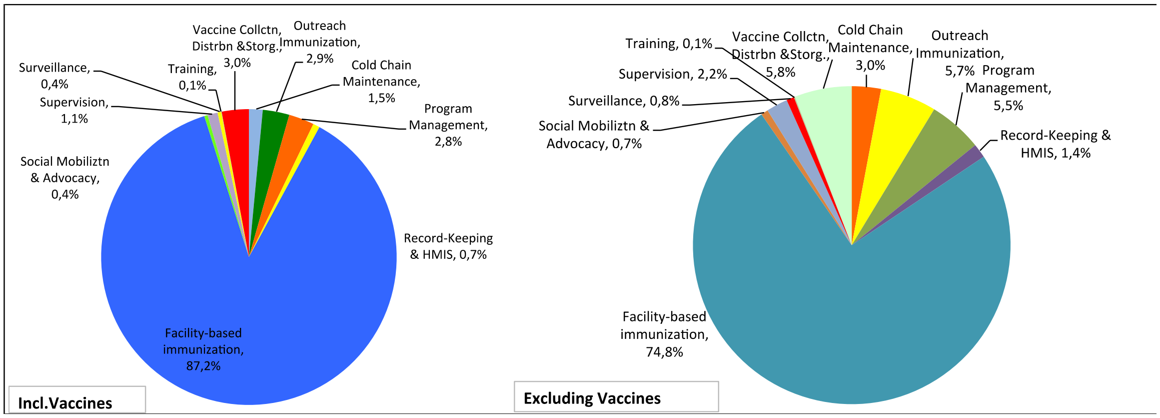
Considering the DHO costs by activity (Figure 14) including the vaccine costs, the support for immunization services accounted for 87%, followed by the vaccine collection and distribution (3%), outreach costs (2.9%), and general program management (2.8%). The remaining activities of supervision, surveillance, training and record keeping all contributed very small proportions.

[33] Transport & fuel costs were unavailable for some DHOs so estimates were used in weighting and aggregation.

Table 3-15: District Health Office Total and Weighted Average Economic Costs for Immunization per Line item (US$, 2011)

TOTAL DHO WEIGHTED COSTS BY LINE ITEM (US$)	Adjumani W.Cost	Buikwe W.Cost	Bushenyi W.Cost	Gulu W.Cost	Hoima W.Cost	Iganga W.Cost	Kampala W.Cost	Kanungu W.Cost	Lira W.Cost	Moroto W.Cost	Rakai W.Cost	Tororo W.Cost	W.Av District Econ. Cost	Av. % Distribution
Line Items														
Salaried Labor	10 927	7 997	9 589	22 698	10 828	13 157	10 521	6 171	5 537	5 777	7 250	13 910	10 364	5,5%
Per Diem & Travel Allow.	176	792	1 001	1 345	1 756	550	413	550	550	634	534	770	756	0,4%
Vaccines & Supplies	50 764	137 046	89 782	159 925	165 687	160 808	543 406	71 223	136 378	34 716	176 905	165 735	157 698	84,1%
Transport/Fuel	-	-	643	-	9 458	-	-	965	-	8 383	20 520	-	3 331	1,8%
Vehicle Maintenance	83	55	242	3 582	815	62	5 320	173	449	648	1 928	105	1 122	0,6%
Cold Chain Energy Costs	1 309	2 242	707	2 659	815	628	1 378	6 691	1 658	1 309	1 484	907	1 816	1,0%
Subtotal recurrent	*63 259*	*148 132*	*101 965*	*190 209*	*189 359*	*175 206*	*561 038*	*85 773*	*144 572*	*51 467*	*208 622*	*181 428*	*175 086*	*93,3%*
Cold Chain Equipment	548	976	1 081	1 160	937	767	1 695	819	1 044	588	450	745	901	0,5%
Vehicles	1 922	1 167	1 882	42 437	11 994	858	36 126	1 882	5 765	9 031	10 642	1 882	10 465	5,6%
Other Equipment	-	-	-	58	-	-	-	-	-	49	-	-	9	0,0%
Building	2 669	554	2 627	986	901	491	1 648	2 098	739	515	305	386	1 160	0,6%
Subtotal capital	*5 139*	*2 696*	*5 589*	*44 641*	*13 832*	*2 116*	*39 469*	*4 799*	*7 548*	*10 183*	*11 398*	*3 013*	*12 535*	*6,7%*
Weighted DHO Immunization Co	**68 398**	**150 828**	**107 554**	**234 850**	**203 191**	**177 322**	**600 508**	**90 572**	**152 120**	**61 650**	**220 019**	**184 442**	**187 621**	**100%**
DHO Weighted Cost (excl. vaccs)	17 634	13 783	17 772	74 925	37 504	16 513	57 101	19 349	15 742	26 934	43 114	18 706	29 923	

Figure 14: Proportion of District Health Office Weighted Economic Costs by activity, including and excluding Vaccines & syringes/supplies*



As explained earlier, the economic costing applied a 3% discount rate over the useful lifespan of the items. When calculating the districts' financial costs (applying a zero discount), the total DHO cost reduce by only 0.13%. Therefore these figures are not presented separately here.

3.2.2 Results - national level costs

National level expenditure data were obtained from UNEPI, MOH, and all the development partners who fund immunization activities in Uganda. They include the costs of managing the national level activities and overall program coordination, quality control and the other national level functions described in the introduction. Vaccine costs are also included at this level, as per the Common Approach.[9]

The breakdown of total economic and financial costs is shown below by line item (Table 3-16) and this is then compared to costs by activity (Figure 15). (Note these are the costs of *national level* EPI functions, not the total country immunization costs).

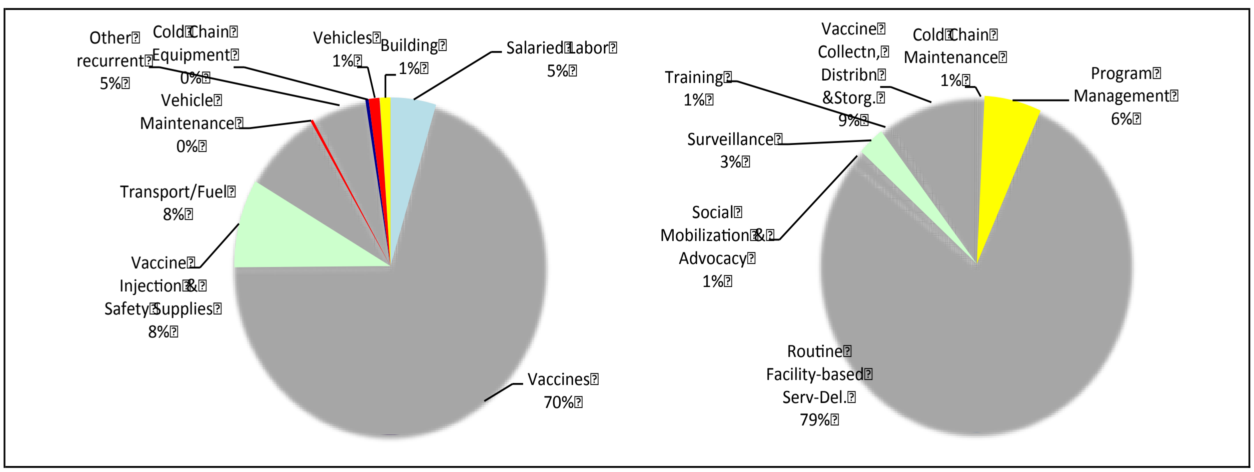
The bulk of national level costs were recurrent (96.8%), mostly going towards vaccine purchase (69.7%) and their distribution (8%). Salaries only formed 4.7% of the total. The economic and financial cost estimations for capital items differed by around 20%, but this did not result in substantial differences in total costs.[34] In the year of study, most new purchases of cold chain equipment went towards NUVI for the pending roll-out, and thus were not captured here under routine immunization.

[34] The economic costing used a discount rate of 3% when depreciating capital costs over the useful life years of specific capital items. The financial costs applied a 0% discount rate (straight-line depreciation).

Table 3-16: National Level Economic and Financial Costs of Routine Immunization by line item (including Vaccines, US$, 2011)

TOTAL NATIONAL SPENDING (US$) BY LINE ITEM	Economic Costs (US$)	Financial Costs (US$)	Economic Distribution %
Line Items			
Salaried Labor	715 432	715 432	4,7%
Volunteer Labor	-	-	0,0%
Per Diem & Travel Allowances	-	-	0,0%
Vaccines	10 604 626	10 604 626	69,7%
Vaccine Injection & Safety Supplies	1 283 851	1 283 851	8,4%
Other Supplies	-	-	0,0%
Transport/Fuel	1 220 164	1 220 164	8,0%
Vehicle Maintenance	41 699	41 699	0,3%
Cold Chain Energy Costs	69 486	69 486	0,5%
Printing	-	-	0,0%
Building overhead, Utilities, Comms.	-	-	0,0%
Other recurrent	792 305	792 305	5,2%
Subtotal recurrent	*14 727 562*	*14 727 562*	*96,8%*
Cold Chain Equipment	59 735	52 415	0,4%
Vehicles	182 326	167 000	1,2%
Lab equipment	-	-	0,0%
Other Equipment	6 964	6 457	0,0%
Other capital	-	-	0,0%
Building	240 439	163 149	1,6%
Subtotal capital	*489 463*	*389 021*	*3,2%*
Total National-Level Immunization Cost	**15 217 025**	**15 116 583**	**100%**

Figure 15: Proportion of National Level Routine Immunization Costs by line item and activity (%, 2011)



3.2.3 Total costs of the Ugandan Routine Immunization

A major challenge faced in the Uganda costing was the absence at central level of data on immunization service outputs (numbers of DTP3 children or doses administered) for all facilities and districts. Inter alia, this made it impossible to apply weighted unit costs obtained at the facility and district levels to all the DTP3 immunized children, or doses administered, in the country.

The weighted average total cost by facility type, including the vaccine costs, was therefore applied to all the facilities of the same type in the country. The weighted average total cost of the sampled districts, excluding vaccines, was then applied to all the districts in the country. These aggregated facility and district level estimates were then added to the national level spending (after excluding the national level vaccine costs).

This process can be represented as Total national cost T= $T_{CENTRAL} + T_{DISTRICT} + T_{HF}$

a. *Findings – Total Ugandan Immunization Program Economic Costs*

The total economic costs of immunization in Uganda were estimated to be **US$ 40 million** in 2011. Removing the vaccine costs, the total delivery cost of immunization in Uganda was almost US$ 27 million.

The largest share (80%) was incurred at facility level (where the vaccine costs were captured), followed by national level costs (11.5%, excluding the vaccine costs). The district level only contributed 8.4% of the total routine immunization cost. Of the facility level costs, the HC II had 30% share of total costs, HC III had 37%, HC IV only 12% and the general hospitals 21%.

Table 3-17: Total Estimated Routine Immunization Economic Costs in Uganda (US$, 2011)

Total Aggregated Immunization Costs	Tot.Fac.Cost (incl.Vaccines)	No of public & NGO facilities	Total Govt & NGO Facility Cost	
Facility	**W.Av/fac (US$)**	**in Uganda**	**(US$)**	**% Share**
HC II	4 309	2215	9 544 937	*30%*
HC III	9 957	1180	11 749 226	*37%*
HC IV	21 160	185	3 914 616	*12%*
General Hospital	53 793	127	6 831 707	*21%*
Total Facility level (incl.vaccines)			**32 040 486**	**80,1%**
District level costs (excl. vaccines)	29 923	112	3 351 389	8,4%
National level (excl.vaccines)			4 612 399	11,5%
Total Immunization costs in Uganda (US$)			**40 004 275**	100,0%
Total Immunization Delivery costs in Uganda (US$)			**26 950 257**	

Arriving at national unit costs posed some challenges due to the lack of national level data on total numbers of DTP3 vaccinated children and numbers of doses. Even the population figures were somewhat outdated. Therefore two approaches were used, for comparison. The first used for the denominator the cMYP's estimated number of DTP3 immunized children and the total doses in 2011, and in the second, the numbers were estimated applying the WHO coverage rates for each vaccine to the estimated surviving infant population (4.5% of the total population in 2011), including wastage rates for the dose estimation. The results are presented in the table below.

Table 3-18: Estimates of the National Immunization Unit Costs – two approaches

	Method 1.	Source 1.	Method 2.	Source 2.
Total child doses administered	11 964 835	cMYP (2011) estimate at 82% coverage rate (excl. wastage)	10 182 590	Estimated applying WHO coverage rates for each vaccine
Infant population	1 476 164	cMYP (2011) estimate of surviving <1 yr olds	1 486 509	Estimated assuming 4.5% of total population
Total DTP3 Vaccinated Children	1 210 455	cMYP (2011) DTP3 estimate at 82% coverage rate	1 189 208	Estimated applying WHO coverage rates for DTP3 vaccines
Total population	32 939 800	cMYP (2011) pop.estimates	33 170 650	MOH & WEUNIC (2013)
Unit Costs (US$)				**Variance**
Cost per Dose	3,34		3,93	18%
Cost per child	27,10		26,91	-1%
Cost per DTP3 Vac child	33,05		33,64	2%
Cost per capita	1,21		1,21	-1%
Delivery Unit Costs (US$)				
Delivery cost per Dose	2,25		2,65	18%
Delivery cost per child	18,26		18,13	-1%
Delivery cost per DTP3 Vac child	22,26		22,66	2%
Delivery cost per capita	0,82		0,81	-1%

Applying the second approach, the average unit cost per DTP3 child came to US$ 33.64 which included the facility, district and national level costs aggregated, while the unit cost per dose was US$ 3.93. After removing the vaccine costs, delivery costs were US$ 22.66 per DTP3 child and US$ 2.65 per dose.

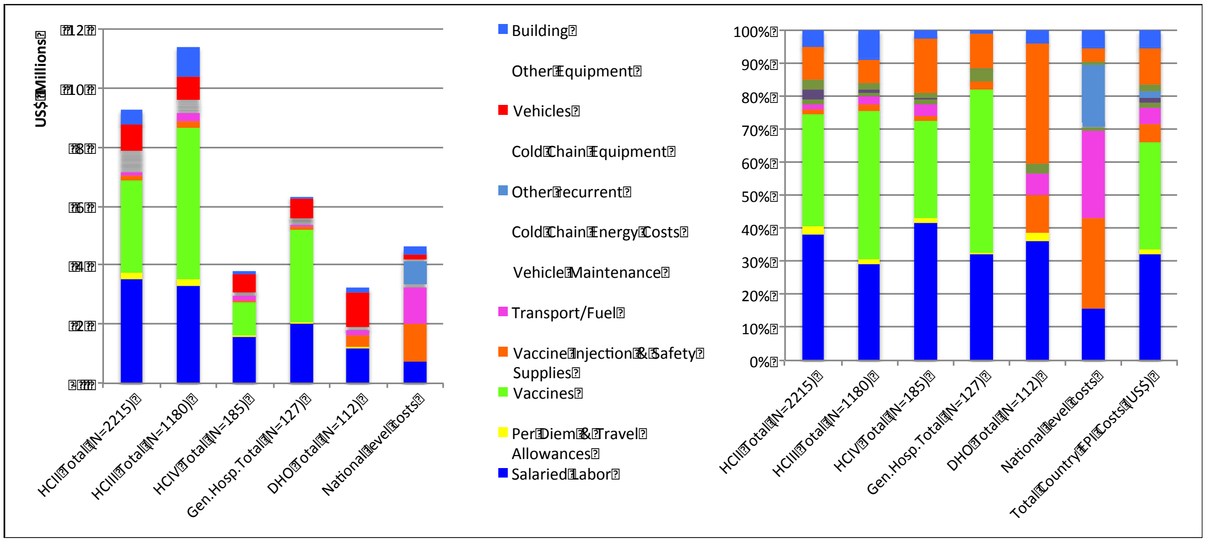
The table and figure below provide the breakdown of the total Ugandan routine immunization program costs by line item.

Table 3-19: Total Economic Costs for Routine Immunization in Uganda (US$, 2011)

EPI Estimated Economic Costs (US$, 2011)	HCII Total	HCIII Total	HCIV Total	Gen.Hosp. Total	DHO Total	National level costs	Total Country EPI Costs (US$)	% Share by Line-Item
N	2215	1180	185	127	112			
Line Items								
Salaried Labor	3 551 982	3 306 360	1 581 195	2 021 586	1 160 718	715 432	12 337 272	31%
Volunteer Labor	-	-	-	-	-	-	-	0%
Per Diem & Travel Allowances	199 188	213 580	59 940	54 483	84 669	-	611 860	2%
Vaccines	3 135 278	5 118 840	1 119 805	3 112 770	-	-	12 486 693	31%
Vaccine Injection & Safety Supplies	147 724	228 920	51 615	139 446	373 058	1 283 851	2 224 614	6%
Other Supplies	280 260	149 860	23 495	40 132	125 655	-	619 402	2%
Transport/Fuel	142 599	267 860	140 415	2 667	203 338	1 220 164	1 977 044	5%
Vehicle Maintenance	147 530	88 500	62 160	225 806	-	41 699	565 695	1%
Cold Chain Energy Costs	258 971	341 020	104 710	485 775	-	69 486	1 259 961	3%
Other recurrent	-	-	-	-	-	792 305	792 305	2%
Subtotal recurrent	7 863 531	9 714 940	3 143 335	6 082 665	1 947 438	4 122 936	32 874 845	82%
Cold Chain Equipment	293 881	213 580	44 030	32 131	100 893	59 735	744 250	2%
Vehicles	913 958	800 040	636 030	652 145	1 172 128	182 326	4 356 627	11%
Other Equipment	2 647	30 680	925	762	997	6 964	42 975	0%
Building	470 920	990 020	90 280	64 135	129 933	240 439	1 985 727	5%
Subtotal capital	1 681 406	2 034 320	771 265	749 173	1 403 951	489 463	7 129 578	18%
Total EPI Estimated Costs	9 544 937	11 749 260	3 914 600	6 831 838	3 351 389	4 612 399	40 004 424	100%
% Share by Health Facility	24%	29%	10%	17%				
% Share by Level	80%				8%	12%		

Recurrent costs accounted for 82% of the total economic costs in 2011, of which the bulk was for vaccines (31%), salaries were 31%, and capital items formed 18%, of which the bulk was due to vehicles (11%). Injections and other supplies contributed 6%, transport related costs 6%, and building costs a further 5%.

Figure 16: Total Estimated Economic Costs for Uganda Routine Immunization (US$, %, 2011)



The proportional breakdown of the estimated unit cost of $ 33.64 per DTP3 immunized child and the US$ 3.93 per dose provides a useful benchmark for future cost estimates, as shown in the table below.

Table 3-20: Line item Contributions to Economic Unit Cost per DTP3 Immunized Child and per Dose (%, US$, 2011)

EPI Estimated Economic Costs (US$, 2011)	Economic Cost per DTP3 child (US$)	Economic Cost per Dose (US$)
Line Items		
Salaried Labor	10.37	1.21
Volunteer Labor	0.00	0.00
Per Diem & Travel Allowances	0.51	0.06
Vaccines	10.50	1.23
Vaccine Injection & Safety Supplies	1.87	0.22
Other Supplies	0.52	0.06
Transport/Fuel	1.66	0.19
Vehicle Maintenance	0.48	0.06
Cold Chain Energy Costs	1.06	0.12
Printing	0.00	0.00
Building overhead, Utilities, Comms.	0.00	0.00
Other recurrent	0.67	0.08
Subtotal recurrent	27.64	3.23
Cold Chain Equipment	0.63	0.07
Vehicles	3.66	0.43
Lab equipment	0.00	0.00
Other Equipment	0.04	0.00
Other capital	0.00	0.00
Building	1.67	0.20
Subtotal capital	6.00	0.70
Total EPI Estimated Costs	33.64	3.93

3.3 Discussion

The cost estimates for immunization in Uganda represent an important milestone in obtaining a more comprehensive and accurate reflection of actual costs at facility, district and national levels, based on primary data collection at these levels. The data collection process carefully identified, measured and quantified all the ingredients and activities undertaken in the delivery of routine immunization, estimated their economic and financial costs, weighted and aggregated these to obtain the total costs for immunization in Uganda. The sampling approach ensured that every region was represented, that every purposively selected district was representative of key service delivery contexts, and that each district had at least one randomly selected health facility at each level.

However, certain limitations of the study mentioned above in section 3.1.7 should be borne in mind. In particular, lack of available data at national level does not allow for assessment of possible sample biases and the limited sample size for each type of facility, particularly HCIV and hospitals, may limit generalizability. The probability-based weighting applied to each facility and district may also not be ideal, and the weighting could not be validated using utilisation (output) data. The overall national level unit costs may also be an over- or under-estimation if the cMYP estimates of number of DTP3 children and number of doses required were not accurate.

The costing results are compared to the cMYP estimates for 2011 below, and to the MOH total budget for the year.

3.3.1 Comparison with updated cMYP estimates for 2011

When comparing the above estimated total economic costs of immunization in Uganda with the cMYP estimates of resources required for 2011, we find a variance of US$ 11.9 million, with some substantial variances in particular line item and activity costs (Table 3-21). Although comparisons are made more difficult by different classification of costs in a mix of line items and activities in the cMYP,[35] the difference can largely be explained when comparing the line items.

The largest variance between this costing study's estimates and those of the cMYP was US$ 5.67 million for salaries, due to extra effort made by this study to quantify personnel time and costs for immunization through the primary data collection at facility and district levels. The second largest variance was US$ 2.16 million more estimated for injections and supplies by this costing study, while our vaccine estimates were US$ 2.2 million less than the cMYP's. This may indicate that there was lower actual utilization of vaccines than had been anticipated by the cMYP, as it is possible that the country did not achieve its immunization targets for 2011.

The cMYP also did not include vehicles and other district level expenditure in 2011 (in subsequent years these were estimated). This would help to explain the US$ 4.7 million more that were estimated by this study for vehicles and other capital including

[35] The cMYP included some activities (not line items) such as training, mobilization, program management – all of which are activities made up of various production factors, including salaries.

building costs. Other facility and district level costs which were higher than in the cMYP included over US$ 2 million for the summation of transportation, maintenance, overheads and other recurrent costs, which were only captured for national level in the cMYP. The cMYP estimated higher cold chain equipment costs which may have included investments anticipated for the NUVI roll-out.

Table 3-21: Comparison of Costing Study Estimates with cMYP Estimates for 2011 (US$)

Routine Immunization Line Items	cMYP est. (2011)	Costing Study est. (2011)	Variance Cost.Estimates - cMYP (US$)	% Variance Cost. Estimates vs cMYP
Routine Recurrent Costs	**US$**			
Vaccines (routine vaccines only)	14 700 754	12 486 693	- 2 214 061	-15%
Injection & other supplies	683 248	2 844 016	2 160 768	316%
Personnel	7 274 916	12 949 132	5 674 216	78%
Transportation	826 362	1 977 044	1 150 682	139%
Maintenance and overhead	763 284	1 825 656	1 062 372	139%
Short-term training	200 000	In the study these are captured under personnel & other recurrent	- 200 000	-100%
IEC/social mobilization	155 690		- 155 690	-100%
Disease surveillance	762 985		- 762 985	-100%
Programme management	56 027		- 56 027	-100%
Other routine recurrent costs	211 269	792 305	581 036	275%
Subtotal	*25 634 535*	*32 874 845*	*7 240 310*	***28%***
Routine Capital Costs				
Vehicles	-	4 356 627	4 356 627	100%
Cold chain equipment	2 283 654	744 250	- 1 539 404	-67%
Other capital equipment (incl Bldg)	150 600	2 028 702	1 878 102	1247%
Subtotal	*2 434 254*	*7 129 578*	*4 695 324*	193%
Total Routine Immunization	**28 068 789**	**40 004 424**	**11 935 634**	**43%**

Note:. Slight variances between cost estimates shown here and those in Tables above arise because cost categories had to be adjusted to match the cMYP categories (see footnote 35).

3.3.2 Comparison with the national budget for Immunization

The report to the Ugandan Parliament on the budget and performance of the Ministry of Health (2012) reported that Uganda's immunization coverage had fallen, that staff were inadequate and demotivated, with only 58% of approved posts being filled (with the HC II being worst affected), and with an anticipated budget shortfall for salaries in 2012/13. The 2011/12 health budget equated to only US$ 10 per capita, as opposed to the recommended US$ 48 per person, of which a large portion was funded by development partners.[36]

> *"The committee established that under the strategic objective of disease prevention, immunization was grossly underfunded with an allocation of Ushs 1 bn only [US$ 270,000]. There was a funding gap of Ushs 7 bn [US$ 2 million] for counterpart funding of the EPI-GAVI grant. Uganda now ranks 10 worst countries in immunisation rates. The Committee recommended that Ushs 7bn[US$ 7 million] required as counterpart funding of expanded program for immunization – GAVI program be availed".* Ugandan Parliament (2012:8).

---

[36] Parliament of Uganda. 2012. Report of the Parliamentary Committee on Health on the Ministerial Policy Statement for the Health Sector for the Financial Year 2012/2013

In 2011/12, the MOH budgeted US$ 220 million (UGX 800 million) on health (8.3% of the total government budget), which was a reduction from 9.6% in 2009/10.[37] Of this amount, US$ 164 million was sourced from GOU's own revenue, the rest (US$ 55 million) from donors, development and taxes. The estimated total immunization cost from above (US$ 40 million) therefore accounts for 18% of total resources for health, 21% of GOU expenditure on health from own revenue, and 0.18% of GDP.

3.3.3 Comparison of unit costs with previous estimates

Comparisons of unit costs of immunisation should be made with caution due to differences in methodology, time period and country contexts. However, the estimated unit cost of US$ 34 per DPT3 vaccinated child is higher than the $23.26 estimate derived from the cMYP of per DTP3 child in 2011. The main contributor to the difference is human resource costs, but probably also more complete enumeration of other costs, especially operational costs at facility and district levels.

Vaccine costs contribute around 39% of routine immunisation costs in this study. This suggests that, in so far as some benefits may have been gained from reduced conventional vaccine prices over recent decades, any further savings available from this source are likely to have limited impact on overall immunization program costs. A further constraint on reducing average unit costs may be if most coverage is extended through HCII, which tend to have relatively high costs. Although accurate comparison of the unit cost of outreach and facility based immunization was not feasible with available data, there were indications that outreach services may have higher unit costs on average, consistent with anecdotal reports and findings of previous studies internationally.[2] The need to rely on outreach to adequately service many communities may also impose constraints on the ability to reduce unit costs.

The Uganda unit cost suggests that its unit costs are comparable to, and somewhat higher than previous international benchmark estimates of an average cost per child of $17 derived from an evaluation of 50 FSPs,[1] $20 per fully immunized child,[2] and $28 per fully immunized child derived from an analysis of 56 cMYPs between 2004 and 2012,[5] as well as various other studies in particular countries.[38]

Particularly for a low income country like Uganda, true unit costs may not have fallen as much as might as was hoped due to vaccine cost reductions. The immunization costs per DPT3 child are also relatively high when compared to estimates of per capita health spending in Uganda of US$ 10.29 in 2011/12.[18]

There are indications that human resources unit costs in Uganda are small relative to higher income countries (see other Country reports from the Multi-Country Study).

---

[37] Ugandan Annual Health Sector Performance Report (2011/12). MoH.

[38] See e.g. Kaddar M Tanzi VL Dougherty L. 2000. *Case Study on the Costs and Financing of Immunization Services in Côte d'Ivoire*. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc. ; Kaddar M Mookherji S DeRoeck D Antona D. 1999. *Case Study on the Costs and Financing of Immunization Services in Morocco*. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.; Khan M. Khan S. Walker D. Fox-Rushby J. Cutts F. Akramuzzaman S. 2004. Cost of Delivering Child Immunization Services in Urban Bangladesh: A Study Based on Facility-level Surveys. Journal of Health Population Nutrition: 22(4): 404-412.; Levin A Howlader S Ram S Siddiqui SM Razul I Routh S. 1999. *Case Study on the Costs and Financing of Immunization Services in Bangladesh*. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

3.3.4 Sensitivity analyses

Sensitivity analyses assessed the effect of plausible changes in key cost drivers for which data or assumptions were subject to significant uncertainty, or where new policy, plans or management might substantially affect costs:

- Wastage rates for RI were reduced from 50% to 25% for OPV and measles. Other default WHO rates for DPT- HepB-HIB (5%) and BCG (50%) were retained.
- Outreach staff costs were reduced by 15% across the facility types, assuming that this might be achieved by better scheduling, routes or staff mixes.
- Vehicle costs, the largest capital expense, were reduced by 5%.

The impact of these changes on the total immunization cost was estimated. In addition, the potential effect of different immunization coverage assumptions on unit cost per FIC was tested (assuming UNEPI was actually reaching 70% of targeted infants, not 82%). Other sensitivities of national unit costs to assumptions are discussed above.

Table 3-22: Sensitivity of cost estimates to data uncertainty or changed assumptions

Total National Routine Immunization cost	Unit of Measure	Baseline	Adjusted	% change from baseline
Scenario 1: Routine vaccine wastage is reduced	Total National Routine Immunization cost (US$)	40 004 275	39 804 253	-0,50%
Scenario 2: Outreach personnel costs reduce by 15%		40 004 275	39 681 945	-0,81%
Scenario 3: Vehicle costs reduce by 5%		40 004 275	39 786 466	-0.54%
Scenario 4: Actual coverage rates are lower than 82% estimated, at 70%	Unit cost per DTP3 child	33,64	38,71	15,09%

Table 3-22 shows results of the sensitivity analyses. Managing vaccine, staff and vehicle inputs more efficiently is shown to have a substantial effect, although each individual aspect has limited influence on overall costs. The importance of coverage and reliable monitoring and reporting, for both public health impact and operational management efficiency, is illustrated by the substantial sensitivity to coverage rates.

3.4 Summary and Conclusions

The sections above presented the costs for routine immunization at the level of facilities, districts and the national coordination and program management function. At facility level both total costs and unit costs were explored and compared for different facility types. Costs for line items and specific immunization activities were assessed. The weighted costs were aggregated to estimate the total cost of RI for Uganda. Finally, costs were compared to the cost estimates in the cMYP and the national health budget.

Several important conclusions can be drawn from the results, which are likely to be robust despite limitations of data and methodology that have been noted above.

Planning and financing

- The study provides planners, managers and funders with much more robust and comprehensive information on costs for estimating resource requirements and for resource allocation decisions for routine immunization at all delivery levels.

- Previous cMYP cost estimates have had limitations in their comprehensiveness. Better quality information on costs and resource flows from this study should enhance confidence in future cMYP and other planning and funding estimates.
- Overall the costs of the Ugandan routine immunization programme are higher than previous estimates, in large part due to more complete assessment of staff costs, and facility and district level operational costs.
- Immunization unit costs are higher than recent ones available for Uganda for similar reasons. The estimated unit costs seem comparable to, or somewhat higher than, the unit costs reported by studies in other countries.
- Unit costs are highest in HCII due mainly to the staffing costs of high time per dose. Some efficiencies may be possible here. However, overall system costs are likely to mainly be affected by HCII (60% of facilities), and HCIII which have the lowest unit costs and over 31% of facilities and immunizations.
- Traditional planning approaches based on e.g. average costs by facility type or average staff cost, can potentially be improved on using these results, as there is substantial variation around average unit costs, particularly dependent on service volumes. This is explored further in later sections of the report.

Contributors to costs

- Staff costs and vaccines were the largest cost items, and also contributed the bulk of facility and outreach service costs, the immunization activities with the highest costs. Despite some uncertainty about accuracy of staff and vaccine wastage this conclusion is likely to be robust.
- Outreach accounted for around 40% of immunizations and can have substantial extra costs related to staff time and transport, particularly in more remote populations, for which it is a particularly important delivery model.
- Although capital costs made up only 18% of economic costs, costs of vehicles were substantial. Fiscal costs of purchasing capital items may also pose budget challenges despite relatively low economic costs.
- The cold chain is a critical operational necessity, but contributed a relatively small amount to routine costs.
- Differences in economic vs. financial costs as defined in the Common Approach, or hidden resource contributions to costs, were small. They are thus probably not major issues for planners. However, fiscal costs may be important to consider in budgeting, rather than relying only on economic cost estimates.

Data improvement

- such as outreach, as well as staff time use and vaccine wastage rates, would contribute to more accurate understanding of the costs as well as resource management for routine immunization in Uganda.
- Improved national level availability of facility and district immunization output and utilization data, and quality assurance of routine data, is important to allow for enhanced estimation of unit costs and national total programme costs, as well as for programme management. Such data would also allow for better assessment of the representativeness of sampled facilities in future.
- Certain changes to the financial management system, such as revision of ledger account coding, could improve cost information for immunization as well as general PHC service planners and managers.
- Improved information on vehicle use through e.g. logbooks, could enhance cost information as well as management of this strategic and costly resource.

4 Cost Analysis of New Vaccine Introduction

Uganda has committed to roll out Pneumococcal Conjugate vaccine (PCV), and at the time of this study had commenced with preparatory activities for PCV-10 introduction in 2013.[39] UNEPI developed an Introduction Plan and costed the roll-out. Although they had initially applied for GAVI support in 2011, there were delays and thus they are commencing in 2013/14. This study therefore sought to undertake a largely prospective estimation of the incremental costs for PCV implementation in 2013, drawing on data collected along with the routine immunization costing study, in order to add information to the estimates in the Introduction Plan.

4.1 Methods

4.1.1 Perspective and key assumptions

The WHO Guidelines for Estimating Costs of Introducing New Vaccines into the National Immunization System were the basis for these NUVI cost estimates (WHO, 2002).[40] The perspective taken was that of the public service provider, acknowledging that NGO facilities also deliver services on behalf of the government.

Only the incremental costs incurred as a result of introduction of the new vaccine, have been included. The definition of incremental was aligned with the definition referred to and provided in the Common Approach and the WHO Guidelines (2002, and subsequent clarifications and guidance issued during study workshops. The incremental costing was based on the following main assumptions and observations.

- The costing focuses on the *additional* costs related to introducing a new vaccine;
- By definition the incremental costing does not include costs of pre-existing resources that have spare capacity that is used in the new vaccine program, and are thus not additional costs associate with it. Incremental costing will therefore tend to understate the full economic cost and total resources used in the provision of the new vaccine;
- Overhead costs have been excluded as national stakeholders indicated that no additional overhead capacity would be required;
- In line with the Common Approach, this study estimated the economic costs of additional staff time per PCV dose, and the additional cold chain volume of the PCV vaccines (see also Table 4-2);
- Any additional costs incurred, but which are associated with other new vaccines or with enhancing capacity for existing services, are excluded. This applied even if introducing new vaccines may have triggered the expenditure.

[39] Uganda introduced PCV10 (Synflorix). The 2-dose vial liquid formulation does not need reconstitution.

[40] World Health Organization. 2002. Guidelines for estimating costs of introducing new vaccines into the national immunization system. Geneva, Switzerland.

The PCV Introduction Plan assumed that 90% coverage would be achieved in the first year.[41] This may be a challenging target, but UNEPI indicated that the 90% assumption been used in their GAVI application and should be applied for this study. However, for comparison, the study also estimated costs for two other coverage scenarios: 60% (for comparability with the Zambian PCV costing), and 45% (approximately the level achieved by many other countries' in the first year of NUVI).[42]

This study projected the costs required for roll-out in 2013, using 2013 prices (see Table 4-1). For the costing the introduction period was assumed to begin six months before the roll-out (mid-2012) and end when the target immunization coverage in the year of introduction has been achieved (estimated to be the end 2013). Some preparatory capital investments were made in 2011, prior to this period. However, as they were outside the study period, they were omitted. Only the cold chain space required for the PCV was estimated by applying the WHO Vaccine Volume calculator.[43]

Table 4-1: Unit Prices and key assumptions for the NUVI PCV vaccine (US$, 2013)

Vaccine Unit Price and Assumptions		
Vaccine	Cost per Vial (US$)	Presentation
PCV 10	7,00	Synflorix: 2 dose vial reconstituted with no preservatives. Discarded after 6 hours once opened.
Buffer stock at first year of introduction		25%
PCV10 price per dose (US$, 2013)		3,5
Wastage on injection equipment		5%
Wastage factor		1,1
Average unit price of a safety box (incl.5% for procurement)		0,74
Capacity of safety boxes		100

* Refer to Appendix 6 for details of unit costs of all ingredients for the delivery of NUVI.

The WHO (2002) suggested incremental costs to be evaluated for a new monovalent vaccine (PCV) introduction were used to guide the costing. These costs and related methodological issues are listed in Table 4-2.

Table 4-2: Incremental Costs and methodology included in the NUVI PCV Cost Estimates

Inputs	Methodology to Estimate
Vaccines, syringes, diluent, additional safety boxes	Estimations were informed by WHO Guidelines (2002), the Uganda cMYP, and key informant interviews with the WHO and UNICEF country offices. PCV-10 (Synflorix) is being used in Uganda. Each 2 dose vial is already reconstituted with no preservatives and is discarded after 6 hours once opened. Administration is IM on outer aspect of the right thigh. The estimated coverage for PCV was set at 90%, as per the Introduction Plan and GAVI application. Sensitivity to achieving 60% and 45% coverage was tested. The wastage target was 1%, and the wastage factor 1.1. The incremental buffer stock was set at 25% (although facilities reported a 6 month buffer stock). The current price of PCV-10 was applied. A percentage for freight costs was added to each vaccine unit cost.

[41] The cMYP applied an 86% target coverage rate

[42] Brenzel L, 2013 pers comm.

[43] The capital investments are however reported in the financial mapping section.

	The cost of safety boxes was based on the annual number of additional syringes (ADS) resulting from the introduction of the new vaccine, relative to the storage capacity of the boxes purchased. Cost = price per vial x number of vials (equal to the number of vaccines required).
Vaccine storage – cold chain requirements	Information from key informant interviews and review of relevant documents, indicated that there was sufficient cold chain capacity to accommodate introduction of PCV (see also the EVMA 2011 report). However, an additional 35% capacity requirement for PCV was estimated using the WHO Vaccine Volume Calculator.
Distribution system costs for transport	Key informant interviews indicated that PCV will be transported to health facilities using existing systems and infrastructure. No new vehicle purchases were planned, nor additional trips anticipated. Thus no capital investment or incremental recurrent transport costs were included in estimates.
Waste management costs	Key informant interviews indicated no need for extra waste management supplies/systems to introduce PCV. However, national level requirements at were obtained from the Introduction Plan. At facility level, pits or incinerators were already available.
Additional personnel time	Respondents at facility, district and national level indicated that no additional staff would be needed to roll-out PCV. However, many PHC service staff interviewed at the sampled facilities in the costing study indicated that staff are over-worked and work for long-hours. This study assumes that staff are potentially fully utilized on actual or potential PHC tasks and have no spare capacity. There is thus a real opportunity cost associated with allocating time to administering new vaccines. Therefore the cost of administering a dose of new vaccine is based on a proportion of the weighted average cost per dose calculated during the facility based costing, inflated to 2013 prices. The UNEPI manager suggested that the extra workload per NUVI dose was equivalent of 10% of the staff time per routine immunization dose. The Common Approach suggested an additional 15mins per dose, but in consultation with EPIC principals 33% of the weighted average time required to administer a dose of DTP1 vaccine was applied. This was obtained from the primary costing data (see Section 3), and was used as a default assumption, leading to an estimated average staff cost of US$ 1.09 (2013 prices) per PCV dose, across the facility types. The sensitivity analysis also applied the 10% additional time as was requested by the UNEPI Manager. The total cost was calculated by multiplying this by the target number of doses administered (90%, 60% and 45% coverage) and then split between the activities as reported by sampled facilities. As Uganda does not use volunteers to support immunization activities (VHWs receive stipends), the costs of volunteer time did not have to be estimated.
Disease surveillance related to new vaccine	The incremental cost of surveillance associated with new vaccine introduction were estimated at national level, based on key informant interviews. They include estimates for printing guidelines and recording materials. No need for additional staff time was anticipated for surveillance, so staff costs were not estimated. An external Post Introduction Evaluation was included in the cost.
Initial training	UNEPI planned national, regional, district and sub-district trainings. This initial set-up cost it was treated as a capital cost, discounted at 3% and annualized over useful life of 2 years, after which refresher training (recurrent costs) would take place. Training costs include costs of: training staff; venue rental; per dia, accommodation and travel for participants; and materials development and reproduction. Estimates were based on UNEPI interviews, and the training plan in the PCV Introduction Plan.
Social Mobilisation	The analysis included costs of advocacy, awareness raising and social mobilization associated with introducing PCV, at district, sub-national and national levels. Extensive interviews and the Introduction Plan, were used to establish what activities would be undertaken before and during introduction. The costs include media and other events, and costs of printing, distributing and communicating messages.
Other printing & operating costs	Printing costs were included under their respective activity – social mobilisation, monitoring or IEC. No other costs were identified.

Source: Adapted from WHO (2002). p8.

Data was collected in local currency and converted to US dollars based on the annual average exchange rate. Further details of various parameters and assumptions used to cost ingredients and activities are provided in Appendix 5.

Economic, financial and fiscal costs
In order to improve the usefulness of the cost estimates for new vaccine introduction, the study considered economic costs, financial costs and fiscal costs. The difference between economic cost and financial cost was limited to the difference in calculating the annualized cost of capital equipment (discounted at 3% vs. non-discounted straight line depreciation, respectively).

Fiscal costs reflected the full, additional expenses which will have to be budgeted and paid in the introductory period to introduce the new vaccine. Fiscal costs exclude any non-cash costs or costs which are already covered through the routine program. For example, there is an economic cost when existing personnel are diverted to NUVI. But, if no additional amounts would actually be spent on salaried labour as no new staff were employed, then the fiscal costing reflected no cost. Where capital assets are procured the full cost of the asset was included, not just the annualized portion.

4.1.2 Data collection instruments and process

The primary sources of information on the types of planned activities for the PCV were key informant interviews with the UNEPI manager and staff, the Introduction Plan, DHOs who were asked about capacity to implement new vaccines, and Development Partners who provide financial support for the new vaccine introduction. In addition, the Ugandan GAVI New Vaccine Application and cMYP provided valuable information.

At the facility level, data sources included interviews with key staff about additional staff time required, and other operational and capacity requirements such as storage and transport. Responses were captured in the facility questionnaire used for the routine costing, and were entered into the facility database costing tool.

Data Quality and verification process
Data were checked and cleaned by the Uganda data collection team, their completeness and rationale were scrutinized, and any errors were addressed. The findings were compared against the Introduction Plan's costs, and causes of any variances were explained or corrected. Preliminary estimates were discussed with key stakeholders and any gaps, inconsistencies or inaccuracies were addressed.

Data entry and analysis
Data were captured into a Excel data sheet, and calculations and analysis were performed manually in Excel.

4.1.3 Limitations of the approach

As Uganda had not begun the roll-out of PCV, the data collected was prospective, based on key informants' perspectives and estimates. Actual expenditure data was only available for a few items. At facility level most staff had not been involved in NUVI planning, so few had well-informed estimates of NUVI resource needs.

4.2 Results

4.2.1 Total incremental NUVI costs

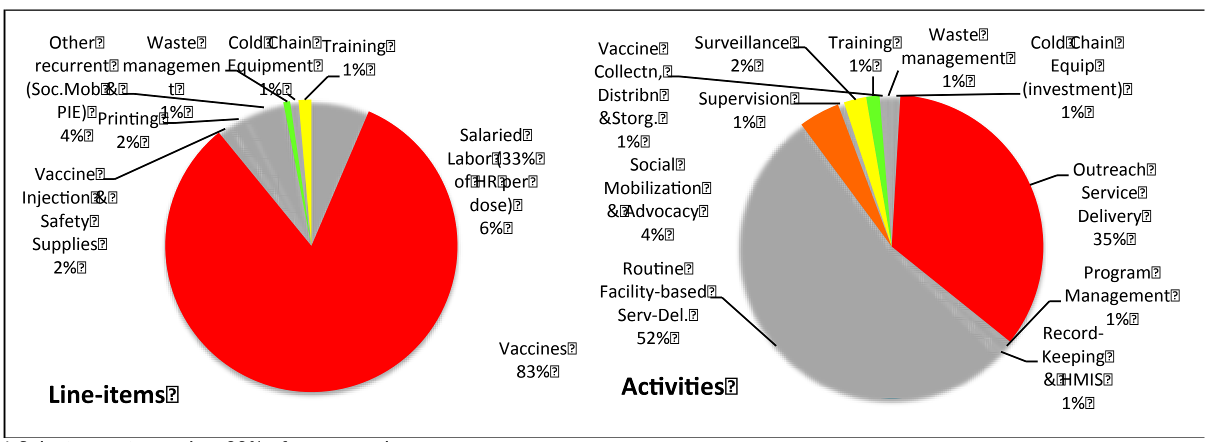
The estimated incremental NUVI costs are set out in Table 4-3 and Table 4-4 below, by line item and activity, for the 90% and 45% coverage scenarios (see 60% scenarios in Annex 8). The assumed outputs for these scenarios are as follows:

Anticipated Outputs	90% Coverage Achieved		
Total number of doses	5 718 253		
Total number of target children	1 448 624	(90%)	
Total population	35 081 678	(cMYP estimate 2013)	
Anticipated Outputs	45% Coverage Achieved		
Total number of doses	2 859 127		
Total number of target children	724 312	(45%)	
Total population	35 081 678	(cMYP estimate 2013)	

The estimated total economic costs of PCV introduction amount to $ 24.2 million with 90% coverage and $ 13.2 million with 45% coverage (assuming additional staff time and cost per additional dose). Although coverage has effectively reduced by 50%, total costs only fall by 45%. The costs do not decline in proportion to coverage as there are certain fixed costs of starting the program.

In both scenarios vaccines contribute by far the largest economic costs, equivalent to 83% and 76% respectively (see also Figure 17). Human resources (around 6%) and social mobilization (4%) are the next largest economic costs. Facility and outreach service delivery are the most costly program activities.

Figure 17: NUVI Economic Costs by Line Item and Activity: *90% coverage* (%, 2013)



* Salaries estimated at 33% of cost per dose.

Of the economic costs, *start-up costs* (costs which are incurred when introducing the vaccine but which will not recur) amount to 8% and 15% of costs in the 90% and 45% coverage scenarios respectively. The largest contributor to start-up costs is the buffer stock of 3 months of vaccines. *Financial costs* do not differ substantially from economic costs. However, in both scenarios, fiscal costs are higher than economic costs indicating the need to budget for more than economic cost amounts. This is primarily due to paying full costs for cold chain equipment, rather than accounting for it over several years as an economic or financial cost.

Table 4-3: Estimated costs of PCV introduction by line item and activity (Economic, Financial & Fiscal, US$, 2013): *90% coverage*

Expenditure Line Items	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Salaried Labor (33% of HR per dose)	1 556 256		1 556 256	6,4%	1 556 256	6,4%		0,0%
Vaccines	20 013 887		20 013 887	82,7%	20 013 887	82,7%	20 013 887	72,4%
Vaccine Injection & Safety Supplies	380 417		380 417	1,6%	380 417	1,6%	380 417	1,4%
Transport/Fuel			No additional costs anticipated					
Vehicle Maintenance			No additional costs anticipated					
Cold Chain Energy Costs			No additional costs anticipated					
Printing	462 100	462 100		1,9%	462 100	1,9%	462 100	1,7%
Building overhead, Utilities, Comms.			No additional costs anticipated					
Other recurrent (Soc.Mob & PIE)	1 054 484	997 509	56 975	4,4%	1 054 484	4,4%	1 054 484	3,8%
Waste management	182 333		182 333	0,8%	182 333		182 333	
Subtotal recurrent	*23 649 477*	*1 459 609*	*22 189 868*	*98%*	*23 649 477*	*97%*	*22 093 221*	*79%*
Cold Chain Equipment	222 419	222 419		0,9%	215 747	0,9%	4 908 798	17,8%
Training	340 865	340 865		1,4%	326 118	1,3%	652 235	2,4%
Vehicles			No additional costs anticipated					
Building			No additional costs anticipated					
Subtotal capital	*563 285*	*563 285*	*-*	*2,3%*	*541 864*	*2,2%*	*5 561 033*	20,1%
Total NUVI Estimated Costs	24 212 762	2 022 893	22 189 868	100%	24 191 341	99%	27 654 254	99%
		8%	92%					
Total NUVI Cost/ Month	1 345 153							
Total Delivery Costs (excl. Vaccines & Supplies)	3 818 457	2 022 893	1 795 564		3 797 037		7 259 950	
		53%	47%					
Total NUVI Delivery Cost/ Month	212 137							

Activity	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Cold Chain Equip (investment)	222 419	222 419		0,9%	215 747	0,9%	4 908 798	17,8%
Outreach Service Delivery	8 435 667		8 435 667	34,8%	8 435 667	34,9%	8 157 722	29,5%
Program Management	268 082		268 082	1,1%	268 082	1,1%		0,0%
Record-Keeping & HMIS	133 588		133 588	0,6%	133 588	0,6%		0,0%
Routine Facility-based Serv-Del.	12 695 059		12 695 059	52,4%	12 695 059	52,5%	12 236 582	44,2%
Social Mobilization & Advocacy	1 065 152	997 509	67 643	4,4%	1 065 152	4,4%	997 509	3,6%
Supervision	160 109		160 109	0,7%	160 109	0,7%		0,0%
Surveillance	581 417	462 100	119 317	2,4%	581 417	2,4%	519 075	1,9%
Training	344 385	340 865	3 520	1,4%	329 638	1,4%	652 235	2,4%
Vaccine Collectn, Distribn &Storg.	124 550		124 550	0,5%	124 550	0,5%		0,0%
Waste management	182 333		182 333	0,8%	182 333		182 333	
Total NUVI Estimated Costs	24 212 762	2 022 893	22 189 868	100%	24 191 341	99%	27 654 254	99%
NUVI Cost/Month	1 345 153							

Table 4-4: Estimated costs of PCV by line item and activity (Economic, Financial & Fiscal, US$, 2013): ***45% coverage***

Expenditure Line Items	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Salaried Labor (33% of HR per dose)	778 128		778 128	5,9%	778 128	5,9%		0,0%
Vaccines	10 006 944		10 006 944	75,6%	10 006 944	75,7%	10 006 944	57,3%
Vaccine Injection & Safety Supplies	190 209		190 209	1,4%	190 209	1,4%	190 209	1,1%
Transport/Fuel			No additional costs anticipated					
Vehicle Maintenance			No additional costs anticipated					
Cold Chain Energy Costs			No additional costs anticipated					
Printing	462 100	462 100		3,5%	462 100	3,5%	462 100	2,6%
Building overhead, Utilities, Comms.			No additional costs anticipated					
Other recurrent (Soc.Mob & PIE)	1 054 484	997 509	56 975	8,0%	1 054 484	8,0%	1 054 484	6,0%
Waste management	182 333		182 333	1,4%	182 333		182 333	
Subtotal recurrent	*12 674 197*	*1 459 609*	*11 214 588*	*96%*	*12 674 197*	*95%*	*11 896 069*	*67%*
Cold Chain Equipment	222 419	222 419		1,7%	215 747	1,6%	4 908 798	28,1%
Training	340 865	340 865		2,6%	326 118	2,5%	652 235	3,7%
Vehicles			No additional costs anticipated					
Building			No additional costs anticipated					
Subtotal capital	*563 285*	*563 285*	*-*	*4,3%*	*541 864*	*4,1%*	*5 561 033*	31,9%
Total NUVI Estimated Costs	13 237 482	2 022 893	11 214 588	100%	13 216 061	99%	17 457 102	99%
		15%	85%					
Total NUVI Cost/ Month	735 416							
Total Delivery Costs (excl. Vaccines & Supplies)	3 040 330	2 022 893	1 017 436		3 018 909		7 259 950	
		67%	33%					
Total NUVI Delivery Cost/ Month	168 907							

Activity	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Cold Chain Equip (investment)	222 419	222 419		1,7%	215 747	1,6%	4 908 798	28,1%
Outreach Service Delivery	4 217 833		4 217 833	31,9%	4 217 833	31,9%	4 078 861	23,4%
Program Management	134 041		134 041	1,0%	134 041	1,0%		0,0%
Record-Keeping & HMIS	66 794		66 794	0,5%	66 794	0,5%		0,0%
Routine Facility-based Serv-Del.	6 347 530		6 347 530	48,0%	6 347 530	48,0%	6 118 291	35,0%
Social Mobilization & Advocacy	1 031 330	997 509	33 821	7,8%	1 031 330	7,8%	997 509	5,7%
Supervision	80 054		80 054	0,6%	80 054	0,6%		0,0%
Surveillance	550 246	462 100	88 146	4,2%	550 246	4,2%	519 075	3,0%
Training	342 625	340 865	1 760	2,6%	327 878	2,5%	652 235	3,7%
Vaccine Collectn, Distribn &Storg.	62 275		62 275	0,5%	62 275	0,5%		0,0%
Waste management	182 333		182 333	1,4%	182 333		182 333	
Total NUVI Estimated Costs	13 237 482	2 022 893	11 214 588	100%	13 216 061	99%	17 457 102	99%
NUVI Cost/Month	735 416							

4.2.2 NUVI Unit costs

Table 4-5 and Table 4-6 show the total unit costs and the service delivery unit costs (i.e. excluding vaccine costs) with 90% and 45% PCV coverage respectively. The tables also show the effect on costs if the incremental staff time required for each new vaccine dose falls from 33% to 10% of the average staff time per dose, as anticipated by UNEPI. Note the different outputs for each scenario, which affects the unit cost, which is more efficient at 90% coverage. Unit costs of start-up and ongoing resource requirements are shown in Figure 18. (Appendix 8 shows the 60% coverage scenario).

Table 4-5: Unit costs of PCV (Economic, Financial & Fiscal, US$, 2013): *90% coverage*

Anticipated Outputs	90% Coverage Achieved		
Total number of doses	5 718 253		
Total number of target children	1 448 624	(90%)	
Total population	35 081 678	(cMYP estimate 2013)	

1. Salaries estimated at 33% of cost of HR per dose

NUVI Unit Costs (incl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 4,23	$ 4,23	$ 4,84
Unit cost/ PCV Imm. Child	$ 16,71	$ 16,70	$ 19,09
Unit cost/ capita	$ 0,69	$ 0,69	$ 0,79

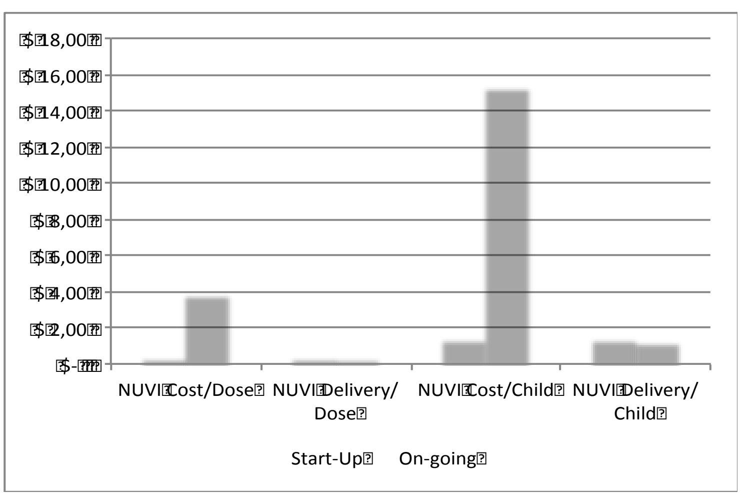
NUVI Delivery Costs (excl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 0,67	$ 0,66	$ 1,27
Unit cost/ PCV Imm. Child	$ 2,64	$ 2,62	$ 5,01
Unit cost/ capita	$ 0,11	$ 0,11	$ 0,21

2. Salaries estimated at 10% of cost of HR per dose

NUVI Unit Costs (incl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 4,04	$ 4,04	$ 4,84
Unit cost/ PCV Imm. Child	$ 15,97	$ 15,95	$ 19,09
Unit cost/ capita	$ 0,66	$ 0,66	$ 0,79

NUVI Delivery Costs (excl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 0,48	$ 0,47	$ 1,27
Unit cost/ PCV Imm. Child	$ 1,89	$ 1,87	$ 5,01
Unit cost / capita	$ 0,08	$ 0,08	$ 0,21

Figure 18: Start-up and Ongoing NUVI Unit Economic Unit Costs (per dose/ per immunized child) *at 90% coverage* (US$, 2013)



NB. Assuming salary costs at 33% cost per dose

Table 4-6: Unit costs of PCV (Economic, Financial & Fiscal, US$, 2013): *45% coverage*

Anticipated Outputs	45% Coverage Achieved					
Total number of doses	2 859 127					
Total number of target children	724 312	(45%)				
Total population	35 081 678	(cMYP estimate 2013)				
1. Salaries estimated at 33% of cost of HR per dose						
NUVI Unit Costs (incl.Vaccines)	Economic Costs		Financial Costs		Fiscal Costs	
Unit cost/ PCV dose	$	4,63	$	4,62	$	6,11
Unit cost/ PCV Imm. Child	$	18,28	$	18,25	$	24,10
Unit cost/ capita	$	0,38	$	0,38	$	0,50

NUVI Delivery Costs (excl.Vaccin	Economic Costs		Financial Costs		Fiscal Costs	
Unit cost/ PCV dose	$	1,06	$	1,06	$	2,54
Unit cost/ PCV Imm. Child	$	4,20	$	4,17	$	10,02
Unit cost/ capita	$	0,09	$	0,09	$	0,21

2. Salaries estimated at 10% of cost of HR per dose						
NUVI Unit Costs (incl.Vaccines)	Economic Costs		Financial Costs		Fiscal Costs	
Unit cost/ PCV dose	$	4,44	$	4,43	$	6,11
Unit cost/ PCV Imm. Child	$	17,53	$	17,50	$	24,10
Unit cost/ capita	$	0,36	$	0,36	$	0,50

NUVI Delivery Costs (excl.Vaccin	Economic Costs		Financial Costs		Fiscal Costs	
Unit cost/ PCV dose	$	0,87	$	0,87	$	2,54
Unit cost/ PCV Imm. Child	$	3,45	$	3,42	$	10,02
Unit cost / capita	$	0,07	$	0,07	$	0,21

At the planned 90% coverage and assuming 33% of routine immunization staff costs per dose, full economic unit costs per PCV immunized child are $ 16.71 while full economic unit costs per dose are $ 4.23. If staff costs are only 10% additional time per dose, they fall to $15.97 and $ 4.04 respectively. Service delivery costs make up around 16% of the full unit costs. Financial unit costs are almost identical to the economic costs in any scenarios.

Fiscal unit costs are, however, substantially higher than economic unit costs as they include the full, un-annualized initial costs of cold chain, printing and training procurement. Full fiscal unit costs per immunized child range at the planned 90% coverage are $ 19.09, while full fiscal costs per dose are $ 4.84.

In the lower 45% coverage scenario, unit costs per dose and per child are higher, due to the lower outputs as well as the relatively fixed costs such as cold chain investments which are not reduced in proportion to the lower initial coverage target. Full economic unit cost per PCV immunized child is $ 18.28 (at 45% coverage and salary costs at 33% of cost per dose) while full economic unit costs per dose was $ 4.63. Fiscal unit costs are even higher, rising as high as $ 24.10 per immunized child and $ 6.11 per dose (at 45% coverage).

4.3 Discussion

4.3.1 Comparison with NUVI introduction grant

The Ugandan PCV Introduction Plan used the cMYP to estimate the costs of introduction with 90% coverage.[44] The Introduction Plan's cost estimates are compared with this study's results in
Table 4-7 below. Comparisons are complicated by the mix of line item and activity costs reflected in the Introduction Plan, which are not directly comparable to cost categories in the costing study. Nevertheless, important observations can be made. The Introduction Plan costs are compared to the 90% coverage scenario below, and assuming the salaries costs are 33% of the cost per dose.

Table 4-7: Comparison of PCV Introduction Plan Costs and Study Estimates (Economic and Fiscal) for 90% coverage

At 90%cov.target (HR 33% of dose HR cost)						
Activity	**GOU Intro Plan Costs (US$)**	**Study Economic Costs (US$)**	**Variance (US$)**	**Study Fiscal Costs (US$)**	**Variance (US$)**	**Variance (%)**
Vaccine & supplies	22 433 019	20 394 304	- 2 038 715	20 394 304	- 2 038 715	-9%
Programme Management	192 916	268 082	75 166	-	- 192 916	-100%
Microplanning (Record keeping)	143 816		- 143 816		- 143 816	-100%
Training	697 423	344 385	- 353 038	652 235	- 45 188	-6%
Cold Chain equipment & repairs	80 844	222 419	141 575	4 908 798	4 827 954	5972%
Vehicles & transport	75 608		- 75 608		- 75 608	-100%
Surveillance & Monitoring	546 395	519 075	- 27 320	519 075	- 27 320	-5%
Advocacy & Soc.Mobilisation	759 138	997 509	238 371	997 509	238 371	31%
Human Resources	290 721	1 284 654	993 933		- 290 721	-100%
Waste Management	182 333	182 333	-	182 333	-	0%
Grand Total	**25 402 213**	**24 212 762**	**- 1 189 451**	**27 654 254**	**2 252 041**	**9%**

* The fiscal estimates did not include salaries, as per agreed common approach.

Comparison of study economic results with the PCV Introduction Plan, both for 90% coverage, shows a small overall variance of 5%, while the fiscal estimates were 9% higher, but there are substantial differences in projected costs of particular items (Table 4-7). *Note that the fiscal estimates did not include salaries.*

The large variance for vaccines and supplies, is due mainly to use of a 10% wastage factor in the Plan rather than the 5% currently recommended by UNEPI. The Introduction Plan did not include incremental staff costs as defined in this study, which resulted in higher estimations for human resources and management. With assumption that PCV requires an increase in staff time equivalent to the average routine immunization cost per dose, HR economic costs are $ 1 million higher than in the Introduction Plan (but excluded from the fiscal estimates). The training cost estimates are substantially lower than the Plan's.

[44] The cMYP estimate assumed 86% coverage, with requirements of $ 18.6 million for vaccines and supplies.

The Plan estimates did not include costs of cold rooms and refrigerators purchased by JICA and USAID in previous years, in preparation for the roll-out of PCV. Therefore the economic costs of the cold chain space required for PCV were found to be US$ 141,575 more in this costing estimate, with an even higher fiscal cost of US$ 4.8 million. Cold chain costs can be a substantial part of funding applications, and can also be a major focus of NUVI planning.[45] There is some uncertainty about whether expenditures are NUVI-specific, or in large part due to routine immunization cold chain refurbishment and expansion. However, costs of new cold chain capacity may best be considered as a somewhat separate issue from NUVI itself. Firstly, cold chain capacity to deliver NUVI will be heavily dependent on overall existing capacity and cold chain upgrading requirements, rather than NUVI-specific capacity requirements. Secondly, annualized cold chain costs are relatively small in relation to overall immunization funding. They may therefore best be contextualized in relation to overall program costs and priority needs rather than NUVI introduction costs.

Efficiency gains may be possible through ensuring more efficient, systematic plans at each level for distribution such as routes, frequencies and quantities that allow for better cold chain capacity planning. The costing highlighted the need to support the planning process with an accurate assessment of cold chain capacity at facilities. This would result in more accurate estimation of resource requirements and would also support the implementation process. It should be noted that respondents did not identify any requirements for extra vehicles and transport costs for NUVI in this costing study.

4.3.2 Comparisons with overall immunization expenditure and unit costs

Total economic costs during the PCV introduction phase in Uganda are relatively large. Assuming 90% coverage with NUVI, the economic cost of $ 24.2 million represents an addition of 61% to the estimated total routine immunization economic costs of $ 40 million.[46] The estimated *recurring* economic costs will constitute 69% of the current routine program total costs and suggest a high ongoing expenditure requirement. Even the service delivery costs (excluding vaccines) of $ 3.8 million in economic costs, or $ 7.25 million in fiscal costs, amount to substantial incremental costs for UNEPI.

The estimated economic unit costs per PCV immunized child in the introduction period under the 90% coverage scenario are around 50% of costs for all other vaccines per DPT3 child in the routine immunization ($ 33.6 per DPT3 in Uganda). The related economic costs per dose in the introductory period amount to 108% of the estimated $ 3.93 per dose for the routine immunization.[47] In lower coverage scenarios, unit costs are even higher.

The PCV unit cost indicators from this study may be useful to update estimates of the cost effectiveness of PCV in Uganda. However, the estimates of non-vaccine unit costs

[45] The NUVI process for example triggered significant expenditure in cold chain in Zambia and in Ethiopia (Griffiths et al, 2009), as well as in Uganda.

[46] In the 45% coverage scenario, PCV economic costs amount to $16.97 million, a 48% addition to routine EPI costs.

[47] If only recurrent economic costs are considered (i.e. start up costs are removed) the PCV unit costs are reduced by just over 20%, making the unit costs a somewhat smaller proportion of overall EPI unit costs.

of $0.67 or less after roll-out to 90% coverage, seems to be significantly lower than the average for developing countries of $1.27 which was identified in a recent review of PCV cost effectiveness studies.[48] This is probably due to the lower salary costs in Uganda than Zambia, as an example.

4.3.3 Key considerations in cost management and cost effectiveness

The PCV-10 vaccine is a major diver of costs. Cost management may require revision of systems to manage and monitor wastage and stock levels, and for ordering and managing buffer stocks.

The study illustrated challenges for planners and researchers in establishing the extent of needs for more staff and cold chain capacity for NUVI, particularly at facility level, and the potential to over- or under-state NUVI-specific requirements. However, the study also shows that the cost of human resources for PCV introduction is potentially significant when assessing true economic costs, particularly in the context of major human resource capacity challenges, and constrained government resource contributions. They may be particularly important where multiple new vaccines are being introduced, as in Uganda. Perceived increases in workload on program and service staff have previously been noted as the most important negative impact of NUVI, apart from strain on the cold chain.[49]

Significant expenditure was incurred to upgrade the cold chain equipment in the two years leading up to the planned introduction of new vaccines. Griffiths et al (2009) report high expenditure for a revamp of cold chain equipment in Ethiopia linked to Penta single dose vial introduction, and the potential significance of these costs is also illustrated by Uganda.[6] While it can be difficult to identify how much cold chain capacity is required specifically for a particular new vaccine, it is clear that NUVI can trigger large scale expenditure to replace old capacity for existing routine immunization needs, although they are not strictly NUVI incremental costs.

The PCV costing in Uganda suggests that most other resource requirements have low costs, although they may be important functionally. These include transport related costs which were not identified as substantial incremental costs in Uganda. This differs from the finding of Griffiths et al (2009) that Penta single dose vial introduction in Ethiopia was bulky and involved need for larger trucks and more frequent supply.

4.3.4 Implications for funding

The study estimates provide important, extra information to inform planning and budgeting for immunization by governments and development partners.

Of note, country contributions to PCV introduction costs, particularly for staff, are higher than reflected in previous cost estimates, which may affect cost sharing

[48] De la Hoz-Restrepo F. Castaneda-Orjuela C. Paternina A. Alvis-Guzman N. Systematic review of incremental non-vaccine cost estimates used in cost-effectiveness analysis on the introduction of rotavirus and pneumococcal vaccines. Vaccine 31S (2013) C80– C87

[49] WHO. Global Meeting on Implementing New and Under-utilized Vaccines, Bávaro, Dominican Republic, 4-6 June 2013

requirements. Furthermore, the current GAVI grant of 80c per child born clearly only covers a portion of the equivalent non-vaccine fiscal costs ($10.02) and non-vaccine economic costs ($3.45 or more) per PCV immunized child in Uganda.

In terms of anticipated funding for the roll-out of PCV10, at the time of this prospective study there was limited information on secured funding. Therefore, the comparison of the anticipated resource requirements with secured funding could not be undertaken to ascertain if a funding gap would be experienced. However, based on the assumption that the GoU would meet the human resource needs (perhaps without necessarily expanding its capacity, but rather stretching it further), and knowing in hindsight that GAVI disbursed US$ 1.4 million as a new vaccine introduction grant in 2012 and US$ 13,351,587 in 2013 for PCV specifically, we could estimate that there may have been a shortfall of US$ 650,893 for the start-up costs and US$ 7.3 million for the on-going costs, assuming that they achieved 90% coverage in the first year of roll-out. Since this would be unlikely, there may have been no actual short-fall in 2013. However, this could only be ascertained by a further study of the actual roll-out, costs and available funding. Nevertheless, with scale-up efforts, the following years could potentially experience funding shortfalls, depending entirely on the scale of external support to the program and given Uganda's general fiscal constraints within the public budget, discussed earlier.

Table 4-8: NUVI Cost Estimates (90% coverage) and Financing (US$, 2013)

	Start Up Costs	On-going 2013
Reource Needs:		
Estimated Start Up costs	2 022 893	
Estimated On-going costs		22 189 868
Available Funding:		
GAVI new vaccine grant	1 372 000	
GAVI PCV disbursement		13 351 587
Govt HR contribution		1 556 256
Financing Gap	*- 650 893*	*- 7 282 025*

4.4 Conclusions

A number of conclusions can be drawn from the costing of PCV introduction which are useful to planners in Uganda and other countries by enhancing understanding of NUVI cost and sustainability issues. The main conclusions are likely to be robust despite the challenges posed by costing PCV introduction through a prospective study with limited retrospective expenditure data.

A particular challenge for budgeting and costing of NUVI arises from uncertainties around realistic coverage targets and actual implementation timeframes. There are uncertainties around the target coverage that will be achieved in the introduction period and the level of incremental demands on staff time at all levels, and sensitivities to these assumptions have been explored. They are important for planners to consider, but generally have limited impact on overall conclusions.

Using the current ambitious target of 90% coverage as the main reference scenario not only allows some comparison with previous UNEPI estimates, but also gives an indication of the scale of longer term recurring costs. Key conclusions are the following.

1. Introduction of PCV-10 represents a very large addition of around 60% to the routine immunization programme expenditure in Uganda.
    - Fiscal costs – a good reflection of immediate budget requirements, tend to be significantly larger than economic costs, although the latter are a better yardstick for assessing cost effectiveness and longer term sustainability.
2. Reducing vaccine costs will be a key issue in enhancing programme sustainability, as vaccines and injection supplies contribute around 80% of total costs of introducing the new vaccine.
    - Over-estimating initial coverage rates may lead to an over investment in vaccines stocks for routine and buffer purposes, and generate unnecessary wastage and place unnecessary strain on existing cold chain and distribution.
3. Service delivery costs (excluding vaccines and supplies) are also substantial, and are markedly higher than the GAVI implementation grant.
4. The government contribution to NUVI introduction has previously been under-estimated, particularly because substantial staff costs have been excluded from previous estimates. Even where incremental costs of human and other resources specific to NUVI are not identified, government contributes a baseline capacity of staff, cold chain equipment and infrastructure, without which service provision cannot take place.
5. Human resources requirements are substantial, but do not lead to incremental *fiscal* costs as new staff are not being employed.
    - The decision that no new staff should be employed does not necessarily mean that there is not a *need* for additional staff. Results indicate the potential for substantial opportunity costs, new burdens on scarce management and service staff, and trade-offs in health system HR allocations that may impact on other services in various settings. These may be particularly important issues when multiple new vaccines are introduced.
6. Capital costs for cold chain prior to the introduction period were estimated at $4.8 million and a substantial part of this seems to be NUVI related. However, the annualized economic costs of cold chain equipment are a relatively small contributor to total costs.
    - Some of the cost may have reflected replacement of existing obsolete equipment for general immunization purposes rather than NUVI. However, it seems most appropriate for funders to assess requests for cold chain equipment funding on the basis of their merit as a broader immunization investment, rather than just whether they are legitimate NUVI costs per se. Introduction of several new vaccines may also lead to more substantial new cold chain requirements.

5 Productivity analysis

5.1 Background: productivity of immunization and health services

Productivity and efficiency are related concepts which examine the level of output which can be generated from a given unit of input or set of inputs. Productivity can be thought of as the relationship between units of output per unit of input. A more productive facility would be operating closer to its production possibility frontier.[9]

This section presents examples of scatter plot analyses of factors that influenced productivity (in terms of outputs) in delivering immunization services in Uganda. More detailed statistical analysis of facility productivity follows. Appendix 8 presents some further analysis of unit cost (performance) variations. Section 6 presents an analysis of the determinants of total facility costs.

There is a wealth of productivity measurement in the health sector in high-income countries.[50] However, in spite of the particularly necessity to avoid waste of scarce resources in health care in resource constrained settings, which include most countries in Southern and Eastern Africa, most health economic research in Africa has focused on specific intervention programmes or the entire health care system.[51] Benchmarking of service providers is very rarely performed in Africa. A review of the literature indicates that little is known about the productivity and efficiency of small primary health care facilities in African countries even though these institutions treat the majority of patients in most settings. The existing published efficiency studies concentrate on hospitals. These produce findings which are of interest but limited relevance to this study, given our interest in the immunization program which is typically implemented at the primary health care level.

This study provides a unique opportunity to examine variation in unit costs, outputs and total cost for the sample of facilities in Uganda. The literature reports no specific information on studies of productivity factors for immunization in Uganda. Some information is available on factors relating to immunization coverage from a recent analysis of the 2006 Uganda Demographic and Health Survey. This found that factors which have a significant association with levels of childhood immunization are: maternal education (especially post-secondary level), exposure to media, maternal healthcare utilization, maternal age, occupation type, immunization plan, and regional and local peculiarities which are thought to include accessibility of services.[52]

---

[50] Hollingsworth B. 2008. The Measurement of Efficiency and Productivity of Health Care Delivery. Health Economics (17): 1107-1128.

[51] Marshall P Flessa S. 2011. Efficiency of primary care in rural Burkina Faso. A two-stage DEA analysis. Health Economics Review. Vol 1:5. http://www.healtheconomicsreview.com/content/1/1/5

[52] Bbaale E. Factors Influencing Childhood Immunization in Uganda. J Health Popul Nutr. 2013 March; 31(1): 118–129.

A Bangladesh study found that maternal education and child age affected immunization coverage.[53] A Pakistan study by found that female literacy rates, TV ownership, and other provincial dummy variables explained 48% of the variation in immunization coverage at the district level. The study found no relationship between coverage levels and vaccine supply factors, number of vaccinators/capita, training, frequency of supervision, availability of micro-plans, and turnover of managers.[54] Other studies on determinants of immunization outputs and coverage have also identified service and community factors that are worthy of consideration in analysis.[55] [56] [57] [58] [59]

A Tajikistan study of service outputs indicated that the public resources allocated to health and the number of hours facility staff spent on immunization per month were positively and statistically associated with the number of doses administered, but there were no significant associations between volume of doses and distance to a vaccination collection point, community income levels, or amount of GAVI ISS resources in the district.[60]

One of the few studies of the efficiency of primary health care facilities, in Burkina Faso, provides valuable insights into the factors which impact on relative efficiency and productivity.[51] A two stage analysis was used to firstly assess the relative efficiency of a sample of primary health care facilities using DEA methodology, after which regression analysis was used to examine correlation between the output and environmental determinants. The findings indicate that major inputs (infrastructure and staffing) were typically fixed and that efficiency was determined primarily by utilization of the facilities. The authors pointed out that, from a medical perspective, there is a large latent demand for health services but that the uptake and *actual* demand for modern health care is low. Given that closing health care facilities is typically not an option and that costs are fixed in these facilities, improving utilization and understanding the determinants and barriers to service uptake become the key issues. The Burkina Faso study examined various determinants in relation to productivity and efficiency including household income, religion and geographical location. Geographical accessibility is highlighted as a key determinant closely correlated with productivity.

---

[53] Bishai D. 2002. The role of public health programmes in reducing socioeconomic inequities in childhood immunization coverage. Health Pol Plan: 17(4): 412-419

[54] Loevinsohn B Hong R and Gauri V. 2006. Will more inputs improve delivery of health services? Analysis of district vaccination coverage in Pakistan. Int J Health Planning and Management. Vol 21(1): 45-54

[55] Odusanya O. Alufohai E. Meurice F. and Ahonkhai V. 2008. Determinants of vaccination coverage in rural Nigeria. BMC Public Health.

[56] Cutts F Rodriques L Colombo S Bennett S. 1989. Evaluation of Factors Influencing Vaccine Uptake in Mozambique. International Journal of Epidemiology: 18(2): 427-433.

[57] Cutts F Diallo S Zell E Rhodes P. 1991. Determinants of Vaccination in an Urban Population in Conakry, Guinea. Int J Epi: 20(4): 1099-1106.

[58] Maekawa M Douangmala S Sasisaka K Takahashi K Phathammavong O Xeuatvongsa A Kurolwa C. 2007. Factors influencing routine immunization coverage among children aged 12-59 months in Lao PDR after regional polio eradication in Western Pacific Region. BioScience Trends: 1(1):43.51.

[59] Ibnouf A Van den Borne Maerse J. 2007. Factors influencing immunization coverage among children under five years of age in Khartoum State, Sudan. SA Fam Pract: 49(8): 14a-14f.

[60] Brenzel, L. 2008. Immunization Resource Tracking Exercise: Case Study of the Republic of Tajikistan. The World Bank. Washington, D.C

In Eritrea, a study using a similar methodology to the Burkina Faso study examined the efficiency of public hospitals had similar findings, that higher utilization is key to improved productivity and efficiencies. Unlike primary health care centres however, the possibility of re-allocating human resources becomes more feasible to manage productivity.[61] A similar study of human resource efficiency in hospitals and health centres in Zambia also used DEA to estimate the degree of technical, allocative and cost efficiency in individual public and private health centres in Zambia and to identify the relative inefficiencies in the use of various inputs in health centres. Regression analysis was however not carried out as a second step to examine correlations between possible determinants, productivity and efficiency outcomes.[61]

5.2 Methods

5.2.1 Approach to productivity analysis

In the context of the above theory and precedents, the approach to analysis of productivity and determinants of total cost had two stages. The first stage was an analysis of the productivity of the sampled facilities focusing on factors that are the determinants of utilization and output. The second stage of the analysis focused on the determinants of total facility cost, which is addressed in Section 6 below. The research question we sought to address in the first stage was: What determines the total output at facility level?

Selecting the independent variables was guided by the existing research findings outlined above, by the cost analysis and by the hypotheses that the:

- Total facility catchment population is a driver of total facility attendance and therefore total doses and DTP3 children,
- Access to facilities could play a role in determining the level of attendance given a particular catchment population,
- Number of outreach visits or zones supported impact on total facility productivity by reaching populations which may otherwise not have presented at a facility (and also represent infrastructure available for immunization services).

The utilization of the facility is most likely to have greatest impact on the productivity of immunization staff. Utilization is expected to be a function of total facility attendance, which in turn is likely to be a function of the catchment population and the setting. There may be associations between the proportion of services provided at a facility and the proportion provided through outreach activities. Although they have possible impacts on costs based on our observations during data collection, the energy source, collection frequency and similar operational factors were not expected to impact directly on facility productivity.

As a first step, quadrant analysis was used to explore the relationship between a number of determinants and dependent variables, to test hypotheses that utilization and other factors may be the key drivers of productivity.

---

[61] Kirigia, Asbu. Technical and scale efficiency of public community hospitals in Eritrea: an exploratory study. Health Economics Review 2013 3:6.

5.2.2 Statistical methods

Regression analysis followed the scatterplot analyses, to examine the correlation and relationship between the selected dependent and independent variables. STATA software (version 12, College Station, TX) was used to conduct the regression analysis.

After assessing model fit of untransformed data, the normality, and constant variance assumptions were not met. After investigating a number of transformations using the ladder command in STATA, the best transformations were the log transformation (ln) on both the dependent and independent variables.[62]

To investigate factors associated with productivity, least square regression models were fitted. Firstly, to assess the degree of linear relationship between variables, Pearson correlation coefficients were calculated. The correlations are discussed further in section 5.3.2 below. Bonferroni adjusted significant levels were used to account for multiple comparisons.

Variables were included in productivity models if they were considered to be associated with the dependent productivity variable based on economic theory. Where a number of independent variables were highly correlated with each other, one or more of them were excluded from the model. For example the number of days that immunization occurred in a week would be excluded where it was highly correlated with a number of other independent variables. (This process was also followed for the cost models in Annex 8 and Section 6).

To assess the model fit a number of diagnostics were undertaken, including assessment of residuals and leverage values. The Breusch-Pagan test of heteroskedasticity was used to check for constant variance. The Normality test was done using visual impression, histograms, box and whisker plots as well as normality Q-Q plots. Residuals and leverage plots were used to check for outliers and high influence values. The Shapiro Wilks formal parametric test for normality was also used. Diagnostic analysis to assess key assumptions and model fit are summarised in Appendix 9.

To investigate determinates of productivity the following regression model was fitted:

$$\ln(y_i) = \beta_0 + \beta_1 \ln(x_{1i}) + \beta_2 \ln(x_{2i}) + \beta_3 \ln(x_{3i}) + \beta_4 \ln(x_{4i}) + \beta_5 \ln(x_{5i}) + \beta_6 x_{6i} + \beta_7 x_{7i} + \beta_8 x_{8i} + \beta_9 x_{9i} + \beta_{10} x_{10i} + \beta_{11} x_{11i} + \varepsilon_i$$

Where:

i) x_1 is the number of health staff involved in immunization,
ii) x_2 is the number of immunization zones supported by the facility
iii) x_3 is the number of patients seen at a facility,
iv) x_4 is the district poverty index,
v) x_5 is the distance between the health facility and the pharmacy,
vi) x_6 is a dummy variable for road conditions (0 = good/fair; 1 = poor/very poor)
vii) x_7 is a dummy variable for refrigeration energy source (0 =electricity; 1 =other)
viii) x_8 - is a dummy variable for area (0 = rural, peri-urban/1 = urban), and
ix) x_9 – x_{11} are dummy variables for facility type (0 = otherwise 1 = level IV, (0 = otherwise 1 = level III) and (0 = otherwise 1 = level II) for the three dummy

[62] In summaries however, both untransformed weighted, and weighted geometric, means are reported.

variables respectively. Hospitals were used as the reference facility.

x) y_i is any one of the productivity dependent variables considered, including:
   a. number of children immunized with DTP3,
   b. number of doses administered,
   c. number of doses per FTE,
   d. number of doses per staff per day, or
   e. number of doses per staff per session.

The B_i are unknown regression coefficients, B_0 represents the intercept or mean value when all factors are 0, and ε_i is the error term reflected in the residuals.

5.3 Results – productivity analysis

5.3.1 Quadrant analysis

The following graphs illustrate two-way scatterplots of selected ln-transformed variables that were used in the initial phase of examining the productivity factors in the dataset. All of the graphs represent linear predictions. The specific facilities can be identified from the list of facilities and their unique facility numbers in Appendix 2. The reference lines were placed on the mean of the variable and marked with their value, unless the means are very close to the existing markers. Plots of some untransformed variables have been shown in Section 3.2.1 above and others are shown in Appendix 8.

Figure 19 suggests a positive relationship between the number of doses given per staff full-time equivalent involved in immunization, and number of doses administered: use of staff time tends to be more efficient with larger immunization volumes. Many HCII had both low total doses and low doses per FTE. For HC II, the number of doses per health staff FTEs was generally below the average and also below the fitted line, suggesting relatively inefficient use of staff for given immunization volumes. Most HCIII and HCIV appear to have relatively high doses per FTE for given immunization volumes.

Figure 19: Doses per Immunization Staff FTE vs. Number of Doses Administered

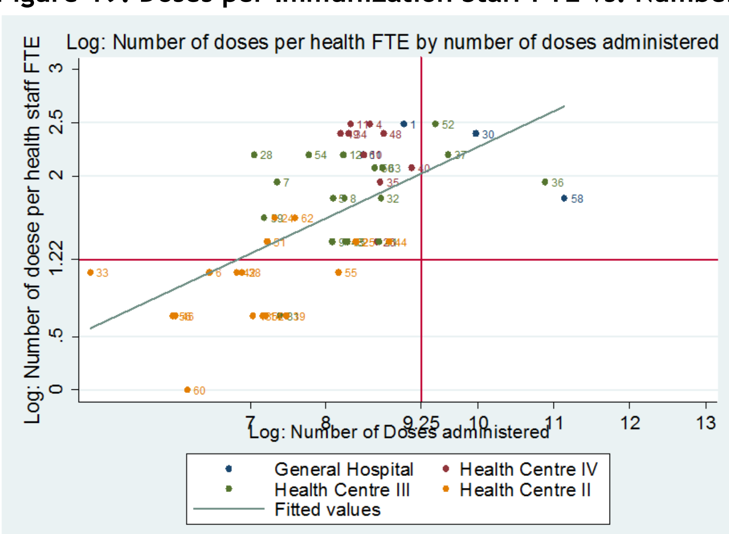
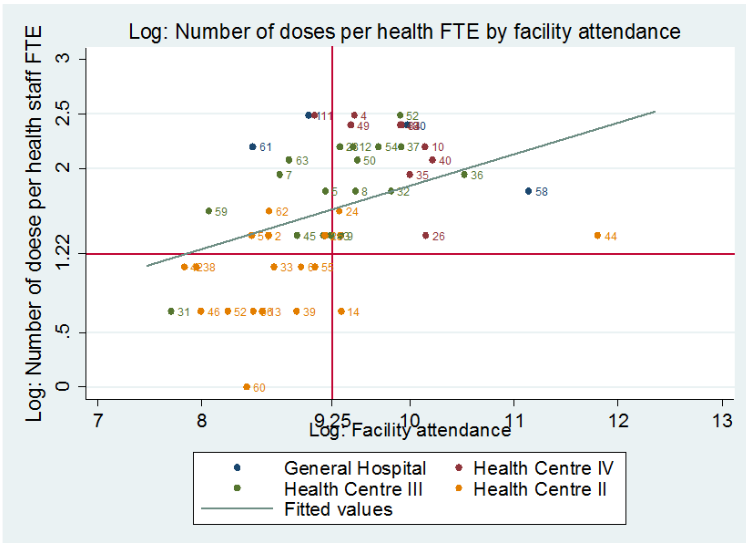


Figure 20 confirms a positive relationship between facility size (number of attendees) and number of doses per FTE (productivity), as well as a similar distribution of facility types in various quadrants and in relation to the fitted line.

Figure 20: Number of Doses per Immunization Staff FTE by Facility Attendance



Other plots suggested that, as might be expected, there were strong associations of facility and staff productivity indicators with independent variables such as facility attendance and catchment population. However, there was no obvious relationship between other variables such as location or district of facilities in similar analyses to those shown.

5.3.2 Statistical analysis

Pearson correlation coefficients were used to identify variables that have a strong linear association and which, in the case of independent variables, should thus not be included in the same productivity models (see Appendix 8 for tabulation of correlations).[63]

[63] There was statistically significant correlation between several *dependent* productivity variables:
DPT3 immunized children, # doses administered, doses per FTE/ and # doses per staff per day.
There was also high correlation *between DTP3 children and the following independent variables*:
health staff involved in immunization, # of immunization days per week, # patients seen at the facility, and the size of facility catchment population.
Total number of doses delivered per facility per year was highly correlated with:
doses per FTE, # doses administered per staff per day, # health staff involved with immunization, # immunization sessions per week, and the size of the population served by a facility.
The *number of doses administered per FTE* was correlated with:
doses per staff per day; # immunization days per week.
Both doses per staff per day and doses per staff per session were correlated with *# of days immunization occurred a week*. Only independent variable significantly correlated with # immunization days per week was population catchment size.
FTEs were correlated with:
# of immunisation sessions per week and population catchment size,
There were also significant correlations between:

Five dependent variables were considered for the productivity analysis; number of DTP3 immunized children; the number of doses administered; doses per FTE; doses per staff per day; and doses per staff per session.

There was high correlation between various independent variables that were initially considered. Thus the number of immunization days per week, catchment population and number of village health workers, which were all correlated with a number of other independent variables, were left out of the final productivity regression models.

5.3.2.1 Determinants of Productivity

Table 5-1 below shows results of the regression models with selected productivity indicators. There was high and significant correlation between dependent variables, thus results from the regression models showed that similar independent variables had the same effect across the dependent variables.

Factors that were significantly associated with the *number of DTP3 immunizations delivered* were: the number of immunization zones supported; the number of patients seen at the facility; the state of the roads in the area; urban sites; and the type of health facility.

An increase of 10% in the number of zones supported by a health facility was associated with a 1.5% increase in the number of DTP3 immunized children, in an adjusted model (Model-1). In the same model, a 10% increase in the total number of attendances at a facility was associated with a 5.4% increase in the number of DTP3 immunized children. Urban sites were associated with 317% higher number of DTP3 immunizations compared to rural sites. When HCIV, HCIII and HCII were compared to hospitals they were associated with 89%, 79% and 93% lower number of DTP3 immunizations respectively. This result was notable because not all facility types fitted the expected pattern of facility patient load: HC IIIs appeared to have greater output than HC IVs. This seems to be because HCIV provide some inpatient maternity services and tend to have relatively high staffing levels and large estimates of catchment populations as a result. Surprisingly, areas with poor road access were associated with a 50% higher number of DTP3 immunizations compared to areas with good road access.

Similar to the model with DTP3 as the independent variable, the *total number of doses* administered at the facility (Model-2) was associated with the number of zones supported, facility attendance, the states of the roads, rural/urban location of the facility, and the type of health facility. Not surprisingly, the signs and magnitudes of the coefficients of the two models where similar since DTP3 contributes part of the doses that make up the total number of doses administered at a facility.

---

health staff involved in immunization and: FTEs; immunization sessions per week; outpatient visits; and facility catchment population,
village health workers and # of immunization zones supported by health facilities

The variables that were significantly associated with the *number of doses per staff per day* were the number of staff involved in immunization sessions, the number of zones supported, facility attendance, state of the roads, rural/urban areas and the type of facility (Model-3). An increase of 10% on the number of staff involved in immunization was associated with a 10% *de*crease in the number of doses administered per staff per day. In contrast, a 10% increase in the number of zones supported, or a 10% increase in the number of attendees at a facility, were associated with 1.6% and 5.5% increases in the number of doses per staff per day respectively. Bad roads were associated with a 68% higher number of doses per staff per day compared to good roads, while urban sites where associated with a 493% higher number of doses per staff per day. Relative to hospitals, level IV, III and II facilities were associated with 89%, 79% and 93% lower number of doses per staff per day in this adjusted model.

Table 5-1: Determinants of Productivity Measure Variables (ln transformed)

	Dependent Variable			
	Model-1	**Model-2**	**Model-3**	**Model-4**
	DTP3 child (ln)	**Total Doses (ln)**	**Doses per staff per day (ln)**	**Doses per staff per session (ln)**
Variable	Coefficient (std error) p- value	Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value
Ln # Staff involved in immunization	0.03 (0.29) 0.93	-0.001 (0.38) 1.00	-1.02 (0.38) **0.01**	-0.90 (0.42) **0.04**
Ln # Zones supported	0.15 (0.06) **0.01**	0.16 (0.7) **0.03**	0.16 (0.07) **0.04**	0.13 (0.08) 0.10
Ln facility attendance	0.54 (0.18**) <0.01**	0.56 (0.23) **0.02**	0.55 (0.23) **0.02**	**0.77 (0.25) < 0.01**
Ln poverty index	0.20 (0.15) 0.19	0.26 (0.19) 0.18	0.27 (0.19) 0.15	0.18 (0.21) 0.40
Ln Distance to collection point	-0.07 (0.05) 0.17	-0.05 (0.06) 0.39		
Roads: Good/Fair Poor/very poor	 Reference (0) 0.41 (0.20) **0.05**	 Ref 0.57 (0.26) **0.03**	 Ref 0.52 (.25) **0.04**	 Ref 0.13 (0.28) 0.63
Energy: Electricity Other sources[&]	 Reference (0) -0.67 (0.41) 0.11	 Ref -0.86 (0.52) 0.11	 Ref -0.88 (0.52) 0.10	 Ref -0.86 (0.59) 0.15
Area: Rural Peri-urban Urban	 Reference (0) 0.19 (0.26) 0.45 1.43 (0.45) **< 0.01**	 Ref 0.46 (0.33) 0.17 1.78 (0.57) **< 0.01**	 Ref 0.46 (0.33) 0.17 1.82 (0.57**) <0.01**	 Ref -0.46 (0.37) 0.22 -0.02 (0.64) 0.88
Facility type: Hospital Health facility IV Health Facility III Health Facility II	 Reference (0) -2.21 (0.73) **<0.01** -1.55 (0.65) **0.02** -2.73 (0.68) **< 0.01**	 Ref -2.22 (0.94) **0.02** -1.53 (0.83) 0.07 -2.64 (0.87) **< 0.01**	 Ref -2.20 (0.94) **0.03** -1.55 (0.82) 0.07 -2.64 (0.86) **< 0.01**	 Ref -1.35 (1.05) 0.21 -0.74 (0.93) 0.43 -0.76 (0.97) 0.44
Constant	2.73 (1.56) 0.09	4.88 (1.99) 0.02	-0.58 (1.98) 0.77	-2.07 (2.23) 0.36
R – squared	0.77	0.70	0.53	0.39
F value	F(12, 36) = 10.3 <0.01	F(12, 36) = 6.9 < 0.01	F(11, 37) = 3.79 < 0.01	F(11, 37) = 2.15 0.04

[&] Other sources of energy include gas, kerosene and solar

The only variables associated with the *number of doses per staff per session* were the number of staff involved in immunization and facility attendance. An increase of 10% in the number of staff involve in immunization was associated with a 9% decrease in the number of doses per staff per session. A 10% increase in the number of facility attendees of was associated with an increase of 7.7% in the number of doses per staff per session (Model 4).

The DPT3 model had the highest R-squared of 0.77, followed by the Total Doses model, while models looking at output in relation to staffing rather than total facilities were less predictive. Models that had dependent variables Doses per staff per day, and Doses per staff per session had relatively low R-squared values (0.39-0.53), indicating that the fitted independent variables had lower predictive power.

Only facility attendance was strongly associated with the selected dependent variable across all of the models. However, the number of zones, facility type, urban location and poor access road also had consistently strong associations with productivity in three of the four models.

Apart from rural location, productivity measures were not significantly associated with any other variables that may have been associated with demand for, or accessibility of, services. These included district poverty index, and other factors relating to infrastructure and remoteness of facilities.

The analysis indicated, overall, that a relatively small but similar set of independent variables were associated with productivity in different models for different productivity variables. The model with the DTP3 children as the dependent variable had the highest R-squared among all other models, thus this was used as an independent variable in all cost determinant models (Section 6). Model fit and associated residual diagnostics for this model are given in Appendix 9.

5.4 Discussion

Statistical analysis of total facility productivity pointed consistently to a statistically significant association between productivity and several factors. In particular, total facility attendance was consistently associated with the total number of doses and of DTP3 immunized children. Productivity was also significantly associated with the number of zones served. The significant association between facility productivity, and number of zones and total attendance, is not unexpected.

Importantly, the analysis found that there were significant associations between productivity and facility type. The facility type may to some extent be considered to be a service delivery model with particular staffing and infrastructure patterns, but is also likely to be a proxy for many other specific variables, such as the size and nature of catchment populations and sites in which they are typically situated. There is limited ability to clearly identify those characteristics of the facility type that might have influenced productivity. Similarly, urban/rural location was strongly and significantly associated with productivity, suggesting that it is a proxy for a combination of several other variables. The strong, significant and positive association of poor road condition with productivity is not readily explained.

All other factors being constant, the regression analysis of productivity indicated limited influence of other indicators of potential influences on immunization demand and supply, such as the distance between the facility and the vaccine collection point, number of staff involved in immunization (except in the case of dose per staff indicators), energy source and district poverty. Some significant associations may however not have been identified due to the limited sample size.

5.5 Conclusions

Total facility productivity in immunization services were most strongly and consistently associated with total patient volumes, number of zones supported and facility type. Less consistently significant or strong associations were found with several other factors such as number of staff and urban-rural location. However, other factors may have been shown to be statistically significant if a larger sample of facilities had been studied.

The strong and consistent association of facility type with productivity and performance (Section 3 and Annex 8) suggests that facility type may be both representative of particular service models (though not specifically outreach and facility based services) and a varying mix of other factors that are associated with output and efficiency and which cannot be readily identified from the independent variables available from this study. Similarly urban/rural location seems to be a proxy for several factors affecting productivity.

The association with facility type, and somewhat separate association of both productivity and efficiency with attendance in Uganda, suggests that there may be a high degree of variability in the significance of various factors between facilities. This high variability may be due to the small size and (diverse) rural settings of most Ugandan immunization facilities.

From a planning perspective expected total outpatient load, number of zones supported and the facility type of any new facility or program expansion should be carefully considered, given their ability, together, to predict a substantial proportion of the total facility immunization outputs. They are thereby also likely to influence efficiency and immunization unit costs. However, particular local contexts will be important to consider in planning, given the variability between facilities' productivity and performance.

Further investigation of underlying causes of outliers and variations, and differences between facility types, would be useful to increase understanding of determinants of productivity and efficiency, and thus inform program management and planning.

6 Analysis of the Determinants of Routine Immunization Costs

6.1 Background: cost function analysis for immunization and primary health care

This section aims to identify determinants of total facility routine immunization costs in Uganda. If a combination of independent variables can be identified as strongly predictive of facilities' total routine immunization costs, this would be important information and might allow for development of tools to assist health service planners.

As noted earlier and in the Common Approach, relatively few studies have explored the cost determinants of immunization in Africa. The existing non-statistical costing studies of immunization have indicated that service volume; number of immunization sessions; type of strategy; and prices affect total vaccination program cost.[64] In Uganda, no specific studies of cost determinants were found. A few international statistical studies of the immunization program cost functions exist. A study in India by Brenzel (2005), applied a Cobb-Douglas functional form for a sample of 120 primary care facilities. The study found that the number of doses administered by a facility and the type of vaccination strategy were positively and significantly associated with facility cost. Population density and numbers of fully immunized children per working hour were negatively and significantly associated with cost.

Previous components of this study on facility costs, unit costs and productivity also provide some indication of the factors which seem likely to influence costs and explain variations in costs of different facilities. The costing has indicated that the largest contributors to facility costs are staff, vaccines and travel-related costs. Vaccine costs are likely to increase in line with immunization numbers, and given their large contribution to costs, could have a substantial influence on total costs of facilities as volumes increase. The size of the facility as measured in terms of doses or DTP3 children thus has a direct impact on the total cost of the facility but does not, on its own, explain the high variability of costs between facilities with similar levels of output, and vice versa. Smaller facilities are likely to have fixed costs such as minimum staffing levels which will not change even if there are small volumes of work and they are under-utilized. In such cases, larger volumes may not necessarily lead to a proportional increase in costs as some of the increase can be met by existing spare capacity, resulting in lower unit costs. Only when existing capacity is exhausted and new staff, sessions or services have to be put in place, will costs rise more rapidly.

Facility type would be expected to be associated with total costs of immunization, not only because some types are expected to have larger catchment populations and service volumes, but also because facility type represents a range of other factors that could affect costs including service delivery methods, staffing structures, logistical challenges and features of communities in which they are established. The importance

[64] See: Phonboon, et al 1989; Brenzel and Claquin; 1993; Kaddar et al 1999a; Kaddar et al 1999b; Levin et al 1999; Brenzel, 2006; Walker et al, 2004.

of transport costs in average facility costs also suggests that factors affecting them (e.g. outreach or remoteness) may also be important determinants.

Several other cost drivers may have been important determinants in other countries, but were not expected to contribute to explaining facility costs in Uganda, because they contribute small proportions of total costs and/or have limited association with total facility productivity (Section 5). These include factors such as the facility energy source. Price difference were also not expected to be a determinant of facility costs as staff and other inputs in all facilities are standardized to the public sector rates.

The above context informed testing and selection of the specific variables that were included in the regression analysis.

6.2 Methods

Total costs are a function of outputs, prices, and other factors that influence the shape or position of the cost curve with respect to outputs (see the Common Approach).[9] Therefore a cost function describes the minimum cost of providing a given volume of output as a function of exogenous prices and can be described as:

$$C = f(Q, P, Z) \qquad (1)$$

Where C is equal to total facility cost; Q represents outputs; P represents input prices; and Z represents a vector of production-related factors.[65] However, the costs of public health services may not be best described by assuming cost minimization, which applies to competitive markets. In particular, empirical data on the value of resources used by non-minimizers tends to show wide variation, with many more services operating far from the minimum cost frontier. In addition, planners can use the average resource use of non-minimizers to indicate what inefficient services will spend, but the average resource use will often not be stable.

Based on findings of studies from elsewhere, it could be hypothesized that that the cost of delivering immunization in Uganda would be a function of the quantity of:

- outputs (number of doses or FICs),
- prices,
- quality and productivity,
- capital investments and
- other environmental and contextual factors.

Indicators of these determinants were incorporated in developing the multiple regression models described below. Selection of variables was influenced by previous findings around costs and productivity in this and other studies.

6.2.1 Data sources and variables incorporated in the determinants analysis

Dependent variables

The three dependent variables were assessed: total facility routine immunization cost; total cost excluding vaccines; and total cost excluding salaries and vaccines.

---

[65] Importantly, these models assume that output levels and input prices are exogenous.

The intention of the analyses that excluded vaccine and/or HR costs was to identify determinants of service delivery costs excluding labour, that may have been obscured by the dominance of vaccine and/or salary costs in total costs.

Independent variables

The primary data source for the facility costs was the facility questionnaire which collected quantitative and some pre-coded qualitative questions. In addition, other data on potential determinants of facility costs were captured in the questionnaire. Secondary data was obtained from the Demographic and Health Survey, the Census and the District Health Information System. Variables that were collected and considered in the determinants analysis were:

i. From the facility-level questionnaire (primary data collection):
   a. Quantities: number of doses administered; number of FICs
   b. Quality: number of FTEs providing immunization-related services; doses/FIC; vaccine wastage rate; number of supervision visits per month; number of outreach visits per month;
   c. Prices: price of a litre of fuel, distance (Km) to the vaccine collection point, wages of health workers, use of community health workers
   d. Capital investment: building, vehicle or other capital costs
   e. Z's and control variables: facility type, proportion of immunizations provided through outreach, urban or rural situation of the facility, facility ownership, number of beds, condition of roads and distance to vaccine collection points
ii. Collected from the district level
   a. Population
iii. Estimated from DHS and census
   a. District poverty index
   b. District supervision visits

Certain variables mentioned above were considered but not used in final analysis. This was because they were not thought to be appropriate due to data quality (e.g. vaccine wastage rates), data validity (e.g. no variation in wages or fuel costs was applicable), high correlation between independent variables (see below) or lack of correlation between dependent and independent variables in question.

6.2.2 Regression Model

A cost determinants model was developed using a similar methodology to that described in Section 5.1 above for the productivity analysis. The model was developed after considering the proportional contribution of various costs to facility level total costs, the pattern or unit costs, plausible economic logic, and tests of the strength of associations between various independent and dependent variables.

Highly correlated independent variables were excluded from the final models, as were independent variables that did not exhibit substantial associations with the dependent variables. For the cost models, the variable measuring the full-time equivalent (FTE) of staff time involved in immunization was excluded from all models since this is known to be the biggest driver of cost. This was done in order to explore drivers of cost other than FTEs.

The cost function analysis was based on both the natural log and the numerical total cost. The model was then rerun with the dependent variable being the total facility cost excluding the vaccine costs, thus representing the service delivery cost. A third run assessed the total facility cost excluding both the vaccine and human resource costs, which (being a large portion of the total costs) may have been masking other interesting facility characteristics contributing to the variation in costs.

Functional form for evaluating the cost function

The model used for the analysis is as follows:

$$\ln(y_i) = \beta_0 + \beta_1 \ln(x_{1i}) + \beta_2 \ln(x_{2i}) + \beta_3 \ln(x_{3i}) + \beta_4 \ln(x_{4i}) + \beta_5 \ln(x_{5i}) + \beta_6 x_{6i} + \beta_7 x_{7i} + \beta_8 x_{8i} + \beta_9 x_{9i} + \beta_{10} x_{10i} + \beta_{11} x_{11i} + \varepsilon_i$$

The independent (*x*) variables were defined as for the productivity analysis in Section 5. However y_i is one of the dependent *cost* variables considered in the cost analysis.

Estimation issues

Least squares regression models were fitted to investigate determinants of the cost of delivering immunization services in Uganda, along lines described in Section 5 for output variables. Firstly to assess the degree of linear relationship between variables, Pearson correlation coefficients were fitted. Bonferroni adjusted significant levels are reported, to account for multiple comparisons. Variables were included in models if economic theory could plausibly associated them with dependent cost variables.

For the cost analysis, the variable measuring the full-time equivalent (FTE) of staff time involved in immunization was excluded from all models, as this is known to be the biggest driver of cost. This allowed for exploration of cost drivers other than FTE. Regression models for cost determinants, unlike the productivity models, also included a productivity variable (number of DTP3 children) as one of the independent variables.

Productivity dependent variables were fitted as independent variables in costing models in two ways;

i. as observed reported values,
ii. as fitted values from the productivity regression models.

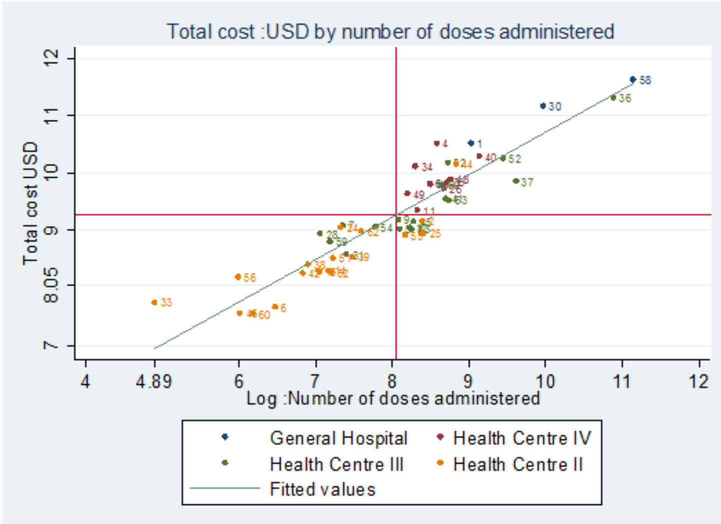
The investigation also considered non-linear forms of the productivity function by including a quadratic productivity term. Natural log (ln) values of variables were used where there was high variability if untransformed variables.

To assess the model fit a number of diagnostics were undertaken, as described in section 5.2.2 above and in Appendix 8.

6.3 Results – determinants of total facility costs

Figure 21 below illustrates results of scatter plot analyses used in developing hypotheses about determinants of total facility costs. The total cost per facility can be seen to be positively related to the number of doses administered. Hospitals with the highest outputs have greater total costs per facility than do the lower level facilities, with the HC IIs having the lowest total costs. In general, HCIII have a wide range of volumes and total costs. HC IV form a cluster above the fitted line, with relatively high volumes and total costs, suggesting somewhat higher cost for given volumes.

Figure 21: Total Facility Cost (US$) by the Number of Doses Administered



6.3.1 Descriptive statistics

Table 6-1 summarizes descriptive statistics of variables considered in regressions.

Table 6-1: Weighted Variable Summary Statistics (US$; N=49)

Cost variable	mean	sd	min	max
Weighted Total Cost	6762	8164	1442	58936
Total cost without vaccines	5181	6401	1311	46867
Total cost without vaccines and salaries	2332	3081	218	18853
HR cost	2849	3761	460	28014
# health staff involved in immunization	4.71	2.67	1.00	12.00
# Village health workers	15.61	15.48	0.00	86.00
# immunizations per session per week	1.71	2.03	0.25	7.00
Zones supported	13.01	19.78	0.00	150.00
Facility attendance	9754	17681	1760	230991
Catchment population	21549	68315	2700	500000
DTP coverage	0.72	0.76	0.00	3.16
Poverty Index	0.24	0.17	0.04	0.76
Distance to vaccination centre	10.06	9.31	0.00	60.00
FIC	298.19	673.76	25.00	8602.00
Vaccine dose per FIC	9.93	3.23	5.36	18.69
Vaccine cost per FIC	11.93	3.13	8.07	23.22
Vaccine Cost per doses administered	1.24	0.18	0.83	1.69
HR cost per FIC	19.64	21.36	1.44	75.55
# doses	2895	5850	134	68920
HR cost per doses administered	2.69	4.16	0.15	14.09
Unit cost per FIC	44.17	23.42	13.11	93.10
Unit cost per dose	5.17	4.56	1.29	17.37
Total cost per DTP3	44.17	23.42	13.11	93.10
HR cost per DTP3	19.64	21.36	1.44	75.55

6.3.2 Regression results

The factors associated with costs of delivering immunization services in the sampled health facilities were explored using multiple linear regression models.

Models firstly explored associations with total costs, HR costs and recurrent costs. Independent variables that had high correlation with total cost included number of health care staff, FTEs, number of days immunizations happened per week, and the size of the catchment population (see Annex 8 Table 8.6). These same variables were also highly correlated with the other cost variables. Thus in the cost regression models, FTEs and the number of immunization sessions per week were included while the catchment population was left out of all models.

To capture the effect of productivity in the costing models, the modelling used ln of both the actual observed numbers of DTP3 children, and the numbers of DTP3 children estimated by the productivity model.[66] This helps to test whether the productivity model adds to the predictive ability of the subsequent cost determinant model.

Models related to total costs, total costs excluding vaccines, and total cost excluding both vaccines and salaries are shown in Table 6-2.

In a multiple regression model, the factors that were associated with *total cost* were DTP3, number of zones supported, measures of poverty, whether the facility was in a rural or urban area and the type of health care facility. In *Model 1*, a 10% increase productivity (number of DTP3 doses administered) resulted in a 4% increase total facility cost, while a 10% increase in the number of zones supported was associated with a 0.5% increase in total cost. In the same model peri-urban facilities were associated with a 42% higher total cost compared to rural facilities, while urban facilities experienced 61% higher costs than rural facilities. Hospital facilities had the highest total cost, followed by health facilities IV, III and II in that order, with 46%, 63% and 66% lower cost respectively compared to hospital-based services.

When *estimated DTP3* (output from the productivity regression model) was used instead of the observed DTP3 *(Model 2)*, both the first and second power terms were significantly associated with total cost.[67] However, in this model the only other variables that were significantly associated with total costs were distance to vaccine collection point and being located in a peri-urban area relative to a rural area. When *estimated DTP3* was used, the predictive ability of the models (R-squared) remained similar to Model 1, suggesting that the productivity function derived in Section 5 is relatively good in predicting utilisation or productivity-related drivers of total costs. A notable change in results between estimated and observed DPT models is the reduced significance of facility type in estimated DPT models. This can be attributed to the fact that the productivity function used to produce estimated DPT values already includes the effect of facilities.

---

[66] Due to the high correlation between total doses and DPT3 children, and the higher correlation of DPT3 children with total costs, the variable DPT3 children was chosen as the preferred variable in the models.

[67] The $DPT3^2$ term was not however significant in any other models of productivity or costs.

When *vaccines expenses were removed* from the total cost (service delivery cost models), in delivery cost *Model 3*, poverty, area and facility type remained predictive factors. An increase of 10% in the poverty index, was associated with a 2.3% increase in delivery cost; peri urban centres and urban centres had 58% and 60% higher costs than rural facilities. Relative to hospitals, HC types IV, III and II had 50%, 74% and 79% lower delivery cost than hospitals. In *Model 4* estimated DTP3, distance to vaccine collection point, peri-urban location and facility type were associated with delivery cost.[68] Similar to the total cost model, number of outpatients seen at the facility and distance to vaccine collection point became more strongly and significantly associated with delivery cost, and facility type when estimated DTP3 was used instead of observed DTP3.

When models *excluded both vaccines and HR costs*, DTP3, state of roads and area were the only variables associated with costs *(Model 5*). An increase of 10% in DTP3 resulted in an increase of total cost that excluded vaccines and HR cost of 5.6%, poor roads were associated with a 65% increase in cost, while peri-urban centres had 164% higher costs than rural centres. The model did not change much when estimated DTP3 was fitted instead of observed DTP3 (*Model 6*), but only peri-urban location remained statistically significant. Of interest, HCIV seemed to have higher costs than hospitals once vaccines and HR were excluded, although this was not statistically significant.

Models that excluded vaccines, or vaccines and HR costs tended to have lower R-squared values, indicating less ability of available independent variable indicators to predict service delivery costs that excluded those cost components. These findings would appear to confirm that it is the vaccine costs and HR costs which are both the largest components of the total costs, and most affected by the independent variables and determinants identified in the analysis.

[68] HCII were omitted from this model due to co-linearity.

Table 6-2: Determinants of Weighted Total Cost, Total Costs without Vaccines, and Total Costs without Vaccines or Human Resources - final models

	Dependent Variable					
	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
	Ln total cost	Ln total cost	Ln total cost *without vaccines*	Ln total cost *without vaccines*	Ln total costs *without vaccines and salaries*	Ln total costs *without vaccines and salaries*
Variable	Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value	Coefficient (std error) p-value
Ln DTP3	0.40 (0.07) **< 0.01**		0.10 (0.09) 0.28		0.56 (0.19) **< 0.01**	
Estimated ln DTP3		0.29 (0.13) **0.03**		0.68 (0.14) **< 0.01**		0.92 (0.30) **< 0.01**
Estimate ln $DTP3^2$		0.04 (0.01) **< 0.01**				
Ln # Staff involved in immunization	0.18 (0.12) 0.15	0.18 (0.12) 0.14	0.31 (0.17) 0.07	0.29 (0.17) 0.09	-0.15 (0.33) 0.65	-0.16 (0.37) 0.68
Ln # Zones supported	0.05 (0.02) **0.03**	-0.005 (0.02) 0.82	0.05 (0.04) 0.15	-0.03 (0.03) 0.25	-0.06 (0.07) 0.36	-0.12 (0.06) 0.07
Ln facility attendance size	0.04 (0.08) 0.56	-0.16 (0.09) 0.08	0.01 (0.11) 0.92	-0.30 (0.13) **0.02**	-0.27 (0.22) 0.23	-0.47 (0.27) 0.10
Ln poverty index	0.18 (0.06) **< 0.01**	0.11 (0.06) 0.10	0.23 (0.09) **0.01**	0.12 (0.09) 0.19	0.16 (0.17) 0.35	0.09 (0.20) 0.65
Ln Distance to collectn pt	0.03 (0.02) 0.15	0.05 (0.02) **0.03**	0.03 (0.03) 0.25	0.07 (0.03) **0.02**	0.07 (0.05) 0.21	0.09 (0.06) 0.14
Roads						
Good/Fair	Reference (0)	Ref	Ref	Ref	Ref	Ref
Poor/very poor	0.02 (0.09) 0.81	-0.06 (0.09) 0.54	0.11 (0.12) 0.35	-0.11 (0.13) 0.37	0.50 (0.23) **0.04**	0.36 (0.28) 0.21
Energy source: cold chain						
Electricity	Ref	Ref	Ref	Ref	Ref	Ref
Other sources[&]	-0.05 (0.17) 0.75	0.19 (0.20) 0.34	-0.12 (0.24) 0.61	0.26 (0.28) 0.36	0.09 (0.47) 0.85	0.33 (0.60) 0.58
Area						
Rural	Ref	Ref	Ref	Ref	Ref	Ref
Peri-urban	0.35 (0.10) **< 0.01**	0.30 (0.10) **0.01**	0.46 (0.15) **< 0.01**	0.35 (0.14) **0.02**	0.97 (0.29) **< 0.01**	0.90 (0.31) **0.01**
Urban	0.48 (0.21) **0.02**	0.06 (0.24) 0.80	0.47 (0.29) 0.11	-0.35 (0.33) 0.31	0.13 (0.56) 0.82	-0.39 (0.72) 0.59
Facility type						
Hospital	Ref	Ref	Ref	Ref	Ref	Ref
Health facility IV	-0.61 (0.33) 0.07	0.35 (0.21) 0.10	-0.69 (0.47) 0.15	0.58 (0.29) 0.06	0.23 (0.91) 0.90	1.04 (0.63) 0.11
Health Facility III	-0.99 (0.28) **< 0.01**	-0.25 (0.13) 0.07	-1.34 (0.40) **< 0.01**	-0.45 (0.19) **0.02**	-0.71 (0.77) 0.36	-0.15 (0.40) 0.72
Health Facility II	-1.08 (0.33) **< 0.01**	-	-1.56 (0.46) **< 0.01**	-	-0.99 (0.90) 0.28	-
Constant	7.04 (0.65) < 0.01	7.26 (0.62) < 0.01	8.66 (0.92) < 0.01	7.10 (0.83) < 0.01	7.40 (1.80) < 0.01	6.40 (1.78) < 0.01
R – squared	0.93	0.93	0.85	0.84	0.75	0.69
F value	F(13, 35)=37.9 **< 0.01**	F(13, 35) = 37.4 **< 0.01**	F(13, 35) = 15.0 **< 0.01**	F(12, 36) = 19 **< 0.01**	F(13, 35) = 8.1 **< 0.01**	F(12, 36) = 6.4 **< 0.01**

6.4 Discussion

As might be expected, the determinants of facility immunization costs in Uganda were primarily those that drive vaccine and human resources costs. There was a considerable of consistency between the findings of models, suggesting that the conclusions are likely to be robust.

The predictors of *total cost* were DPT3 children, facility type, number of zones supported and poverty index. The high correlation between DTP3 children and total doses suggests that total doses (and other quantity variables) would also be a strong cost determinant both for total costs and other measures of cost for which DPT3 was significant. Number of zones supported may represent both service quantity, and other cost factors such as higher transport and staff time requirements when more zones are served (inter-alia, facilities with more zones tended to have more VHWs).

When predictors of *total cost excluding vaccines* were explored, the same determinants were identified as for total costs, with the exception of DPT3 children. The lack of significance of DPT3 children in predicting costs (in contrast to the models of total cost and total costs less vaccines *and* HR) seems to indicate the scale of HR in determining costs and the limited adaptation of HR inputs to service volumes. However, once *both vaccine and salaries were excluded*, only the number of DTP3 children was a significant predictor. This suggests that among the available variables there are no strong, systematic predictors of service delivery costs apart from this variable, with the exception of road condition and peri-urban location, whose strong effect is less easy to explain. The relative strength of facility attendance in *estimated* DTP3 models but not observed DTP3 models, suggests that observed DTP3 masks a potentially important (negative) association between costs and total facility attendance.

As with the analysis of productivity, the consistent, significant association of *facility type* in Uganda seems to be an important proxy for a number of factors related to service delivery models and contexts in which different types of health centres are typically sited. These factors are difficult to identify, but were noted to not be related to the proportion of services delivered through outreach and facility-based models. Of note, facility type was no longer significant in the model of costs excluding vaccines and HR. This suggesting that a mix of factors affecting vaccine costs and staff costs in various facility types drive total costs more than other features of facility types per se.

The significant association of district *poverty index* with dependent cost variables that included vaccines and/or HR, is notable and may be related to larger staff costs in services serving communities with higher poverty indices. The association of peri-urban setting with higher costs was relatively strong and consistent.

Road conditions were not significant determinants of costs in any models until both vaccine and salaries were excluded.

Price variables are difficult to explore, as costs of all inputs in Ugandan immunization services such as salaries and fuel prices are centrally determined. However, it was found that possible proxies for input costs (such as average cost per FTE or use of community health workers) had no significant association with dependent costs variables in a model with other productivity-independent variables. Quality variables were also not identified as significant cost determinants, although they are difficult to define with rigour from available data.

Regressions indicated strong independent association of facility type with total and non-vaccine costs in models that used observed values of DTP3. They also showed limited ability to identify a range of independent variables apart from immunization outputs that were strongly predictive of costs. As in the case of productivity, this may be due to the fact that the vast majority of facilities in Uganda are both rural and small. This could create a high degree of variability in a range of factors that could obscure associations which would be apparent if there were more, large facilities in less diverse contexts (see section 5.4). However, the limited number of significant independent variables may also relate to the limitations of the sample size, with some variables, which are in fact important, not reaching levels of statistical significance.

6.5 Conclusions

The examination of determinants of total immunization facility costs, and total costs excluding vaccines and/or human resources, confirmed expectations and findings of previous studies, that vaccines and human resources are the main determinants of facility costs. Their costs are in turn strongly associated with service volumes. They are also associated with a number of independent variables including facility type and district poverty index. Only numbers of DTP3 immunized children and peri-urban location were consistently and significantly associated with service delivery costs that excluded vaccines and HR, with less consistent associations with road conditions, remoteness and poverty. Facility type may represent a varying combination of a number of other variables related to service models and other factors that drive vaccine and HR costs in particular, that are not easy to identify individually.

Limited ability to identify other variables that are underlying cost determinants suggests that there may be wide diversity in contexts of various services, particularly small sites, which obscures further significant associations. Some which have been found to be significant in other studies, such as number of immunization sessions per week which is very strongly correlated with staffing and service volume indicators in Uganda, are probably effectively represented by other variables in the models. However, it is also possible that some significant associations may not be evident due to the limited sample size.

Consideration of expected service volume, facility type and number of zones served should assist planers in identifying total costs and HR costs for establishing a new facility or of extending coverage through existing services.

7 Mapping of Financial Flows for Routine Immunization

This section presents findings of the mapping of the actual financial flows for routine immunization in Uganda in 2009/10 and 2010/11.

7.1 Background: health care financing and immunization program planning and budgeting in Uganda

As detailed in Section 2.3 above, health care financing in Uganda has been increasing over the last decade. Per capita health spending increased to US$ 11.9 in 2009/10, but this declined to US$ 10.29 in 2011/12. [69] [70] The Government of Uganda's contributions to health spending have also grown substantially over that time (see Table 2-4 above).

Development assistance continues to be important in funding health care and immunization services. Much of this is 'off-budget' making it difficult for the MOH to track these expenditures or to co-ordinate efforts of the development partners, and to thereby ensure the national health priorities were being met. In 2011/12, the government's contribution to health was US$ 163 million, while the on-budget total external funding for health constituted US$ 57 million, bringing the overall health budget to US$ 219 million, excluding off-budget support. Much of the off-budget support went towards HIV/AIDS, TB, malaria and blood transfusion safety.[70]

The Ugandan National Health Accounts (2009/10) estimated that GoU contributed 14.4% of total health expenditure, while 35.6% came from development partners. The remaining 50% was from households, even though user fees had been removed from the lower health care facilities in 2001. Only a small proportion of the population in formal employment has access to private health insurance.[71] National Health Accounts and other aggregate estimates of expenditure provide very limited definition of the details of immunization-related expenditure and flows however.

7.1.1 Planning and budget process for routine immunization

In the budget allocation process, UNEPI receives a budget allocation from the MOH budget, with which it must undertake all the national level immunization activities and cover the UNEPI staff salaries. At the District and facility level, the MOH funds for immunization are included in the primary health care (PHC) grant which is sent from national MOH to the DHOs, and which is based on an estimation of need in each district, taking into account population served, number and level of health facilities, and other indicators. This grant is spent by the DHO as required to deliver integrated primary health care services, of which immunization forms part.

---

[69] Ministry of Financial Planning and Economic Development (MOFPED, 2009). MoH, 2010. Statistical Report: PER 2006, AHSPR 2008/9. Budget Out-Turn 2009/10.
[70] MOH. 2012/13. Annual Health Sector Performance Report. http://health.go.ug/docs/AHSPR_11_12.pdf
[71] MOH, 2010. Ugandan National Health Assessment (2008/09 & 20099/10). http://health.go.ug/docs/NHA_REPORT_FINAL_13.pdf

Spending of this PHC grant on immunization services cannot be differentiated from other activities, as it is included in general health expenditures, such as maintenance of vehicles, fuel, per diems for the village health workers, overheads, gas and other supplies. Development partners also continue to fund their health projects directly (off-budget), or for specific capital investments, rather than funding general health sector recurrent costs, which are nevertheless essential, for example, to ensure that the vaccines purchased by GAVI can actually be delivered to children in need.

7.1.2 Current knowledge on costs and financing of immunization

The National UNEPI program makes use of the cMYP tool for estimating the resources required for implementing their plan (2012-16) and projecting resources available in the future. This has reportedly improved their ability to project their uptake of vaccines, plan for their storage and distribution, and ensure adequate staffing at facilities to deliver immunization services. Of note however, many of the PHC service staff interviewed at the sampled facilities in the costing study indicated that there was limited adjustment of the PHC grant allocations to accommodate increasing need, combined with limited overall public funds for health care and difficulty balancing competing priorities. In relation to staffing, they reported over-working and long-hours, but at the same time felt they had adequate human resource capacity to roll-out the planned NUVI in 2013 and 2014. Similarly, some of the facilities and DHOs reported that the PHC grant is insufficient to cover all key items, so vehicles often remained unused due to lack of fuel or poor maintenance. Hence, there may be need to re-examine the PHC formula and allocations, and to ensure certain recurrent costs are adequately covered.

Further details of the cMYP projections, and mapping of funding sources, are provided and discussed in Section 7.5 below.

7.2 Objectives of the financial mapping

The objectives of the financial mapping were:

- To map the funding flows and key actors involved in immunization in Uganda;
- To identify and quantity all the sources of financing and commodities for immunization in Uganda in 2009/10 and 2010/11;
- To identify the contributions to the various immunization activities, providers and cost components, and;
- To measure the variance between the available funding and the estimated resource needs (from the RI costing study), by programmatic area if possible.

7.3 Methods for quantitative analysis of financial and commodity flows

7.3.1 Approach and Scope

A mapping methodology was applied for the quantitative analysis of the financial and commodity flows, whereby the financial sources and agents were interviewed to obtain their previous years' budgets (or commitments) and expenditure, as well as any commodity contributions (including any in-kind contributions) to routine immunization or NUVI preparatory activities in Uganda. The purpose of this analysis was to better describe these flows, to quantify funding available from various sources for routine immunization, and to identify the funded immunization activities. Mapping of financial flows is somewhat different to collecting data on the expenditures (funds spent) at the service delivery level, and thus did not include verification of the actual expenditure at the service provider level. Often the financial source or agent could provide only the broad figures of commitments or budgets and not the details of actual expenditure by production factor (line items) or activity. But wherever possible, the expenditures were captured and are presented below.

The scope of the analysis included all public and external sources of financing and commodities, and covered the financial years of 2009/10 and 2010/11. The financial sources, the sources of the sources, the financing scheme, the agents, providers, functions and production factors were coded using the new System of Health Accounts (SHA) 2011 classification system.[72] This allows for standardization and comparability across countries, and makes the results compatible with the National Health Accounts (NHA) being undertaken in many countries. For purposes of the mapping, the NHA code for the health care functions for immunization (HC.6.2) was further disaggregated to allow for greater detail on the types of immunization activities. Refer to Table 7-1 below for the details of the NHA disaggregated codes.

7.3.2 Data collection

The data on financial flows were collected primarily from national level public entities and the major development partners, using a standardized Excel questionnaire. For GAVI contributions, the GAVI record of disbursements was used.

The public sector health financing system in Uganda is largely centralized, thus most public sector contributions, for items such as vaccines, were obtained from the national level. A small primary health care grant is given to the district health offices (DHOs) to cover some of their operational costs. Some of this is sent to facilities, and is usually used to pay for incidentals, transport and stipends for the Village Health Workers (VHW). On the whole, the facilities in the sample were unaware of their specific immunization budget (apart from the small petty cash amounts). They could thus not provide information on what they had budgeted nor spent specifically on immunization, except for payment of some small incidentals for the village health workers (VHW) activities. Therefore, in order to estimate the public contributions towards salaries for immunization activities at the facility and DHO levels, the data collected through the primary costing data collection were utilized in the mapping exercise.

---

[72] WHO. 2011. System of Health Accounts (SHA). Geneva, Switzerland

7.3.3 Coding and analysis

The SHA (2011) codes are organized around the following categories, which were applied to the different aspects of the financial mapping for immunization:

- Revenues (Financing Sources-FS): classifies the funding source at country level. Additional codes (such as FS.RI=source of source) were also used;
- Health Care Financing (HF) which describes the mechanism of raising revenue (such as health insurance schemes);
- Financing Agents (FA) which mange the funds;
- Health Providers (HP): type of facility/health care establishment;
- Health Care Functions (HC): similar to activity and functional classifications;
- Health Care Provision (FP): the line item classifications, and:
- The burden of disease (GBD): in this case infectious disease.

As mentioned above, the Health Care Functions (HC) code was further disaggregated since the SHA only has one code for all immunization activities (HC.6.2), and this mapping required more detail. The disaggregation is shown below.

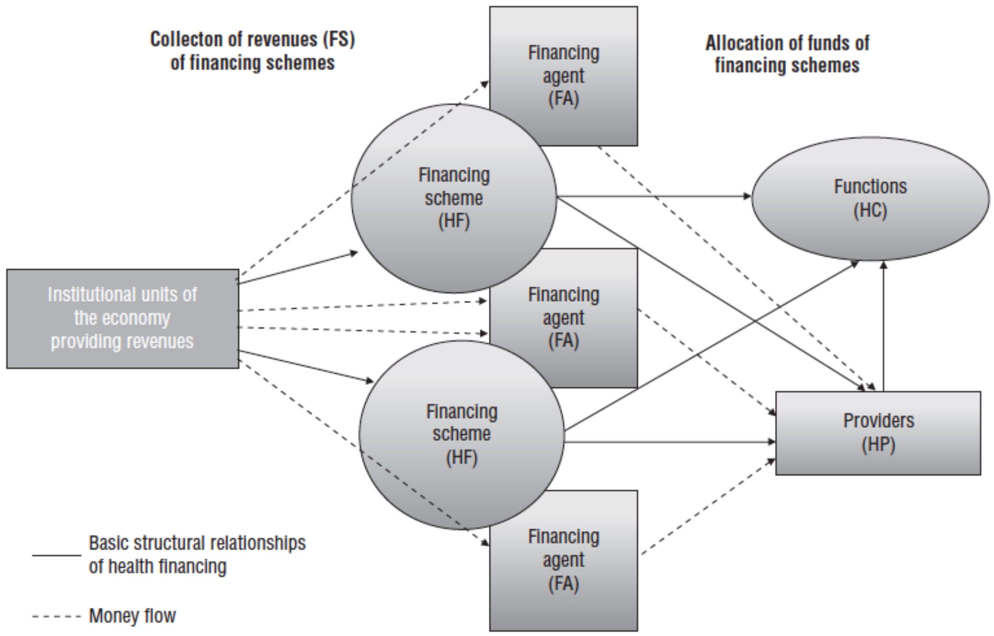
Table 7-1: SHA Codes Applied or Disaggregated for the Immunization Mapping in Uganda

HC.6	**Preventive care**
HC.6.1	Information, education and counseling programmes
HC.6.1.1	*Social mobilization, advocacy*
HC.6.2	Immunization programmes (not disaggregated)
HC.6.2.1	*Facility-based routine immunization service delivery*
HC.6.2.2	*Outreach routine immunization service delivery*
HC.6.2.3	*Training*
HC.6.2.4	*Vaccine collection, storage and distribution*
HC.6.2.5	*Cold chain maintenance*
HC.6.2.6	*Supervision*
HC.6.2.7	*Program management*
HC.6.2.8	*Other routine immunization programme activity*
HC.6.5	Surveillance
HC.6.5.1	*EPI Surveillance*
HC.6.5.2	*Record-keeping and HMIS*
HC.7	*Governance and health system financing and*
HC.99	**Not disaggregated**
HC.RI.3	**Prevention and public health services**
HC.RI.3.3	Prevention of communicable diseases

Appendix 7 sets out the detailed codes and sub-categories under each of the SHA codes which were applied in this analysis.

The following diagram provides the schematic framework of the SHA (2011) codes.

Figure 22: SHA (2011) Financial Framework



Source: IHAT for SHA 2011.

7.3.4 Key assumptions

The UNEPI offices provided figures on GAVI contributions for the two years which were far below the GAVI's own disbursement records. After consultation is was agreed that the GAVI figures should be used as it was reasonable to assume that country counterparts may not have been aware of all the disbursements made to the country.

The estimates of salary expenditure on immunization by the MOH at the DHO and the facility level were collected in the routine program costing exercise for 2011 reported above. Figures from sampled facilities and districts were weighted and aggregated to estimate the entire country public personnel spending. These estimates were assumed to be the actual spending from public sources and were included in this financial mapping. Since the costing study only collected data for 2011, the figure was deflated by 5% to estimate the spending in the previous year (2009/10).

7.3.5 Limitations to the approach

This resource mapping provides the first comprehensive and most rigorous attempt, to date, to quantify and map resources for immunization in Uganda, including normally 'hidden' expenditures such as government human resource costs. However, in addition to possible limitations arising from assumptions above, others should be noted.

- Certain key public funds might have been missed due to being 'embedded' in the general health care spending. However, the primary DHO and facility personnel data that were collected as part of the costing exercise was applied to minimize this effect as far as possible.

- Because the service providers were not interviewed, the actual provider could not be identified for every transaction. Either the sources of funding could indicate with some accuracy which were the providers of the services for their funding, or the most likely provider was assumed, and the best SHA code selected, as indicated from the source's perspective and guided by the Common Approach. For example, for all the vaccine purchases, the provider was assumed to be public health facilities. Since the amount provided was not split between hospitals and primary care sites, it had to be assumed that 60% was facility-based, while 40% was through outreach activities, based on the key respondents' estimates in the costing study.
- Where the health care function (HC) or the health care provision (FP) (activity or cost categories) were not available, they were placed in the "not disaggregated" categories.

The estimate of public sector salary expenditure based on the costing study allowed for substantially more accurate estimation of human resources financing than most resource mapping or resource tracking estimates. However, as it relied on recall by the facility and DHO staff about time spent on immunization activities, it may have some inaccuracies. Time-motion studies could have validated the current study estimates, but the time and cost required would not have been feasible for this study.

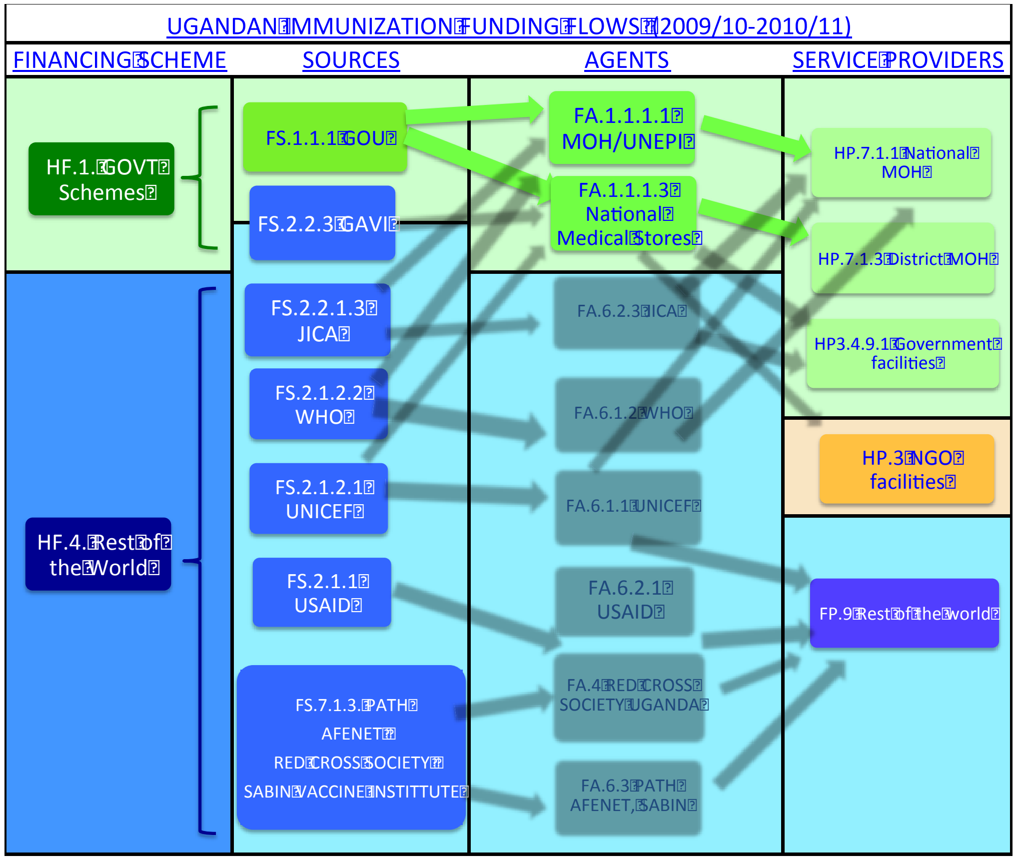
Importantly, any inaccuracies in the salary contributions are unlikely to misrepresent the overall quantum of this government contribution. They are also unlikely to affect overall conclusions that the contribution of the government through the hidden costs of salaries, overheads etc. may be substantial, since the government contributions are usually un-quantified and thus underestimated. However, estimates for 2009/10 public personnel spending are less reliable as no primary data was collected for that year.

7.3.6 Total country mapping of financial flows

The funding flows are graphically represented in Figure 23 below. They reflect the situation in both years.

In 2009/10 and 2010/11 the Government of Uganda and a number of key external development partners funded immunization services in Uganda. The development partners include GAVI, JICA, WHO, UNICEF, USAID (only in 2009/10), PATH, AFENET, Red Cross Society and the Sabin Vaccine Institute. The primary service providers were the public health facilities, the district and national levels of the Ministry of Health, as well as NGO health facilities. Some development partners also spent money themselves in various related activities, and for these expenditures (which were relatively small), they were labeled as 'rest of the world' providers. The results of the mapping are shown below, in a combination of bi-variate matrices and graphs.

Figure 23: Map of Funding and Commodity Flows for Immunization in Uganda (2009/10-2010/11)



NB. '*Rest of the world*' providers in this figure and subsequent sections refers to the external financial sources which spend money themselves in-country for various immunization activities.

7.4 Results - financial mapping

The total amounts of funding found for immunization in Uganda were US$ 24.1 million for 2009/10 and US$ 32.9 million for 2010/11.

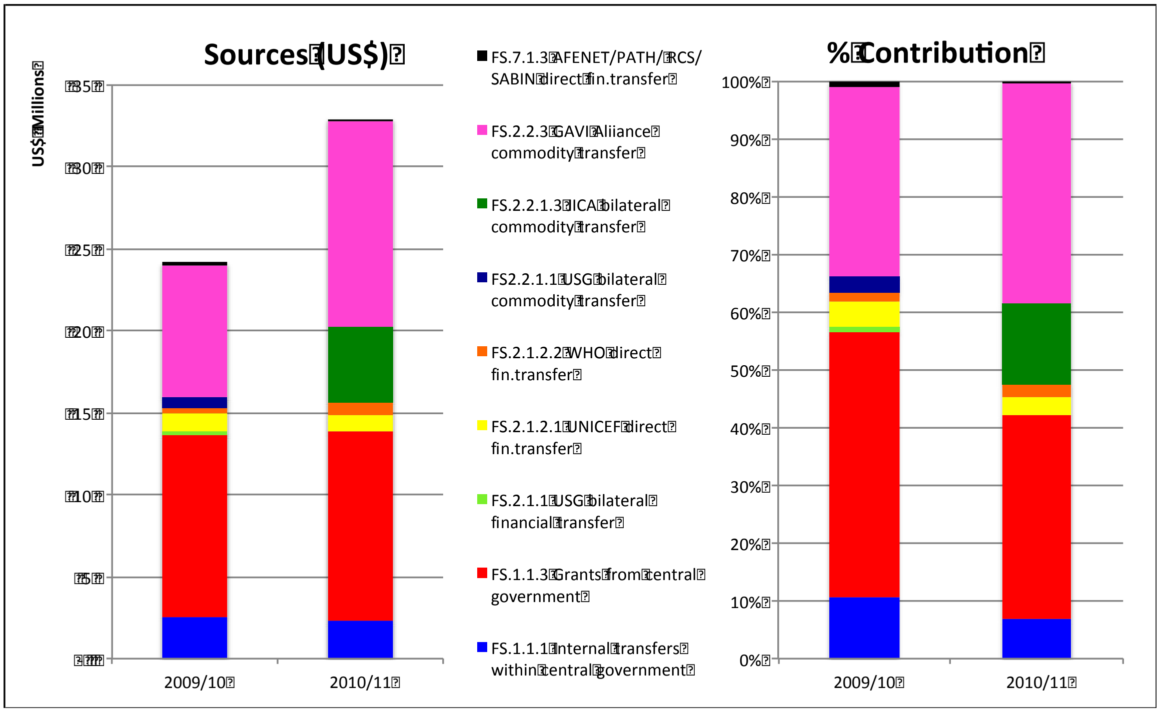
7.4.1 Financing Sources to Financing Agent (FS x FA)

When analyzing the financing source (FS) to financing agent (FA) it can be seen that the slightly larger portion of the funding for routine immunization in 2009/10 and 2010/11 came from the public sector, primarily through grants from central to district level for salaries at DHO and facility level (46% in 2009/10 and 36% in 2010/11). There was also public spending at the national level with public transfers within central government, which made up 11% and 7% in 2009/10 and 2010/11 respectively. The remainder of the total contributions (43% and 47%) were from the development partners, in 2009/10 and 2010/11 respectively.

The contribution of the government reduced proportionally in 2010/11 because JICA made a large injection of funds for cold chain equipment. In nominal terms, the public contribution increased slightly over the two years, as it was assumed that 5% inflation in salaries was experienced in 2010/11.

The Figure 24 provides the breakdown of the financing sources, and further details of the amounts from each source are provided in Table 7-2.

Figure 24: Sources of Total Immunization Financing in Uganda 2009/10 and 2010/11 (US$, %)



Note that the grants from central government are the primary health care grants sent to districts and the salary payments, which have been estimated from the primary costing data collection. The internal transfers within central government are the national level public spending, and include the co-financing required by the GAVI agreement.

Table 7-2 also provides details of the cross-mapping of specific sources to agents for 2009/10 and 2010/11.

Table 7-2: Financing Source (FS) and related Financing Agents (FA) (2009/10 and 2010/11), US$

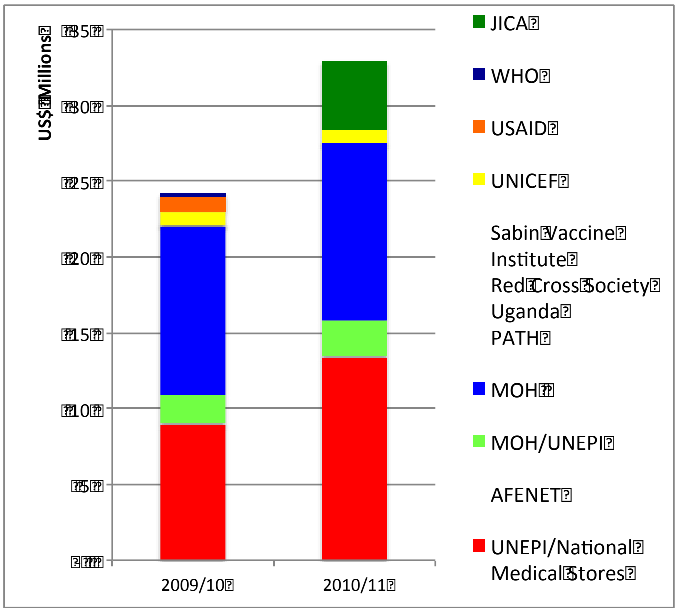
US$ (2009/10)		Financing Agent (FA)											
		AFENET	**UNEPI (MOH)**	**PATH**	**RED CROSS SOCIETY UG.**	**SABIN VACCINE INST.**	**UNICEF**	**USAID**	**WHO**	**National Medical Stores**	**MOH**	**Grand Total (US$)**	**% of Total (FS)**
	FA Code	FA.6.3.4	FA.1.1.1.1	FA.6.3.5	FA.4	FA.6.3.3	FS.2.1.2.1	FA.6.2.1	FA.6.1.2	FA.6.1.1	FA.1.1.1.3		
Financing Source (FS)	**FS Code**												
AFENET	FS.7.1.3	99 986										99 986	0,4%
GAVI	FS.2.2.3									7 962 874		7 962 874	33,0%
GOU	FS.1.1.1 & FS.1.1.3		1 590 485							988 978	11 040 524	13 619 987	56,4%
PATH	FS.7.1.3			89 897								89 897	0,4%
SABIN VACCINE INSTITTUTE	FS.7.1.3					19 997						19 997	0,1%
UNICEF	FS.2.1.2.1		167 976				914 306					1 082 282	4,5%
USAID	FS2.2.1.1 & FS.2.1.1							918 702				918 702	3,8%
WHO	FS.2.1.2.2		109 380						233 104			342 484	1,4%
RED CROSS SOCIETY Int	FS.7.1.3				24 642							24 642	0,1%
Grand Total		**99 986**	**1 867 841**	**89 897**	**24 642**	**19 997**	**914 306**	**918 702**	**233 104**	**8 951 852**	**11 040 524**	**24 160 851**	**100,0%**
% of Total (FA)		0,4%	7,7%	0,4%	0,1%	0,1%	3,8%	3,8%	1,0%	37,1%	45,7%	100,0%	

US$ (2010/11)		Financing Agent (FA)									
		AFENET	**JICA**	**UNEPI (MOH)**	**RED CROSS SOCIETY UG.**	**SABIN VACCINE INST.**	**UNICEF**	**National Medical Stores**	**MOH**	**Grand Total (US$)**	**% of Total (FS)**
	FA Code	FA.6.3.4	FA.6.2.3	FA.1.1.1.1	FA.4	FA.6.3.3	FS.2.1.2.1	FA.6.1.1	FA.1.1.1.3		
Financing Source (FS)	**FS Code**										
AFENET	FS.7.1.3	100 000								100 000	0,3%
GAVI	FS.2.2.3							12 540 611		12 540 611	38,1%
GOU	FS.1.1.1 & FS.1.1.3			1 404 698				873 362	11 621 604	13 899 665	42,2%
JICA	FS.2.2.1.3		4 566 313							4 566 313	13,9%
SABIN VACCINE INSTITTUTE	FS.7.1.3					20 000				20 000	0,1%
UNICEF	FS.2.1.2.1			122 519			854 882			977 401	3,0%
WHO	FS.2.1.2.2			782 344						782 344	2,4%
RED CROSS SOCIETY Int	FS.7.1.3				24 017					24 017	0,1%
Grand Total		**100 000**	**4 566 313**	**2 309 561**	**24 017**	**20 000**	**854 882**	**13 413 973**	**11 621 604**	**32 910 352**	**100,0%**
% of Total (FA)		0,3%	13,9%	7,0%	0,1%	0,1%	2,6%	40,8%	35,3%	100,0%	

7.4.2 Financing Agent to Health Provider (FA x HP)

As shown in Table 7-2 and Figure 25, in 2009/10 the bulk of the immunization funding in Uganda was managed by the MOH (46%), primarily due to the estimated salaries at the district and facility level, followed by Central Medical Stores (37%) and UNEPI (8%). This indicates the important ownership and leadership of the immunization program by the GoU.

Figure 25: Financing Agents for Immunization in 2009/10 and 2010/11 (US$)



In 2010/11, the majority of funds were publicly managed - 35% by MOH for the delivery of services through health care facilities, 41% by the National Medical Stores and 7% managed by UNEPI. However, JICA managed a large proportion (15%) related to its contribution of fridges in preparation for the roll-out of new vaccines. This expenditure is captured under capital investments in the activity tables and figures below, as was USAID's contribution of cold rooms in 2009/10.

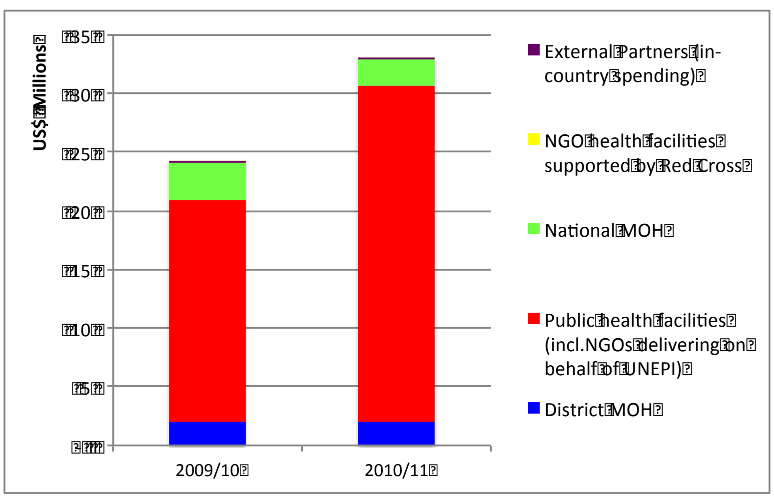
Table 7-3 cross maps the roles of financing agents and related providers of immunization services. Figure 26 in turn illustrates the relative scale of expenditure by different providers of immunization services. Apart from very small spending by the external sources on their own overheads, the bulk of the funds are consumed in the provision of services by the public entities. In 2010/11 public health facilities accounted for 87% of immunization spending, followed by UNEPI (7%), and district level MOH (6%). 'Public facilities' here *includes* those non-profit NGOs and for-profit private facilities which deliver immunization on behalf of the government and obtain their vaccine stocks from the government for this purpose. Thus the NGO portion shown in the figure below only captures expenditure through NGO facilities that were supported by the Red Cross, while most NGO expenditure was in fact captured as public entities. At the time of the study, details of the outputs of non-governmental providers could not be obtained, but this would be addressed in the proposed system of reporting of immunization numbers by all providers.

Table 7-3: Financing Agents and related Health Providers in 2009/10 & 2010/11 (US$, %)

US$ (2009/10)		Health Provider (HP) District MOH	Public health facilities	National MOH	NGO facilities	External Partners	Grand Total	% of Total (FA)
	HP Code	HP.7.1.3	HP.3.4.9.1	HP.7.1.1	HP.3.4.9.3	HP.9		
Financing Agent (FA)	FA Code							
AFENET	FA.6.3.4			99 986			99 986	0,4%
MOH/UNEPI	FA.1.1.1.1			1 867 841			1 867 841	7,7%
PATH	FA.6.3.5	53 116	12 342	24 439			89 897	0,4%
RED CROSS SOCIETY UGANDA	FA.4				24 642		24 642	0,1%
SABIN VACCINE INSTITTUTE	FA.6.3.3					19 997	19 997	0,1%
UNICEF	FS.2.1.2.1	914 306					914 306	3,8%
USAID	FA.6.2.1			918 702			918 702	3,8%
WHO	FA.6.1.2			233 104			233 104	1,0%
National Medical Stores	FA.6.1.1		8 951 852				8 951 852	37,1%
MOH	FA.1.1.1.3	1 102 682	9 937 842				11 040 524	45,7%
Grand Total		**2 070 103**	**18 902 037**	**3 144 072**	**24 642**	**19 997**	**24 160 851**	**100,0%**
% of Total (HP)		8,6%	78,2%	13,0%	0,1%	0,1%	100,0%	

US$ (2010/11)		Health Provider (HP) District MOH	Public health facilities	National MOH	NGO facilities	External Partners	Grand Total	% of Total (FA)
	HP Code	HP.7.1.3	HP.3.4.9.1	HP.7.1.1	HP.3.4.9.3	HP.9		
Financing Agent (FA)	FA Code							
AFENET	FA.6.3.4			100 000			100 000	0,3%
JICA	FA.6.2.3		4 566 313				4 566 313	13,9%
MOH/UNEPI	FA.1.1.1.1		251 835	2 057 727			2 309 561	7,0%
RED CROSS SOCIETY UGANDA	FA.4				24 017		24 017	0,1%
SABIN VACCINE INSTITTUTE	FA.6.3.3					20 000	20 000	0,1%
UNICEF	FS.2.1.2.1	854 882					854 882	2,6%
National Medical Stores	FA.6.1.1		13 413 973				13 413 973	40,8%
MOH	FA.1.1.1.3	1 160 718	10 460 887				11 621 604	35,3%
Grand Total		**2 015 600**	**28 693 008**	**2 157 727**	**24 017**	**20 000**	**32 910 352**	**100,0%**
% of Total (HP)		6,1%	87,2%	6,6%	0,1%	0,1%	100,0%	

Figure 26: Spending by Providers of Immunization Services in 2009/10 and 2010/11 (US$)



7.4.3 Financing agents to health care financing schemes (FA x HF)

The bulk of the funds for immunization went through central government financing schemes which accounted for 89.3% in 2009/10 and 80% in 2010/11 (Table 7-4). A large portion of this was through the primary health care grant from central government to the DHOs and facilities for salaries (as estimated from the costing study). The reduction in the proportion channeled through government in 2010/11 was due to the large capital investment by JICA through cold chain equipment purchases, which was coded under 'rest of the world' financing scheme. However, the absolute amount of funding through government did not decline.

Table 7-4: Financing agent to Health Financing Scheme (FAxHF) 2009/10 & 10/11 (US$)

		Health Financing Scheme (HF)			
US$ (2009/10)		**Rest of the world**	**Central government schemes**	**Grand Total**	**% of Total (FA)**
	HF Code	HF.4	HF.1.1.1		
Financing Agent (FA)	**FA Code**				
AFENET	FA.6.3.4	99 986		99 986	0,4%
Central Medical Stores	FA.1.1.1.1		8 951 852	8 951 852	37,1%
MOH	FA.6.3.5		11 040 524	11 040 524	45,7%
MOH/UNEPI	FA.4	277 356	1 590 485	1 867 841	7,7%
PATH	FA.6.3.3	89 897		89 897	0,4%
RED CROSS SOCIETY UGANDA	FS.2.1.2.1	24 642		24 642	0,1%
SABIN VACCINE INSTITTUTE	FA.6.2.1	19 997		19 997	0,1%
UNICEF	FA.6.1.2	914 306		914 306	3,8%
USAID	FA.6.1.1	918 702		918 702	3,8%
WHO	FA.1.1.1.3	233 104		233 104	1,0%
Grand Total		**2 577 990**	**21 582 861**	**24 160 851**	**100,0%**
% of Total (HF)		10,7%	89,3%	100,0%	

		Health Financing Scheme (HF)			
US$ (2010/11)		**Rest of the world**	**Central government schemes**	**Grand Total**	**% of Total (FA)**
	HP Code	HF.4	HF.1.1.1		
Financing Agent (FA)	**FA Code**				
AFENET	FA.6.3.4	100 000		100 000	0,3%
JICA	FA.6.2.3	4 566 313		4 566 313	13,9%
MOH/UNEPI	FA.1.1.1.1	904 863	1 404 698	2 309 561	7,0%
RED CROSS SOCIETY UGANDA	FA.4	24 017		24 017	0,1%
SABIN VACCINE INSTITTUTE	FA.6.3.3	20 000		20 000	0,1%
UNICEF	FS.2.1.2.1	854 882		854 882	2,6%
National Medical Stores	FA.6.1.1		13 413 973	13 413 973	40,8%
MOH	FA.1.1.1.3		11 621 604	11 621 604	35,3%
Grand Total		**6 470 076**	**26 440 276**	**32 910 352**	**100%**
% of Total (HF)		19,7%	80,3%	100,0%	

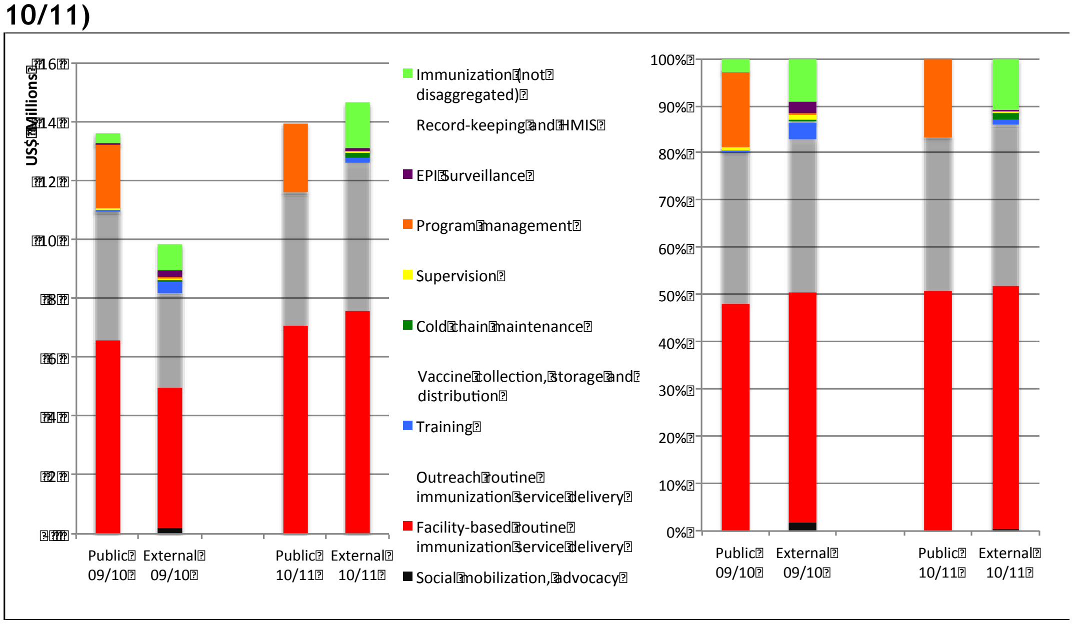
7.4.4 Health care functions and their financing sources (FS x HC)

Figure 27 shows the amount of health care spending on specific program activities. The largest share of the funding - 47% in 2009/10 and 44% in 2010/11 - went to facility-based routine immunization, followed by outreach immunization (31% and 29%). Program management and supervision took 9% and 7% respectively. Some spending could not be disaggregated, as details were not available from the provider level and these were captured under 'not disaggregated' (5% in both years).

Figure 27: Health Care spending on Immunization Activities (2009/10 & 2010/11), US$

Figure 28Figure 28 shows the financing source by the activity funded. This shows similarity in proportional breakdown for the public and external funds. The bulk of both sources was for facility-based routine immunization followed by outreach (due to 60% of vaccine spending being allocated to facility-based and 40% to outreach immunization). The Ugandan government also spent substantial amounts on vaccines as part of its co-financing for the GAVI grant, in addition to its personnel expenditure for outreach and facility based services.

Figure 28: Spending on Immunization Activities by Finance Source (US$, 2009/10 & 10/11)

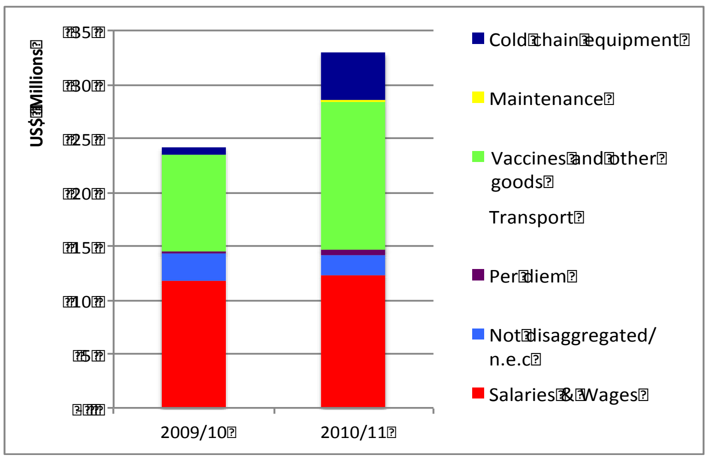


Further details of the breakdown of Financing Sources related to Immunization Activities are provided in Appendix 7.

7.4.5 Financing sources to health care factors of production (FS x FP)

Considering the breakdown by factors of production (line items), it can be seen from Figure 29 and Table 7-4**Error! Reference source not found.** below that the majority of spending was on salaries (49% and 38% in 2009/10 and 2010/11) from GOU, based on the estimates of spending on salaries at DHO and facility level from the costing study. Spending on vaccines and supplies followed (37% and 41%), of which most was funded by GAVI, with the government's co-financing contribution. Cold chain equipment investments were USAID and JICA contributions in 2009/10 and 2010/11 respectively.

Figure 29: Immunization spending by Line item, 2009/10 & 2010/11 (US$)



7.4.6 Immunization activity by health care provision factors of production

The spending on the immunization activities is split into their factors of production in Table 7-6 below.

The largest line item, wages and salaries at DHO and facility level, was split 60% to routine facility-based immunization and 40% to outreach immunization activities. Vaccines were split similarly between these activities.

In 2009/10 USAID contributed cold rooms for storage at national level, and in 2010/11, JICA contributed a large number of refrigerators at facility level (13% of total spending), all in preparation of the roll-out of new vaccines. These are captured under capital investment, and are not attributed to a specific immunization activity, in conformity with the SHA approach.

The above sections have presented the available data for the financial mapping of contributions and commitments made to immunization in Uganda in 2009/10 and 2010/11. These are compared below with the cMYP and the cost estimates presented earlier.

Table 7-5: Financing Source (FS) for Line items (FP) 2009/10 & 2010/11 (US$)

US$ (2009/10)		Factors of Production (FP)							
		Cold chain equipment	Not disaggregated / n.e.c	Per diem	Transport	Vaccines and other goods	Wages & Salaries	Grand Total	% of Total FS
	FP Code	FP.4.1	FP.99	FP.1.3.1	FP.3.3.1	FP.3.2.1.1	FP.1.1		
Financing Source (FS)	FS Code								
AFENET	FS.7.1.3		99 986					99 986	0,4%
GAVI	FS.2.2.3					7 962 874		7 962 874	33,0%
GOU	FS.1.1.1 & FS.1.1.3		768 950	6 181	45 720	988 978	11 810 157	13 619 987	56,4%
PATH	FS.7.1.3		66 376	14 446	2 809	6 266		89 897	0,4%
SABIN VACCINE INSTITTUTE	FS.7.1.3		24 642					24 642	0,1%
UNICEF	FS.2.1.2.1		19 997					19 997	0,1%
USAID	FS2.2.1.1 & FS.2.1.1		1 082 282					1 082 282	4,5%
WHO	FS.2.1.2.2	684 629	234 073					918 702	3,8%
RED CROSS SOCIETY Int	FS.7.1.3		289 553	33 230	19 701			342 484	1,4%
Grand Total		**684 629**	**2 585 860**	**53 857**	**68 231**	**8 958 118**	**11 810 157**	**24 160 851**	**100,0%**
% of Total (FP)		2,8%	10,7%	0,2%	0,3%	37,1%	48,9%	100,0%	

US$ (2010/11)		Factors of Production (FP)								
		Cold chain equipment	Maintenance	Not disaggregated /n.e.c	Per diem	Transport	Vaccines and other goods	Wages & Salaries	Grand Total	% of Total FS
	FA Code	FP.4.1	FP.3.3.2	FP.99	FP.1.3.1	FP.3.3.1	FP.3.2.1.1	FP.1.1		
Financing Source (FS)	FS Code									
AFENET	FS.7.1.3			100 000					100 000	0,3%
GAVI	FS.2.2.3						12 540 611		12 540 611	38,1%
GOU	FS.1.1.1 & FS.1.1.3				403 371	34 061	1 125 197	12 337 036	13 899 665	42,2%
JICA	FS.2.2.1.3	4 374 936	191 378						4 566 313	13,9%
SABIN VACCINE INSTITTUTE	FS.7.1.3			24 017					24 017	0,1%
UNICEF	FS.2.1.2.1			20 000					20 000	0,1%
WHO	FS.2.1.2.2			977 401					977 401	3,0%
RED CROSS SOCIETY Int	FS.7.1.3			711 601	70 742				782 344	2,4%
Grand Total		**4 374 936**	**191 378**	**1 833 020**	**474 113**	**34 061**	**13 665 808**	**12 337 036**	**32 910 352**	**100,0%**
% of Total (FP)		13,3%	0,6%	5,6%	1,4%	0,1%	41,5%	37,5%	100,0%	

Table 7-6: Immunization Activity by Factors of Production (2009/10 and 2010/11), US$

US$ (2009/10)	Immunization Activity (HC)												
Line-items	Facility-based routine immunization service delivery	Outreach routine immunization service delivery	Program management	Record-keeping and HMIS	Social mobilization, advocacy	Supervision	Surveillance	Training	Vaccine collection, storage and distribution	Immunization programmes (not disagg.)	Cold chain maintenance	CAPITAL INVESTMENT	Grand Total
Cold chain equipment												684 629	684 629
Not disaggregated/n.e.c	6 844	19 760	283 145		172 435	139 421	183 299	402 154		1 300 307	78 496		2 585 860
Per diem						14 446	39 411						53 857
Transport	4 691		60 731	2 809									68 231
Vaccines and other goods	5 371 111	3 580 741							6 266				8 958 118
Wages and salaries	5 962 705	3 975 137	1 872 315										11 810 157
Grand Total	**11 345 352**	**7 575 638**	**2 216 191**	**2 809**	**172 435**	**153 867**	**222 709**	**402 154**	**6 266**	**1 300 307**	**78 496**	**684 629**	**24 160 851**
% of Total HC	47,0%	31,4%	9,2%	0,0%	0,7%	0,6%	0,9%	1,7%	0,0%	5,4%	0,3%	2,8%	100,0%

US$ (2010/11)	Immunization Activity (HC)										
Line-items (FP)	Facility-based routine immunization service delivery	Outreach routine immunization service delivery	Program management	Social mobilization, advocacy	Supervision	Surveillance	Training	Immunization prgms (not disagg.)	Cold chain maintenance	CAPITAL INVESTMENT	Grand Total
Cold chain equipment										4 374 936	4 374 936
Not disaggregated/n.e.c			203	44 017	43 323		178 993	1 566 483			1 833 020
Per diem			403 371			70 742					474 113
Transport			34 061								34 061
Vaccines and other goods	8 300 219	5 365 589									13 665 808
Maintenance									191 378		191 378
Wages and salaries	6 276 532	4 184 355	1 876 149								12 337 036
Grand Total	**14 576 751**	**9 549 944**	**2 313 784**	**44 017**	**43 323**	**70 742**	**178 993**	**1 566 483**	**191 378**	**4 374 936**	**32 910 352**
% of Total HC	44,3%	29,0%	7,0%	0,1%	0,1%	0,2%	0,5%	4,8%	0,6%	13,3%	100,0%

7.5 Comparison with cMYP estimates of financing

The UNEPI cMYP work plan (2012-16) estimated that the total resources required for the program would climb from US$ 44,799,799 in 2012 to US$ 91,380,950 in 2016 (See Table 7-7). The future program costs will be driven by:

- The costs for vaccines (including the roll-out of new vaccines);
- Personnel which includes salaries and allowances;
- Activities planned for the NUVI preparation, including cold chain expansion, training, social moblisation, and M&E; and,
- The program recurrent costs and injection supplies.

Table 7-7: cMYP estimated resource needs for the UNEPI Multi-Year Workplan

US$	**Expenditures**	**Future Resource Requirements**					
cMYP Programme Components	2011	2012	2013	2014	2015	2016	Total 2012 - 2016
Vaccine Supply and Logistics	18,566,288	21,487,248	46,233,197	74,797,435	75,100,955	77,376,444	294,995,279
Service Delivery	4,813,551	5,479,923	6,004,158	6,312,481	6,525,855	6,461,838	30,784,256
Advocacy and Communication	155,690	844,430	892,604	943,400	996,800	1,052,967	4,730,200
Monitoring and Disease Surveillance	762,985	1,688,860	1,785,207	1,886,801	1,993,599	2,105,933	9,460,400
Programme Management	482,548	1,429,028	1,496,782	1,584,401	1,681,807	1,739,101	7,931,119
Supplemental Immunization Activities	3,647,974	9,981,997	1,233,191	2,755,658	12,048,201	1,355,475	27,374,521
Shared Health Systems Costs	3,287,727	3,888,313	3,989,125	7,947,402	4,198,239	4,289,191	24,312,271
Grand Total	**31,716,763**	**44,799,799**	**61,634,264**	**96,227,578**	**102,545,456**	**94,380,950**	**399,588,047**

When cMYP resource needs estimates for 2011 are compared to this study's mapping of resources flow for 2010/11, the overall totals were similar. The mapping total estimate is around US$ 4.8 million or 17% higher than the cMYP estimate (Table 7-8).

Comparison of funding estimates for specific program and cost components indicates some notable differences. However, the cMYP program components and mapping categories differed, limiting comparability. To facilitate comparisons, a cross-walk between them was devised as shown in Table 7-8.[73] The largest variance was found in the service delivery, where the mapping estimate is almost US$ 5.9 million more than the cMYP, primarily due to the inclusion of the DHO and facility level costs of salaries, as well as some other costs such as transport, equipment and maintenance. Although

[73] For comparisons the following cross walk was devised:
- cMYP 'Vaccine supply and logistics' were compared with the mapping categories of routine immunization (facility and outreach), 'immunization not disaggregated' (primarily GAVI's contribution to vaccines) and cold chain maintenance costs.
- cMYP "Service delivery" was compared with the mapping categories of supervision, distribution, training and the estimated DHO and facility salary costs (the main costs incurred at service delivery level by GoU).
- cMYP 'Advocacy and communications' was compared with 'social mobilisation',
- cMYP 'monitoring and disease surveillance' was compared with 'surveillance'.
- Programme management was a direct comparison.

The mapping did not have SIA activities or shared health systems costs. Cold chain investments found in the mapping were not compared with any existing cMYP category, as it was not clear which of them incorporated such capital investments.

not directly comparable, some of the $3.28 million for shared health system costs in the cMYP categories might make up some of the gap between the cMYP and the mapping's Service Delivery estimates.

The other large variance was found in the cold chain maintenance costs (US$ 4.4 million) and vaccine supply costs, which were around US$ 3 million more in the cMYP estimates. This could possibly be have been due to somewhat lower actual coverage achieved than was assumed to be achieved in the cMYP. Program Management mapping was somewhat higher (US$ 1.8 million) than the cMYP estimates, probably due to the fact of including the district and national salaries which were labeled as program management. However, identifiable financing for Advocacy and Communication, and for Monitoring and Surveillance, were substantially lower in the mapping, which could not easily identify spending on these activities since such details were not obtained from the service provider level.

Table 7-8: Comparison of Funding Flow Mapping with the cMYP Resource Needs Estimates for 2011 (US$)

	US$	cMYP Estimates	Study Mapping Estimates	Variance between cMYP & Mapping
Cross-walk of categories:				
Mapping Categories	**cMYP Programme Componer**	**2011**	**2010/11**	**2011**
Vaccines/not disagg & cold chain maint	Vaccine Supply and Logistics	18 566 288	15 423 669	-3 142 619
DHO/facility salaries, supervn & trg	Service Delivery	4 813 551	10 683 203	5 869 652
Soc.Mobilization	Advocacy and Communicatior	155 690	44 017	-111 673
Surveillance	Monitoring and Disease Surve	762 985	70 742	-692 243
Prog.Mgmt	Programme Management	482 548	2 313 784	1 831 236
Cold Chain equipment	Cold Chain Equipment Investments		4 374 936	4 374 936
	Shared Health Systems Costs	3 287 727		-3 287 727
	Grand Total	**28 068 789**	**32 910 352**	**4 841 562**

Table 7-9 compares the projected available sources of funding as anticipated in the cMYP with the financial mapping for 2010/11.[74] Central government had much higher spending (US$ 5.5 million more) than anticipated in the cMYP, because of including the salary expenditure at DHO and facility levels in the mapping, rather than in the district local government category (US$ 3.6 million) separately from central government finance due to not tracking funding down to district level. This item would close some of the gap between the cMYP total government funding estimate and the mapping amount.

UNICEF and WHO contributions were much lower than anticipated. JICA spent double its anticipated contribution, probably due to the disbursement of the total amount in 2011 that was meant to have been spread over two years, which was hence all captured in the mapping for 2011. AFENET, Sabine and Red Cross Society also made some small, unanticipated contributions. Overall, once the increase in government sources is considered, external funding identified in the mapping was only around $ 1.2 million (4%) *more than was anticipated* in the cMYP for 2011.

[74] The cMYP list of funding commitments does not relate directly to resource needs included in the cMYP.

Table 7-9: Financing Sources – comparison of cMYP and Financial Mapping (2010/11 US$)

	cMYP Finance Estimates	Study Mapping Estimates	Variance between cMYP & Mapping	
Funding Sources:	**2011 (US$)**	**2010/11**	**2011**	**%**
Central Government	8 437 918	13 899 665	5 461 747	65%
District Local Government	3 587 818		-3 587 818	-100%
UNICEF	3 423 584	977 401	-2 446 182	-71%
PATH *	653 617		-653 617	-100%
WHO	1 584 167	782 344	-801 823	-51%
GAVI	11 746 006	12 540 611	794 605	7%
JICA	2 283 654	4 566 313	2 282 659	100%
TOTAL	**31 716 763**	**32 910 352**	**1 193 588**	**4%**

NB. USAID and PATH contributed in 2009/10 but not 2010/11

Note that the mapping did not collect local government contributions.

7.6 Discussion

The above resource mapping represents the most comprehensive and robust resource mapping exercise for immunization in Uganda to date. There have been no previous studies or routine systems to enable the UNEPI and its partners to map financing by government and its partners. The methodology developed for this study allowed for much more refined and complete mapping of resources to assist policy makers than is feasible from routine NHA, SHA or cMYPs.

Profile of finances and flows

The scale and nature of government's contribution identified in the resource mapping have important implications for discussion of future sustainability and country co-financing. The study indicated that the government of Uganda made the largest contribution to the funding of the routine immunization programme. Its contribution amounted to 56% in 2009/10 and 42% in 2010/11 (when large partner expenditure on cold chain equipment reduced government's proportional contribution, though its nominal contribution remained similar). This is higher than the 38% suggested by the cMYP's identification of public funding sources for the programme in 2011. The mapping estimate also exceeds previous estimates such as the Lydon's (2008) analysis of FSPs which found that governments were on average financing approximately 42% of immunization-specific costs, and Brenzel and Politi's (2012) analysis of 56 cMYPs between 2004 and 2012 which found that governments accounted for around 56% of total financing of routine immunization.

Human resources made up the bulk of the Ugandan government's financial contribution, and this study has provided the most robust estimate of human resources costs to date, based on the costing study. In addition, the GOU also funded substantial expenditure on routine vaccines as part of its co-financing agreement with GAVI, as well as other more 'hidden' delivery costs covered within the health sector.

The mapping also confirmed that development partners still played a key role in immunization even ahead of the introduction of new vaccines, in 2009/10 and 2010/11. GAVI had a central role in financing of vaccines, equivalent to 33% and 38% of total costs in the two years. But other partners often provided catalytic expenditures enabling the immunization system to function effectively, including supporting large non-routine capital expenditures such as cold chain equipment.

Comparison with cMYP, funding gap estimates and sustainability

The ability to compare the study resource mapping with cMYP was complicated by different categorization of expenditure, as the cMYP mixed activity and line item costs. Limited detail was also available about the assumptions and components making up the cMYP estimates. Timing of disbursements and actual expenditures in relation to specific years also posed some challenges. Thus the assessment of differences and possible funding gaps was made difficult.

Nevertheless, this mapping suggested that actual funding flows for various programs activities in 2011 exceeded cMYP resource needs estimates by $1.2 million (4%). This could suggest that the cMYP cost estimates were under the actual funding available, or that performance and therefore actual spending were lower than the anticipated costs.

The sustainability of the immunization program depends to a large extent on whether additional funding can be secured and effectively programmed for increased resource requirements associated with the introduction of new vaccines, improved coverage of existing vaccines, an expanding population and ensuring adequate health and immunization system capacity to support these. The cMYP estimated an increase of immunization costs from $31 million in 2011 to over $96 million by 2014, of which the bulk will be for the vaccines. Increases of this magnitude would require a very large proportional increase on the 2011 government contribution of around $15.3 million to the routine immunization, amounting to 9.4% of the total government health contribution of $ 163 million.

Consideration of the GOU's future capacity to contribute a greater share must take into account their potentially limited fiscal space to do so. The sustainability of the immunization program seems likely to depend on on-going and increased funding from partners for the foreseeable future, combined with increasing contributions from government. The significant contribution which the state already makes to immunization points to a commitment to the program and a strong sense of ownership. Although increased GOU contributions to immunization may be seen as enhancing sustainability and ownership, they will also add more strain on the already over-stretched health budget.

A further major feature of the comparison of the mapping to cMYP, is that there were substantial differences between financing estimates for program sub-components, even if allowance was made for differences in cost classifications, plans and assumptions. Unless there is substantial flexibility to reprogram overall funding to meet under-budgeted needs, some key program components may be under-funded.

The potential for mismatches between planned and actual resource needs may also increase substantially with program expansion, while the capacity to absorb (spend) available funds might decrease. Further investigation seems warranted to explore where there could be significant functional implications of possible mismatches between cMYPs, other plans and actual resourcing and its absorption. If so, both routine immunization resources and additional resource requirements for new vaccines may need to be carefully considered to ensure that key aspects of NUVI or routine immunization are not under resourced, and that capacity is sufficient to absorb the additional funding within proposed timeframes.

Data and methodological challenges

The study highlighted a number of challenges in mapping finances for immunization in Uganda. Government budgeting and expenditure accounting systems do not allow for easy identification of resources allocated to, and spent on, the immunization or other programs, particularly where the expenditures are accounted for within the general PHC grants. The main exception is vaccine expenditure, which has specific funding.

The quality and accessibility of some cost and related activity data from government and various partners was also a challenge. A number of general challenges have been noted above in the costing of routine immunization (Section 3), which also affected the financial mapping, and particularly the estimation of government contributions to service delivery and vaccine related costs. These included: poor quality of output and cost data at various levels in the system; limitations in estimation of certain costs, particularly human resources and vaccine wastage; and the inconsistent categorization of expenditures and resource allocation to inform planning and funding.

This mapping represents an important testing of the applicability of the SHA codes for immunization resources, with adjustment for more disaggregation. The methodology can provide relatively simple tools for the collection and analysis of current and future funding commitments on a routine basis, perhaps annually or biennially. However, there were some limitations in using the SHA codes to analyze the funding flows, particularly with regards to the limited disaggregation of immunization-related activities. In some cases, it was more useful to trace funding flows between institutions rather than to classify the type of health care financing mechanism, and therefore the coding of Financing Agents (FA) was found to be more useful than the codes pertaining to Health Care Financing (HF). It was also apparent that the SHA and cMYP approaches, as well as the accounting information from government and partners, are not yet sufficiently harmonized to readily allow operational conclusions to be drawn and planning decisions to be made. This is exacerbated at sub-national level, where the data are even more difficult to collect and analyze.

Further consideration therefore needs to be given to harmonizing the approaches and systems, as both national and sub-national levels, where this can be done cost effectively in order to produce financing information that can facilitate management for results. Possible areas for rationalization are the cMYP classifications, and ways of ensuring consistency between financing and expenditure projections. The disaggregated, adjusted SHA codes developed for this study may be a useful reference in such processes, and the extension of the methodology to the sub-national level could provide valuable insight into financing sources and flows at this level.

Clearer tracking of resources to the non-governmental and for profit providers would be beneficial, as would assessments of the volume of vaccines provided to these entities and out-of-pocket payments made to private for profit providers for immunization services.

Some lessons and experiences could also be drawn from NHA and National AIDS Spending Assessment (NASA) efforts to track all sources of expenditure for health and HIV specifically. These approaches have evolved over several years and now make routine contributions of detailed actual expenditure data that informs planning, resource allocation and financial management. At the same time, mapping of the resource envelope in terms of commitments/ budgets provides information on the intended contributions, against which to measure the actual absorption of funds.

7.7 Conclusions

The resource mapping is the most comprehensive estimation of flows of financing for routine immunization in Uganda to date and provides particular clarity around the contribution of government to the programme. The mapping highlights that the Government of Uganda is in fact the largest funder of routine immunization (42% in 2010/11), particularly through its funding of personnel and other support functions at national, district and facility levels. However, the contributions of development partners remain critical for the immunization programme, particularly GAVI for vaccines (38% of expenditure in 2010/11) and JICA, USAID, WHO and other partners for cold chain equipment and other strategic inputs.

The findings have important implications for country ownership, sustainability and co-funding decisions. Comparison of the mapping to the cMYP estimates of resource needs and financing flows shows various discrepancies in estimations of financing gaps. Functional implications of differences in expected and actual funding flows in total, and for particular activities, are worthy of further assessment to ensure key processes and activities function optimally.

The large costs of introducing new, expensive vaccines will create new challenges for the Uganda MOH within fiscal space constraints and likely budget rigidities within the health sector, as well as to manage the increased finances for maximum absorption and optimal results.

Further mapping initiatives are thus likely to be valuable in coming years to quantify the increasing funding needs, funding flows and gap analyses. A useful option would be to ensure that there is a single system which can accurately capture all funding and contributions from partners and at the same time reconcile government reported figures to plans, as well as donor reports. Such reconciliations may not always be possible, but it should be feasible to establish a system which accurately records all substantial donations, their primary purpose and actual expenditures at each level of the health system above facility level. This would at least provide a more accurate indication of levels and adequacy of financing flows and, in turn, would support planning, budgeting and immunization management. A harmonized system for coding all these funding flows by health activity (such as the disaggregated SHA codes developed here) would facilitate this process.

Sustainability and improved coverage can also benefit from more detailed financing analyses by programmatic area and line items, as well as the identification of potential bottlenecks, delays and fund re-allocations. Improved accounting and transparency around actual expenditures by government and partners, would have the potential to improve the efficiency of funding utilisation. Other areas that could be explored further include sub-national funding flows and funding related to non-governmental providers.

8 Conclusions and Recommendations

This study involved the collection and analysis of detailed primary data from health facilities and higher levels of the health system to estimate the costs incurred in delivering routine immunization in 2011, and for the introduction of PCV in 2013. Regression analyses were undertaken to explore the factors affecting productivity and the determinants of cost. Finally a financial mapping ascertained the contributions of the key financial sources to immunization in 2009/10 and 2010/11, and estimates of the resource gap were assessed.

8.1 Main conclusions

Routine immunization program costs

The cost estimates for immunization in Uganda represent an important step forward in obtaining a more comprehensive and accurate reflection of actual costs at facility, district and national levels for planners and managers. Several main conclusions arose from the costing in relation to contributors to costs.

- The bulk of routine program costs (80%) were incurred at facility level (when including the vaccine costs at facility level), followed by the national level (11.5%), and then district level (8.4%).
- HCII contributed an estimated 30% of all facility level immunization costs although they represent 60% of facilities. HCIII represented 30% of facilities and 37% of costs, HCIV 5% of facilities and 12% of costs, and hospitals 4% of facilities and 21% of costs.
- Vaccines and vaccines supplies (38% together) were the largest cost item in the total national immunization costs, followed by salaries at 31%. These three categories also contributed the bulk of facility and outreach service costs, the immunization activities with the highest costs. Despite some limitations on accuracy of staff costs and vaccine wastage this conclusion is likely to be robust.
- Outreach accounted for around 40% of immunizations and can have substantial extra costs of staff time and transport, particularly in remote populations, for which it is a particularly important delivery model.
- Program management costs amounted to a relatively high 19%, 5.5% and 29% of *non-vaccine* costs at facility, district and national levels respectively.
- Capital costs made up only 18% of economic costs, with vehicles contributing the largest part (11%). The cold chain is a critical operational investment, but contributed a relatively small amount (2%) to routine economic costs. The fiscal costs of purchasing capital items may however pose budget challenges.
- Differences between economic and financial costs were small. Hidden resource contributions to routine immunization are thus not major issues for planners.

Other information of particular relevance to planning and financing included the following.

- The total cost of the Ugandan routine immunization program (US$ 40 million in 2011) was higher than previous estimates, in large part due to more complete assessment of staff costs, and facility and district level operational costs. The estimated total routine immunization cost would have accounted for 18% of total resources for health and 24% of GOU expenditure on health from own revenue in 2011/12. These figures have implications for sustainability of routine immunization and new vaccines, and funding decisions by partners.
- Previous cMYP cost estimates have had limited comprehensiveness. The cMYP for 2011 under-estimated personnel costs and vehicles as well as other district level expenditures, but also may have over-estimated vaccine costs (or the anticipated coverage rate was higher than the actual). This study provides better quality information on costs and resource flows in key cost areas, which should enhance confidence in future cMYP and other planning estimates.
- The total weighted average facility total spending on immunization by type ranged from US$ 4,309 for HC II, US$ 9,957 for HC III, US$ 21,160 for HCIV and US$ 52,793 for hospitals. However there is wide variation around these means.
- Immunization unit costs were slightly higher than recent ones available for Uganda due to previous underestimation of staff and transport costs in particular. The total unit cost per DTP3 child was US$ 33.64 and US$ 3.93 per dose, *including the district and national level costs*. Excluding the vaccine costs, the national delivery unit costs per DTP3 child and per dose were US$ 18.13 and US$ 2.65 respectively. The estimated unit costs are similar to, but somewhat lower than, unit costs reported by the EPIC studies in the other countries, primarily due to much lower personnel salaries.

At facility level, there was wide variation in the weighted total unit costs.

- The cost per DTP3 immunized child ranged from US$ 31.25 in HCIII to US$ 34.25 in general hospitals, US$ 44.30 in HCIV, and up to US$ 52.42 in HCII. The average facility level cost across all facility types per DTP3 child was $ 44.17.
- *Facility performance* or *efficiency* (indicated by unit costs per dose or per DPT3) is associated with the volume of immunizations provided, the number of people attending facilities, the number of zones served, distance to vaccine collection point, and the type of facility.
- HCIII tend to have low unit costs, while HCIV appear less efficient than others with the same immunization volumes. There is however, wide variation within facilities of the same type and at the same levels of output.
- Although there was a consistent pattern of variables associated with efficiency, variables could not readily explain large proportions of efficiency.
- Overall system cost estimates are likely to mainly be affected by HCII with the highest unit costs, and HCIII which had the lowest unit costs but which contribute 60% and 32% of facilities respectively. In addition, most extension of immunization coverage seems likely to be through HCII and III.

Traditional planning approaches based on average costs by facility type, for example, can potentially be improved by using these results. There may be particular benefits of using unit costs that reflect service volumes and other determinants, as there is substantial variation around their average unit costs.

Incremental costs of PCV introduction

The incremental costs for PCV in 2013 amounted to US$ 24.2 million for 90% coverage, or US$ 13.2 million at 45% coverage. Given that the actual roll out of PCV in Uganda has been delayed, these costs are likely to roll over into 2014.

- Introduction of PCV-10 represents a very large addition of as much as 61% to the routine immunization program expenditure in Uganda (at 90% coverage), or 33% additional at 45% coverage.
- Reducing vaccine costs will be a key issue in enhancing program sustainability, as vaccines and injection supplies contribute between 84% and 77% of total costs of introducing the new vaccine, at 90% or 45% coverage respectively. Human resources (around 6.4%) and other recurrent (including social mobilization) were the next largest economic costs (4.4%).
- More realistic estimation of the initial coverage rates may be important to avoid over-investment in initial vaccines stocks and unnecessary wastage and strain on existing cold chain and distribution. Improved recording at facility level, and aggregation of these to national level outputs would greatly enhance forecasting.
- The estimated economic unit costs per PCV immunized child in the introduction period under the 90% coverage scenario are between $ 15.97 and $ 16.71, equivalent to around 50% of costs for all other vaccines per DPT3 child in the routine immunization. The economic costs per dose in the introductory period amount to $ 4.04 - $ 4.23, or 108% of the estimated $ 3.93 per dose for the routine immunization. In lower coverage scenarios, unit costs are even higher.
- Service delivery costs (excluding vaccines and supplies) are also substantial. The fiscal service delivery costs ($ 5.01 per PCV immunized child) are likely to be markedly higher than the GAVI implementation grant of 80c per birth.
- The government contribution to NUVI introduction has previously been under-estimated, particularly because substantial staff costs had not been included. These contributions to staff, cold chain and infrastructure are essential without which service delivery cannot take place.
- Human resources requirements are substantial, but do not lead to incremental *fiscal* costs as new staff were not being employed. However, particularly when several new vaccines are introduced, additional capacity may be needed in order to avoid substantial opportunity costs, burdens on scarce management and service staff, and trade-offs in health system personnel allocations.
- Cold chain capital *fiscal* costs before the introduction period were estimated at $5.6 million. A substantial part was NUVI-related, but some may have been to replace obsolete equipment. Requests for cold chain equipment funding should probably be judged on soundness as a broader immunization investment, rather than whether they are specific NUVI costs. Annualized economic costs of cold chain equipment would be relatively small (around US$ 222 000).

Productivity and cost determinants

Scatter plots and multiple regressions identified more details of which factors are the most important predictors of total outputs and costs of immunization at facility level. There was a high degree of consistency between the findings of models and the main conclusions are likely to be robust. Several main conclusions were identified.

Analysis of total facility productivity (indicated by total doses or DPT3 immunized children) found a small set of variables that tended to be associated with productivity quite consistently. Identifiable factors could account for up to 77% of facilities' immunization volumes in some of the final models.

- Statistically significant associations between productivity and total facility attendance indicated that, when attendance increased 10%, immunization outputs generally increased by around 5%.
- Other consistent and significant associations were with the number of zones served, urban location and facility type. The significant association between immunization outputs and the number of zones, total attendance and urban location is not unexpected. Of note, the HCIII facility type *per se* is associated with higher outputs than HCIV and HCII.
- Productivity when measured as *doses per staff FTE*, fell with higher immunization staffing levels and, once again, rose with facility attendance, zones supported and urban location. Doses per immunization staff FTE tended to be low in HCII, indicating less productive use of staff time than HCIII, HCIV and hospitals.
- There was limited influence of other factors on productivity (e.g. numbers of staff and village health workers involved in immunization, district poverty, remoteness and infrastructure).

The difficulty in identifying a range of significant factors which can explain a large proportion of efficiency and performance may be due to Uganda having a large number of small and rural facilities. These tend to have high levels of variability in a range of factors, which could obscure associations that may be more consistent and apparent when there are more, larger facilities. Other associations may also have been shown to be statistically significant if the sample size had been larger.

The study considered a range of possible ***determinants of total facility immunization costs***, related to quantity, price, quality, capital investments and service context.

- Results confirmed expectations and findings of previous studies, that vaccines and human resources are the main determinants of facility costs. Their costs are in turn strongly associated with service volumes: a 10% rise in DTP3 children was associated with a 4% rise in facility costs.
- They are also associated with: number of zones served, which may represent both service quantity and cost factors of servicing more zones; urban or peri-urban location; and facility type. HC IV, III and II had 46%, 63% and 66% lower cost respectively compared to hospital immunization services, independent of other factors. A further association with district poverty requires further study, but may relate to levels of staffing in poorer contexts.
- Delivery costs that *excluded vaccines and HR* were only significantly associated with patient volumes (number of DTP3 immunized children), peri-urban/rural location and road condition. Thus vaccine and HR costs do not seem to obscure major effects of other determinants.
- No other determinants of facility costs were identified as consistently significant, although some significant associations may have been hidden due to the limited sample size. Capital costs appear to be less strongly and systematically associated with total costs than recurrent expenditures or various other determinants of costs.

The strong and recurring association of performance, productivity and facility costs with facility type was notable. The association suggests that facility type captures a substantial amount of variation related to delivery context and models of different facility types (e.g. particular staffing, equipment and transport functions), that is not accounted for by attendance or other specific independent variables which can be easily identified individually. Of note, the proportions of immunization provided through outreach or facility based service models did not seem to be a strong influence on performance.

From a planning perspective the facility type, number of zones supported and expected total outpatient load of any new facility or program expansion should be carefully considered. Together they are able to predict a substantial proportion of the total facility immunization outputs, likely efficiency and immunization unit costs. However, particular local contexts will be important to consider in planning, given the variability between facilities' productivity, performance and costs.

Further investigation of underlying causes of outliers and variations, and differences between facility types, would be useful to increase understanding of determinants of productive and efficiency, and thus inform program management and planning.

Resource Mapping

The mapping of resources for immunization was the most comprehensive in Uganda to date, and was able to draw on the costing study to produce more accurate information on items such as personnel costs at facility, district and national level. The project has also developed an extension of the SHA coding system to provide more detail specific to immunization.

The mapping identified a total of US$ 24 million in 2009/10 and US$ 33 million in 2010/11. Comparing these resources with the study's total estimated national cost of US$ 40 million in 2011, there may have been an estimated overall financial gap of US$ 7 million in 2011, but in reality, most of this would have been absorbed by the MOH in routine service expenditure.

The mapping highlights that the Government of Uganda was in fact the largest funder of the routine immunization (42% in 2010/11), particularly through funding of personnel and other support functions at national, district and facility levels. However, the contributions of development partners remain critical, particularly the GAVI contribution for vaccines (38% of expenditure in 2010/11).

The mapping produced similar estimates of overall resources to the cMYP's estimated financing sources in 2011, in fact slightly more than the cMYP anticipated (US$ 1.2 million more, 4%). However, there were some discrepancies in estimates for various activities, line items and their financing gaps. Overall however, it would appear the cMYP was fairly accurate in estimating the future available financing.

Further mappings are likely to be valuable in coming years. Funding needs, flows and gaps are likely to be larger with introduction of PCV and Rotavirus vaccines, and program efficiency and sustainability could be compromised without robust resource mobilization and tracking. A useful option would be to establish a single system which can accurately capture all funding and contributions from partners and at the same time reconcile plans with government and partner reports of commitments, disbursements and actual expenditures. More detailed analyses would also be useful to explore financing related to programmatic areas, line items, sub-national funding flows and non-governmental providers.

Utility and Reliability of the Findings

This study applied a rigorous and standardized Common Approach methodology and collected critical costing data at facility and district levels, that were previously unavailable. The costing was based on a sample of facilities that ensured representation of a range of service contexts, regions and facility types. The sample was smaller than ideal, and lack of available service data at national level did not allow for assessment of possible sample biases or alternative weighting approaches. However, the sample was expected to be large enough to allow for regression models with up to five variables. In addition, samples of HCII and HCIII were relatively large, and facility types with smaller samples (hospitals and HCIV) are responsible for a relatively small proportion of facilities and immunization in Uganda, so impact on weighted estimates and overall conclusions are likely to be limited.

Quality and availability of financial and programmatic data also posed challenges at each level, with particular challenges in vaccine and supplies data, district level expenditure records and possibly staff cost estimations. However, these do not seem likely to affect overall conclusions. The deficiencies also have implications for the system's ongoing ability to plan and manage services.

Overall, the findings of this study should be adequately generalizable to other public settings in Uganda, for informing planning and budgeting for immunization services.

However, some caution is needed in using results to assess benchmarks and for various management and planning decisions. Firstly, a more comprehensive primary health care perspective is required in assessing efficiencies and options, as immunization services and costs cannot be managed in isolation. In addition, comparison of costs, unit costs and determinants with other countries, may have limitations. For example, the likelihood that Ugandan health worker remuneration is lower than various other developing countries may complicate judgments of efficiency and identification of cost drivers. Finally, it is also important to note that SIA's play a critical role in boosting immunization coverage in Uganda, but were not costed in this study. Thus total resource requirements to achieve targets may be underestimated particularly at facility and district level.

8.2 Recommendations

The following main recommendations are made, based on the findings of this study, and in addition to some of the suggestions made throughout the report.

Costing, budgeting and financing

1 *Planners and managers should use the results from this study* to inform more accurate prediction and management of costs at the various levels of the system, for expanding coverage and new vaccine introduction by UNEPI in Uganda. The findings provide useful benchmarks for planners around the costs of different

activities, and the composition and levels of costs. In general, cost estimates from this study can give useful guidance in planning at facility and higher levels However, specific local context and ingredients-based budgeting will be important to consider particularly for smaller facilities, as indicated by the high variation in facility level efficiency, productivity and costs.

- Planners should use judgment in applying the study unit costs to expand coverage as actual unit costs may be relatively high (e.g. when new HCII are the main mode of delivery) or may be lower (e.g. if staff are currently under-utilized in the services).
- Benchmarks for facility types, adjusted for specific levels of utilization may improve on estimates used in traditional planning. Cost projections based on regression models may also be feasible when better input data is available, but limitations of models' predictive ability should be kept in mind.

2 *The cMYP assumptions should be updated* with the primary costing data presented here, and include the revised estimates of GoU contributions and costs, particularly the personnel estimates.

3 *Consider potential to manage costs and efficiency of the main line items, activities and particular services* that are cost drivers or appear inefficient (e.g. HCIV, outreach).

4 *Revised estimates of resource needs, mapping of financing sources and estimates of the funding gap*, should be considered by government, GAVI and other partners to ensure long-term sustainability especially in light of new vaccine introduction.

- Estimates, particularly of government contributions and constraints, may warrant review of co-funding requirements and NUVI implementation grants.

5 *Consider implications of significant expansions of the immunization program and of new vaccines* (particularly more than one) in terms of staff and management capacity, as the study suggest that they could have significant opportunity costs for the broader PHC system and services, and could overburden various service staff and management.

Management

6 *Disseminate key results to district and facility managers* in a process that can *support application of results* in improved planning and management.

7 *Systems should be reinforced* to strengthen the management and monitoring of key cost drivers and resources, including:

- o Vaccine stocks at all levels,
- o Use and maintenance of vehicles,
- o Human resource capacity,
- o Outreach costs, and;
- o Wastage rates especially with expensive new vaccines.

Improving information

8 Uganda should continue efforts to *improve quality and national level availability of data on facility and district immunization output* and utilization. This will enhance program management, allow for enhanced estimation of unit costs and

total immunization program costs, and assist in assessing the representativeness of sampled facilities.

9 *Further research on differences in facility costs and productivity* (especially with regards to facility types, outliers and key components such as outreach) would be useful to enhance sustainable and efficient program planning and management.
- Research should consider a comprehensive approach to immunization within PHC services, as well as explore issues of equity and human resource capacity constraints.
- Ways to enhance capacity utilization in low volume settings or particular HC models could be explored to enhance efficiency. This may appropriately involve consideration of a comprehensive package of cost effective PHC interventions to ensure that, overall, capacity is well utilized.

10 *Review the current ledger account system and coding* to assess potential for improving cost information for immunization and general PHC services. This would assist planners and managers in service management and may help to resolve concerns about the adequacy and equity of PHC grants.

11 *Actual costs, of PCV and Rotavirus introduction, including possible hidden opportunity costs* in Uganda, should be monitored to validate issues highlighted by the prospective costing.

12 Uganda and partners should consider further investigation to *assess functional implications and risks of differences in expected and actual funding flows*, as well as to identify potential bottlenecks, delays and needs for fund re-allocations.

13 Uganda should develop a *coordinated, single mechanism to accurately capture all contributions* received from partners, and at the same time reconcile government reported to donor reports figures. Enhanced resource needs estimates, financial tracking and gap analyses will be increasingly important given the scale of NUVI funding and potential for bottlenecks, delays and limited sustainability.
- Improved accounting and transparency with regard to the actual expenditures for immunization will improve efficient and sustainable use of available resources.
- Partners and Uganda should consider instituting a system of disaggregated SHA codes and tools for immunization and PHC that would allow for more systematic, easier tracking of program finances, particularly at sub-national levels

Appendix 1: References

Bishai D. 2002. The role of public health programmes in reducing socioeconomic inequities in childhood immunization coverage. Health Policy and Planning: 17(4): 412-419.

Brenzel L. Politi C. 2012. Historical Analysis of the Comprehensive Multi-Year Plans in GAVI-Eligible countries (2004 - 2015). Mimeograph. World Health Organization. http://www.who.int/immunization_financing/analysis/Historical_cMYP_Analysis_2012.pdf

Brenzel L. Claquin P. 1994. Immunization Programs and Their Costs, *Social Science and Medicine*, 39(4): 527-536.

Brenzel L. 2005. Note on Returns to Scale for Immunization Services. The World Bank. Washington, D.C.

Brenzel L. 2008. Immunization Resource Tracking Exercise: Case Study of the Republic of Tajikistan. The World Bank. Washington, D.C.

Brenzel L. 2013. Common Approach for the Costing and Financing of Routine Immunisation and New Vaccines. Bill and Melinda Gates Foundation. Seattle.

Clinton Health Access Initiative (CHAI). May 2011. Facility-Based Unit Costing for Anteretroviral Treatment in five Sub-Saharan African Countries. Mimeograph.

Cutts F. Diallo S. Zell E. Rhodes P. 1991. Determinants of Vaccination in an Urban Population in Conakry, Guinea. International Journal of Epidemiology: 20(4): 1099-1106.

Cutts F. Rodriques L. Colombo S. Bennett S. 1989. Evaluation of Factors Influencing Vaccine Uptake in Mozambique. International Journal of Epidemiology: 18(2): 427-433.

De la Hoz-Restrepo F. Castaneda-Orjuela C. Paternina A. Alvis-Guzman N. Systematic review of incremental non-vaccine cost estimates used in cost-effectiveness analysis on the introduction of rotavirus and pneumococcal vaccines. Vaccine 31S (2013) C80–C87

Griffiths U. Korczak VS. Ayalew D. Yigzaw A. 2009. Incremental system costs of introducing combined DTwP–hepatitis B–Hib vaccine into national immunization services in Ethiopia. Vaccine 27:1426–1432

HSLP Africa limited. 2008. Estimates of Costs of the Uganda National Minimum Health Care Package (UNMHCP).

Hollingsworth B. 2008. The Measurement of Efficiency and Productivity of Health Care Delivery. Health Economics (17): 1107-1128.

Hottum P. Schaff M. Muller-Gorchs M. Howahi F. Gorlitz R. Capturing and Measuring quality and productivity in health care service systems.

Ibnouf A. Van den Borne H. Maerse J. 2007. Factors influencing immunization coverage among children under five years of age in Khartoum State, Sudan. South African Family Practice: 49(8): 14a-14f.

Kaddar M. Tanzi VL. Dougherty L. 2000. *Case Study on the Costs and Financing of Immunization Services in Côte d'Ivoire*. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

Kaddar, M. Mookherji S, DeRoeck D, Antona D. 1999. *Case Study on the Costs and Financing of Immunization Services in Morocco*. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

Khan M. Khan S. Walker D. Fox-Rushby J. Cutts F. Akramuzzaman S. 2004. Cost of Delivering Child Immunization Services in Urban Bangladesh: A Study Based on Facility-level Surveys. Journal of Health Population and Nutrition: 22(4): 404-412.

Levin A. Howlader S. Ram S. Siddiqui SM. Razul I. Routh S. 1999. *Case Study on the Costs and Financing of Immunization Services in Bangladesh*. Special Initiatives Report. Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc.

Levin A, England S, Jorissen J, Garshong B, Teprey J. 2001. *Case study on the costs and financing of immunization services in Ghana*. Abt Associates, Bethesda MD;

Loevinsohn B. Hong R. Gauri V. 2006. Will more inputs improve the delivery of health services? Analysis of district vaccination coverage in Pakistan. The International Journal of Health Planning and Management. Vol 21(1): 45-54.

Lydon P, Beyai P, Chaudhri I, Cakmak N, Satoulou A, Dumolard L. 2008.Government financing for health and specific national budget lines: The case of vaccines and immunization. Vaccine 2008:26. 6727–6734

Maekawa M. Douangmala S. Sasisaka K. Takahashi K. Phathammavong O. Xeuatvongsa A. Kurolwa C. 2007. Factors influencing routine immunization coverage among children aged 12-59 months in Lao PDR after regional polio eradication in Western Pacific Region. BioScience Trends: 1(1):43.51.

Marshall P. Flessa S. 2011. Efficiency of primary care in rural Burkina Faso. A two-stage DEA analysis. Health Economics Review. Vol 1:5. http://www.healtheconomicsreview.com/content/1/1/5

Measure Evaluation. 2010. *Sampling Manual for Health Facility Surveys*. Washington DC. http://gametlibrary.worldbank.org/FILES/665_Sampling%20Manual%20for%20Health%20Facility%20Surveys.pdf

McLaughlin C. Coffey S. 1990. Measuring productivity in services. International Journal of Service Industry Management 1(1): 46-64.

Ministry of Health, Republic of Uganda. Statistical Report for 2010. Kampala.

Ministry of Health, Republic of Uganda. 2010. Ugandan National Health Accounts report. www. http://health.go.ug/mohweb/

Ministry of Health, Republic of Uganda. Annual Performance Report 2012. Kampala

Ministry of Health, Republic of Uganda. 2012. Uganda National Expanded Program on Immunization Multi-Year Work Plan (2012-2016).

Odusanya O. Alufohai E. Meurice F. Ahonkhai V. 2008. Determinants of vaccination coverage in rural Nigeria. BMC Public Health.

Parliament of Uganda. 2012. Report of the Parliamentary Committee on Health on the Ministerial Policy Statement for the Health Sector for the Financial Year 2012/2013.

Phonboon K, Shepard DS, Ramaboot S, Kunasol P, Preuksaraj S. 1989. "The Thai expanded program on immunization: role of immunization sessions and their cost-effectiveness," *Bulletin of the World Health Organization*, 67(2): 181-188.

Robertson RL, Davis JH, Jobe K. 1984. "Service volume and other factors affecting the costs of immunizations in the Gambia," *Bulletin of the World Health Organization*, 62(5): 729-736.

Somda ZC. Meltzer MI. Perry HN. Messonnier NE. Abdulmini U. Mebrahtu G. Massambou S. Toure K. Ouedraogo KS. Okorosobo T. Alemu W. Sow I. 2009. Cost analysis of an integrated disease surveillance and response system: case of Burkina Faso, Eritrea, and Mali. Cost Effectiveness and Resource Allocation 2009, **7**:1.

Uganda Bureau of Statistics. 2011. Uganda Demographic and Health Survey: 2011. www.measuredhs.com

Uganda EVA Assessment Report: Findings and Recommendations of the Assessment Team. 2011.

Valdmanis V. Walker D. Fox-Rushby J. (2003). "Are Vaccination Sites in Bangladesh Scale Efficient?" Int J Technology Assessment in Health Care 19(4): 692-697.

Walker D. Mosquiera NR. Penny ME, Lanata CF. Clark AD. Sanderson CFB. Fox-Rushby JA. 2004. Variation in the costs of delivery routine immunization services in Peru. Bulletin of the World Health Organization 82(9): 676-682.

World Health Organization. 2002. Guidelines for estimating costs of introducing new vaccines into the national immunization system. Geneva, Switzerland.

World Health Organization. 2008a. Immunization Costing & Financing: A Tool and User Guide for comprehensive Multi-Year Planning (cMYP). Geneva, Switzerland.
World Health Organization. 2008b. WHO guide for standardization of economic evaluations of immunization programmes. Geneva, Switzerland.

World Health Organization Logistics Planning Tool spreadsheets (http://www.who.int/immunization_delivery/systems_policy/logistics/en/index4.html)

World Health Organization. 2011. System of Health Accounts (SHA). Geneva, Switzerland.

World Health Organization Vaccine Volume Calculator spreadsheet (http://www.who.int/immunization_delivery/systems_policy/logistics/en/index4.html)

Appendix 2: Sampling frame

Figure 2.1: Uganda Districts and Regions

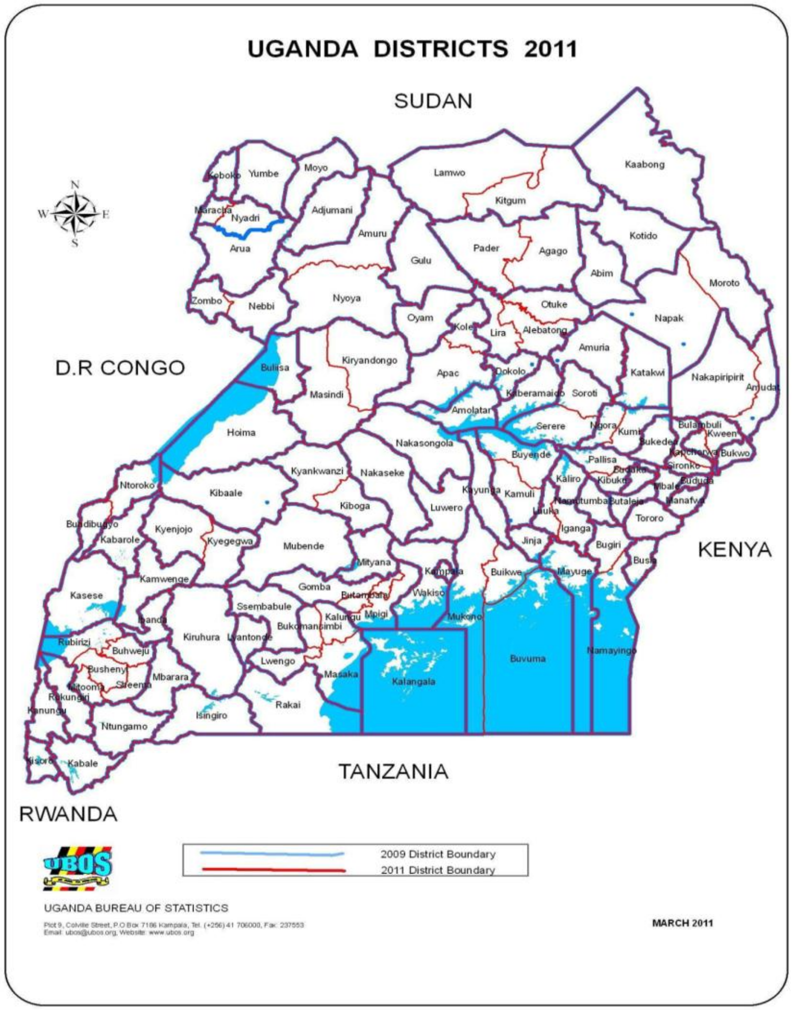


Table 2.1: Ugandan Government and NGO health facilities by region by level of care (in brackets is the number studied)

	West Nile	Mid Northern	North East	Mid-Eastern	East Central	Mid-Western	South Western	Central 1	Central 2	Kampala	**Total**
District Health Offices	7(1)	15(2)	13(1)	15(1)	12(1)	12(1)	15(2)	10(1)	12(1)	1(1)	**112(12)**
District Hospitals											
Government	4(1)	7(0)	5(0)	8(0)	6(0)	7(0)	7(0)	6(1)	8(1)	5(0)	**63(3)**
NGO	5(0)	5(0)	5(0)	7(1)	4(0)	4(0)	13(0)	5(0)	7(0)	9(0)	**64(1)**
Health Centre IV											
Government	8(1)	16(2)	12(1)	19(1)	19(1)	16(1)	41(2)	17(1)	19(0)	3(1)	**170(11)**
NGO	0	1(0)	0	2(0)	0	3(0)	2(0)	1(0)	3(0)	3(1)	**15(1)**
Health Centre III											
Government	69(0)	92(2)	74(1)	132(0)	92(0)	113(2)	146(1)	83(0)	107(2)	8(2)	**916**
NGO	19(1)	18(1)	18(2)	20(1)	28(0)	36(0)	43(0)	36(1)	34(0)	12(1)	**264**
Health Centre II											
Government	103(1)	223(2)	133(2)	166(1)	206(3)	170(1)	347(4)	161(1)	183(0)	3(0)	**1695(15)**
NGO	17(0)	35(1)	35(0)	42(0)	86(0)	40(0)	108(1)	75(0)	66(1)	16(1)	**520(4)**

Table 2.2: Government and NGO health facilities by region by Rural/Urban status (in brackets are the number studied)

	West Nile		Mid Northern		North East		Mid-Eastern		East Central		Mid-Western		South Western		Central 1		Central 2		Kla
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	U
DHO	5(1)	2(0)	10(0)	5(2)	10(1)	3(0)	11(0)	4(1)	10(1)	2(0)	8(1)	4(0)	10(1)	5(1)	6(0)	4(1)	6(1)	6(0)	1(1)
Hospitals																			
Govt	2(1)	2(0)	1(0)	6(0)	3(0)	2(0)	3(0)	5(0)	4(0)	2(0)	4(0)	3(0)	3(0)	4(0)	1(1)	5(0)	4(1)	4(0)	5(0)
NGO	2(0)	3(0)	3(0)	2(0)	5(0)	0	3(0)	4(1)	3(0)	1(0)	0	4(0)	6(0)	7(0)	1(0)	4(0)	5(0)	2(0)	9(0)
HC IV																			
Govt	3(1)	5(0)	9(2)	7(0)	9(1)	3(0)	11(1)	8(0)	16(1)	3(0)	9(1)	7(0)	20(1)	21(1)	9(1)	8(0)	8(0)	11(0)	3(1)
NGO	0	0	0	1(0)	0	0	2(0)	0	0	0	1(0)	2(0)	1(0)	1(0)	1(0)	0	1(0)	2(0)	3(1)
HC III																			
Govt	37(0)	32(0)	46(1)	46(1)	57(2)	17 (0)	88(0)	44(0)	66(0)	26(0)	57(2)	56(0)	83(1)	63(0)	30(0)	53(0)	42(2)	65(0)	8(2)
NGO	8(1)	11(0)	7(1)	11(0)	13(1)	5(0)	11(1)	9(0)	22(0)	6(0)	17(0)	19(0)	22(0)	21(0)	14(1)	22(0)	13(0)	21(0)	12(1)
HCII																			
Govt	57(1)	46(0)	129(2)	94(0)	105(2)	28 (0)	76(1)	90(0)	171(3)	35(0)	64(1)	106(0)	176(4)	171(0)	50(1)	111(0)	68(0)	115(0)	3(1)
NGO	7(0)	10(0)	14(1)	21(0)	27(0)	8(0)	33(0)	9(0)	70(0)	16(0)	17(0)	23(0)	57(1)	51(0)	29(0)	46(0)	32(1)	34(0)	16(0)
Total Facilitie (Sample	116 (4)	109 (0)	209 (7)	188 (1)	219 (5)	58 (0)	227 (3)	169 (0)	351 (4)	89 (0)	169 (4)	220 (0)	368 (6)	339 (1)	135 (4)	245 (0)	173 (4)	260 (0)	59 (6)

Table 2.3 Sampled Health Care Facilities

DISTRICT	HEALTH CENTRE	LEVEL	OWNERSHIP	RURAL/ URBAN
Adjumani	Pachara	HC II	GOVT	Rural
	Adjumani	Hospital	GOVT	Rural
	Robidire	HC III	NGO	Rural
	Mungula	HC IV	GOVT	Rural
Buikwe	Lugazi Muslim	HC II	NGO	Rural
	Busabaga	HC III	GOVT	Rural
	Makindu	HC III	GOVT	Rural
	Kawolo hospital	Hospital	GOVT	Rural
Gulu	St Mauritz	HC II	NGO	Rural
	Bar-Dege	HC III	GOVT	Urban
	Awach	HC IV	GOVT	Rural
	Lalogi	HC IV	GOVT	Rural
Hoima	Kyakapeeya	HC II	GOVT	Rural
	Buhimba	HC III	GOVT	Rural
	Butema	HC III	GOVT	Rural
	Kikuube	HC IV	GOVT	Rural
Kanungu	Mishenyi	HC II	GOVT	Rural
	Kibimbiri	HC II	NGO	Rural
	Katete	HC III	GOVT	Rural
	Kihihi	HC IV	GOVT	Rural
Kampala	Komamboga Health Centre	HC III	GOVT	Urban
	Kiswa Health Centre	HC III	GOVT	Urban
	Mbuya Reach Out	HC II	GOVT	Urban
	St Stephen's Dispensary	HC III	PRIVATE	Urban
Moroto	Army Clinic	HC IV	GOVT	Rural
	DMO's Clinic	HC II	GOVT	Rural
	Kidepo Rupa	HC II	GOVT	Rural
	Kosiroi	HC II	GOVT	Rural
	Loputuk	HC III	NGO	Rural
	Nadunget	HC III	GOVT	Rural
Rakai	Bbale Ggunda	HC II	GOVT	Rural
	Bikiira Maria	HC III	NGO	Rural
	Kakuuto	HC IV	GOVT	Rural
	Rakai	Hospital	GOVT	Rural
Tororo	Kidoko	HC II	GOVT	Rural
	Mifumi	HC III	NGO	Rural
	Mulanda	HC IV	GOVT	Rural
	Tororo St Anthony	Hospital	NGO	Urban
Bushenyi	Bushenyi	HC IV	GOVT	Urban
	Nyarugoote	HC II	GOVT	Rural
	Buyanja	HC II	GOVT	Rural
	Ryeishe	HC II	GOVT	Rural
Iganga	Busesa	HC IV	GOVT	Rural
	Iganga Prisons	HC II	GOVT	Rural
	Buzaya	HC II	GOVT	Rural
	Nawansinge	HC II	GOVT	Rural
Lira	Ober	HC III	GOVT	Rural
	Ngetta	HC III	NGO	Rural
	Anyangatire	HC II	GOVT	Rural
	Onywako	HC II	GOVT	Rural

Table 2.4: List of Facilities and their ID Numbers (for quadrant analysis interpretation)

Facility name	Facility ID	District	Area type*	Region
Adjumani Hospital	1	Adjumani	1	West Nile
Anyagatire HC II	2	Lira	1	Mid North
Awach Health Centre IV	4	Gulu	1	Mid North
Bar Dege HC III	5	Gulu	3	Mid North
Bbaale Gunda HC II	6	Rakai	1	Central 1
Bikira Maria HC III	7	Rakai	3	Central 1
Buhimba HC lll	8	Hoima	1	Mid West
Busabaga HC lll	9	Buikwe	1	Central 2
Busesach IV	10	Iganga	3	East Central
Bushenyi HC lV	11	Bushenyi	2	South West
Butema HC lll	12	Hoima	1	Mid West
Buyanja HC ll	13	Bushenyi	1	South West
Buzaaya HC II	14	Iganga	1	East Central
DMOS Clinic HCII	24	Moroto	3	North East
Iganga Prisons HC II	25	Iganga	4	East Central
Kakuuto HC IV	26	Rakai	2	Central 1
Katete HC III	28	Kanungu	1	South West
Kawolo Hospital	30	Kanungu	3	South West
Kibimbiri HC III	31	Moroto	1	North East
Kidepo Rupa HCIII	32	Tororo	4	Mid Eastern
Kidoko HC II	33	Kanungu	1	South West
Kihihi HC IV	34	Hoima	3	Mid West
Kikuube HC lV	35	Kampala	4	Kampala
Kiswa HC III	36	Kampala	4	Kampala
Komamboga HC III	37	Kampala	4	Kampala
Kosiroi HCII	38	Moroto	1	North East
Kyakapeeya HC ll	39	Hoima	1	Mid West
Lalogi Health Centre IV	40	Gulu	1	Mid North
Loputuk HCIII	41	Moroto	1	North East
Lugazi Muslim HCT	42	Buikwe	3	Central 2
Makindu HC lll	43	Buikwe	1	Central 2
Mbuya Reach Out	44	Kampala	4	Kampala
Mifumi HC III	45	Tororo	1	Mid Eastern
Mishenyi HC II	46	Kanungu	1	South West
Mulanda HC IV	48	Tororo	1	Mid Eastern
Mungula HC IV	49	Adjumani	1	West Nile
Nadunget HCIII	50	Moroto	1	North East
Nawansinge HC II	51	Iganga	1	East Central
Ngetta HC III	52	Lira	3	Mid North
Nyarugoote HC ll	53	Bushenyi	1	South West
Ober HC III	54	Lira	1	Mid North
Onywako HC II	55	Lira	1	Mid North
Pachara Health Centre II	56	Adjumani	1	West Nile
Rakai Hospital	58	Rakai	2	Central 1
Robidire Health Centre III	59	Adjumani	1	West Nile
Ryeishe HC ll	60	Bushenyi	1	South West
St Anthony Hospital	61	Tororo	4	Mid Eastern
ST Mauritz Health Centre II	62	Gulu	3	Mid North
St.Stephen's Dispensary Luzira HC III	63	Kampala	4	Kampala

Appendix 3: Sample and weightings of facilities

Table 3.1 Regional and district probability of being selected

Region (all 10 represented)	District (n)	Total No. of districts in region (N)	Sample district's probability (n/N)	DHO weighting (Inverse)
West Nile	Adjumani	7	0.14	7
Central 2	Buikwe	12	0.08	12
Mid West	Hoima	12	0.08	12
East Central	Iganga	12	0.08	12
Kampala	Kampala	1	1.00	1
North East	Moroto	13	0.08	13
Central 1	Rakai	10	0.10	10
Mid Eastern	Tororo	15	0.07	15
South West	Bushenyi	15	0.13	7.5
South West	Kanungu	15	0.13	7.5
Mid North	Gulu	15	0.13	7.5
Mid North	Lira	15	0.13	7.5
Total		112		

Table 3.2: Facility sampling probabilities and weightings

REGION	DISTRICT	HEALTH CENTRE (m)	LEVEL	No of facilities (public & NGO) by level in district (Mi)	Sample facility's probability (m/Mi)	District Probability (n/N)	Facility probability = n/N x m/Mi	Weighting (reciprocal = N/nm x Mi)	Adjusted Weighting
West Nile	**Adjumani**	Pachara	HC II	23	0.04	0.14	0.006	161.00	106.37
		Adjumani	Hospital	1	1.00	0.14	0.143	7.00	6.05
		Robidire	HC III	10	0.10	0.14	0.014	70.00	56.52
		Mungula	HC IV	1	1.00	0.14	0.143	7.00	5.90
Central 2	**Buikwe**	Lugazi Muslim	HC II	18	0.06	0.08	0.005	216.00	142.71
		Busabaga	HC III	10	0.20	0.08	0.017	60.00	48.44
		Makindu	HC III	10	0.20	0.08	0.017	60.00	48.44
		Kawolo hospital	Hospital	5	0.20	0.08	0.017	60.00	51.84
Mid West	**Hoima**	Kyakapeeya	HC II	17	0.06	0.08	0.005	204.00	134.78
		Buhimba	HC III	32	0.06	0.08	0.005	192.00	155.02
		Butema	HC III	32	0.06	0.08	0.005	192.00	155.02
		Kikuube	HC IV	3	0.33	0.08	0.028	36.00	30.34
East Central	**Iganga**	Busesa	HC IV	2	0.50	0.08	0.042	24.00	20.23
		Iganga Prisons	HC II	39	0.08	0.08	0.006	156.00	103.07
		Buzaaya	HC II	39	0.08	0.08	0.006	156.00	103.07
		Nawansinge	HC II	39	0.08	0.08	0.006	156.00	103.07
Kampala	**Kampala**	Komamboga HC	HC III	20	0.15	1.00	0.150	6.67	5.38
		Kiswa HC	HC III	20	0.15	1.00	0.150	6.67	5.38
		St Stephen's Dispensary	HC III	20	0.15	1.00	0.150	6.67	5.38
		Mbuya Reach Out	HC II	19	0.05	1.00	0.053	19.00	12.55
North East	**Moroto**	DMO's Clinic	HC II	9	0.22	0.08	0.017	58.50	38.65
		Kosiroi	HC II	9	0.22	0.08	0.017	58.50	38.65
		Kidepo Rupa	HC III	5	0.60	0.08	0.046	21.67	17.49
		Lopotuk	HC III	5	0.60	0.08	0.046	21.67	17.49
		Nandunget	HC III	5	0.60	0.08	0.046	21.67	17.49
Central 1	**Rakai**	Bbale Ggunda	HC II	66	0.02	0.10	0.002	660.00	436.06
		Bikiira Maria	HC III	24	0.04	0.10	0.004	240.00	193.77
		Kakuuto	HC IV	1	1.00	0.10	0.100	10.00	8.43
		Rakai	Hospital	2	0.50	0.10	0.050	20.00	17.28

REGION	DISTRICT	HEALTH CENTRE (m)	LEVEL	No of facilities (public & NGO) by level in district (Mi)	Sample facility's probability (m/Mi)	District Probability (n/N)	Facility probability = n/N x m/Mi	Weighting (reciprocal = N/nm x Mi)	Adjusted Weighting
Mid Eastern	**Tororo**	Kidoko	HC II	41	0.02	0.07	0.002	615.00	406.33
		Mifumi	HC III	19	0.05	0.07	0.004	285.00	230.11
		Mulanda	HC IV	3	0.33	0.07	0.022	45.00	37.93
		Tororo St Anthony	Hospital	4	0.25	0.07	0.017	60.00	51.84
South West	**Bushenyi**	Bushenyi	HC IV	2	0.50	0.13	0.067	15.00	12.64
		Nyarugoote	HC II	21	0.14	0.13	0.019	52.50	34.69
		Buyanja	HC II	21	0.14	0.13	0.019	52.50	34.69
		Ryeishe	HC II	21	0.14	0.13	0.019	52.50	34.69
South West	**Kanungu**	Mishenyi	HC II	34	0.06	0.13	0.008	127.50	84.24
		Kibimbiri	HC II	34	0.06	0.13	0.008	127.50	84.24
		Katete	HC III	9	0.11	0.13	0.015	67.50	54.50
		Kihihi	HC IV	9	0.11	0.13	0.015	67.50	56.89
Mid North	**Gulu**	St Mauritz	HC II	53	0.02	0.13	0.003	397.50	262.63
		Bar-Dege	HC III	14	0.07	0.13	0.010	105.00	84.78
		Awach	HC IV	2	1.00	0.13	0.133	7.50	6.32
		Lalogi	HC IV	2	1.00	0.13	0.133	7.50	6.32
Mid North	**Lira**	Ober	HC III	14	0.14	0.13	0.019	52.50	42.39
		Ngetta	HC III	14	0.14	0.13	0.019	52.50	42.39
		Anyangatire	HC II	11	0.18	0.13	0.024	41.25	27.25
		Onywako	HC II	11	0.18	0.13	0.024	41.25	27.25

Appendix 4: Details of various costing assumptions and unit prices

Table 4.1: Unit prices of Refrigerators (2011, UGX, US$)

Refrigerator Make	Model 120-30	Capacity	Unit Cost (UGX)	Unit Cost (US$)
Electrolux	RCW 42 EG/CF	12	5 164 701	2 255
Electrolux	RCW 42 EK/CF	19	6 106 871	2 667
Electrolux	TCW 1152/CF	169	8 347 398	3 645
Electrolux	RCW 42AC/CF	24	6 627 593	2 894
Electrolux	RCW 42DC/CF	28	7 515 416	3 282
BP Solar	VR50F	23	25 990 109	11 349
Electrolux	TCW 1990	38	6 147 086	2 684
LEC RefrigerationPLC	VC 139 F	108	8 939 127	3 904
Norcoast	NRC 30-10	28	10 915 386	4 767
Fortum AES	CFS49 SI	25	18 383 808	8 028
Electrolux	FCW 20 EG/CF	14	3 953 553	1 726
Electrolux	FCW 20 EK/CF	14	4 831 495	2 110
Vestfrost	MK 074	20	2 912 685	1 272
Sun Frost	RFVB-134a	71	21 830 772	9 533
Dulas	VC-150 F	99	14 023 399	6 124
Electrolux	TFW 800	145	8 232 499	3 595
Vestfrost	MK 204	63	2 585 223	1 129
Vestfrost	MK 304	108	3 056 308	1 335
TATA BP Solar	TBP VR 50	23	16 947 573	7 401
Sibir	V 170 GE	91	4 783 812	2 089
Sibir	V 170 EK	91	6 353 904	2 775
Sibir	V 110 GE	32	4 084 652	1 784
Sibir	V 110 KE	32	4 624 677	2 020
Electrolux	RCW 50 EG/CF	24	6 445 823	2 815
Zero	PR 245 K/E	38	3 849 110	1 681
Zero	GR 245 G/E	38	3 533 138	1 543
Electrolux	RCW 50 EK	24	7 284 584	3 181
Norcoast	Model 120-30	93	14 936 844	6 523
Electrolux	RCW 50DC/CF	29	7 284 584	3 181
Electrolux	RCW 50 AC	32	6 733 070	2 940
Zero	PF 230 P KE	144	5 204 916	2 273
Electrolux	FCW 300	264	6 733 070	2 940
Electrolux	FCW 200	144	6 733 070	2 940
Solamatic	PVR150	37	11 489 880	5 017
Zero	GR 265 G/E	16	4 860 219	2 122
Dulas	VC-65 F	47	20 101 545	8 778
Kyocera Solar	VaccPack XL 2100	31	17 148 646	7 488
Kyocera Solar	VaccPack XL 6000	70	28 638 526	12 506

Refrigerator Make	Model 120-30	Capacity	Unit Cost (UGX)	Unit Cost (US$)
Bright Light Solar	PS65	47	19 532 796	8 530
Dometic	TCW 3000	127	13 321 080	5 817
Zero	PR 265 K/E	47	5 963 248	2 604
Bright Light Solar	PS40	20	19 532 796	8 530
Dometic	TCW 2000	102	13 853 923	6 050
Vestfrost	MKS044	20	8 975 894	3 920
Dometic	TCW3000DC	158	17 847 231	7 794
Vestfrost	MK304	105	5 983 930	2 613
Haier	HBC-200	90	3 952 519	1 726
Haier	HBC-70	45	2 929 919	1 279
Haier	HBD-286	224	2 993 114	1 307
Haier	HBD-116	92	2 355 425	1 029
Dometic	TCW2000DC	106	17 638 115	7 702
Dometic	TFW800	107	16 423 634	7 172
Vestfrost	MKF074	21	5 621 998	2 455
Vestfrost	MK204	75	5 139 423	2 244
Vestfrost	MK404	135	6 973 208	3 045
True Energy	BLF100AC	103	11 449 665	5 000
Dometic	TCW2000AC	72	16 962 510	7 407
Haier	HBC-340	200	6 870 948	3 000
True Energy	PS65i	38	10 455 791	4 566
Dometic	TCW3000AC	150	17 702 458	7 730
Haier	HBC-60	21	8 249 734	3 603
True Energy	BLF100 DC	93	22 951 035	10 022
SunDanzer	BFRV55	55	13 213 362	5 770
Generic	Refrig_SDD_1	150	27 575 712	12 042
Generic	Refrig_SDD_2	91	27 575 712	12 042
Vestfrost	VLS 400	216	6 402 161	2 796
Vestfrost	MK 144	48	4 495 990	1 963
Vestfrost	MF 314	271	4 495 990	1 963
Vestfrost	MF 114	98	3 305 638	1 444
Vestfrost	MF 214	138	3 844 514	1 679
Dulas	VC 65-2	38	22 520 165	9 834
Dulas	VC 150-2	86	34 584 539	15 102
Dulas	VC 200-1	127	25 737 331	11 239
Dometic	TCW3000 SDD	156	38 831 198	16 957
Vestfrost	VLS 200	60	4 568 376	1 995

Source: WHO, 2011.

Table 4.2: Estimates of useful life for equipment

The following table indicates the useful life years applied to equipment reported used in the EPI programme.

Equipment	Useful life (Years)		Equipment	Useful life (Years)
Buildings	30		TST Indicator strips or others	3
Cold Room	25		Desk Top Computer	4
Ice-lined Refrigerator	8		Laptop Computer	4
Solar refrigerator	8		Tablet Computer	4
Gas refrigerator	8		Other Computing Instrument	4
Kerosene refrigerator	8		Printer	4
Electrical refrigerator	8		Peripherals	4
Other refrigerator	8		Fax machine	4
Cold Box	15		Megaphone	10
Vaccine carrier	25		Public address system	10
Ice Packs	15		Other media equipment	10
Dial thermometer	15		Tables	10
Other thermometer (Alcohol)	15		Chairs	5
Generator	25*		Cabinet	5
Voltage regulator	15		Bench	5
Air conditioner	15		Lamp	10
Incinerator	25		Sharps boxes - 5 L	0
Electric autoclave	3		Waste Bags	0
Non-electric autoclave	3		Bin liners	0
Electric dry heat sterilizer	3		Motorcycle	3
Non-electric pot (steam boil)	3		Bicycle	3
Heat source	3		Pickup truck	5
Timer	3			

* Generators found at the facilities were generally around 15 to 20 years old. Respondents reported that they tended to last around 25years.

Table 4.3. Unit Prices of salaries, goods and supplies for Immunization in Uganda (2011, UGX and US$)

Public Salary Scale	Annual Salary (UGX)	Annual Salary (US$)
U1	19 542 792	8 534
U2	17 272 248	7 542
U3	12 793 344	5 587
U4	10 160 952	4 437
U5	6 470 460	2 826
U6 (Medical)	4 650 588	2 031
U7 (Medical)	4 017 408	1 754
U8 (Medical)	2 015 784	880
U8 (Others)	1 818 192	794

Vaccine/supply	Cost per VIAL (UGX)	Cost per VIAL (US$)
BCG	4 855	2,12
OPV	5 908	2,58
DTP	6 458	2,82
Measles	5 427	2,37
Tetanus Toxoid	2 748	1,20
AD Syringes 0.05ml for BCG	234	0,10
AD Syringes 0.5ml	188	0,08
Syringes 2ml for dilution BCG/Hib	95	0,04
Syringes 5ml for dilution Msls/YF	108	0,05
Safety boxes	2 977	1,30
Waste Disposal	**(UGX)**	**(US$)**
Sharps box	2 977	1,30
Bio-hazard waste bags	190	0,08
Bin Liners	1 530	0,67

Fuel	Unit Cost (UGX)	Unit Cost (US$)
Kerosene (per litre)	3 000	1,31
Gas (per bottle)	90 000	39,30
Diesel (per litre)	3 500	1,53
Petrol (per litre)	3 435	1,50
Electricity (per kwh)	540	0,24
Fuel efficiency (km/l)	6	

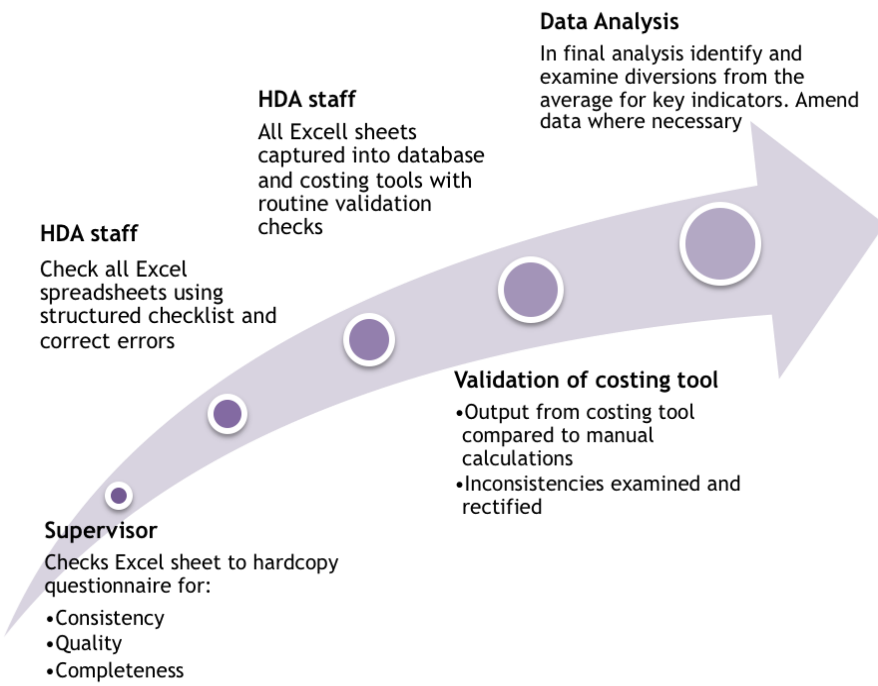
Equipment	Unit Cost (UGX)	Unit Cost (US$)
Ice-lined Refrigerator	2 323 512	1 014,63
Solar refrigerator	5 589 890	2 441,00
Gas refrigerator	2 290 000	1 000,00
Electrical refrigerator	6 586 407	2 876,16
Cold Box	366 400	160,00
Vaccine carrier	27 480	12,00
Ice Packs	103	0,04
Dial thermometer	36 893	16,11
Other thermometer (Alcohol)	36 420	15,90
Incinerator	500 000	218,34
Desk Top Computer	1 832 000	800,00
Laptop Computer	824 400	360,00
Printer	728 400	318,08
Tables	80 000	34,93
Chairs	80 000	34,93
Cabinet	150 000	65,50
Bench	120 000	52,40
Lamp	30 000	13,10
Sharps boxes 5 L	2 977	1,30
Waste Bags	190	0,08
Bin liners	1 530	0,67

Vehicles	Unit Cost (UGX)	Unit Cost (US$)
Replacement cost of motorcycle	12 757 646	5 571,02
Replacement cost of bicycle	255 909	111,75
Bicycle annual maintenance cost	47 833	20,89
Bicycle replacement of tyre	15 307	6,68
Bicycle replacement of rear or front Rim	31 092	13,58
Motorcycle annual maintenance cost / or cost	870 568	380,16
Motorcycle repalcement of tyre	245 864	107,36
Replacement cost of Pickup truck	123 899 023	54 104,38
Replacement cost of Pickup truck	70 622 663	30 839,59
Pickup truck annual servicing cost	3 303 853	1 442,73
Pickup truck cost for replacing tyres	619 443	270,50
Replacement cost of truck (National)	259 356 988	113 256,33
a. National Truck cost per service	1 652 166	721,47
b. National Truck cost per service	8 259 871	3 606,93
Truck cost for replacing tyres for National Truck	1 197 748	523,03

Appendix 5: Quality Assurance process

The following diagramme summarises the quality assurance process used in costing data collection and analysis.

Figure 5.1: Quality assurance process



Appendix 6: Details of NUVI Cost inputs and Assumptions

Table 6.1: NUVI vaccine in injection supplies costing assumptions

Pneumococcal Vaccine		Estimates for 2013	Notes
A	Surviving Infants	1 609 582	Projected population from the cMYP
B	Coverage Target	90% / 60% / 45%	Sensitivity analysis range
C	Target Children	724 312 (at 45%)	= A * B
D	Doses in Schedule	3	
E	Target Children x Doses	2 172 936	= C * D
F	Wastage Target	1%	As in Common Approach
G	Wastage Factor	1,1	
H	Total Doses (incl. Wastage)	2 287 301	
I	Buffer (at first year of introduction)	571 825	25%
J	Total Doses Needed	2 859 127	= H + I
K	Vaccine price per dose (2013)	US$ 3.5	
L	**Total Vaccine Cost ($) at 45% coverage**	**$ 10 006 944**	**= J * K**
AD Syringes			
M	AD Syringes (+ waste)	2 287 301	= E * G
N	Buffer Stock	571 825	= M * I
O	Price of AD Syringes	$ 0,06	
P	**Total Cost of AD Syringes ($)**	**$ 171 548**	**= (M+N) * O**
Safety Boxes			
Q	Capacity of safety boxes	100	
R	Safety Boxes (+ waste)	25 389	= (M * G) / Q
S	Average unit price of a safety box (incl.5% for procurement)	$ 0.74	
T	**Total Cost of Safety Boxes ($)**	**$ 18 661**	**= R * S**
Grand Total ($) for NUVI Vaccines and Supplies (at 45% coverage)		**$ 10 197 152**	**= L + P + T**

Table 6.2: NUVI Unit Prices

Vaccine and supplies assumptions	
Buffer stock at first year of introduction	25%
Vaccine price per dose (US$, 2013)	3,5
Wastage on injection equipment	5%
Wastage factor	1,1
Average unit price of a safety box (incl.5% for procurement)	0,74
Capacity of safety boxes	100

The PCV vaccine cost was $3.50 per dose (the guaranteed price for 10 years) plus 1% freight / handling. Supply of PCV is subject to an Advance Market Commitment (AMC) agreement with manufacturers. Under the AMC, manufacturers are given an incentive to invest in vaccines research and development for diseases that affect mainly developing countries. Sponsors have provided a $1.5 billion incentive for PCV, which is used to make a top-up payment of $3.50 on 20% of PCV doses, in addition to the long term price of $3.50.

NUVI Unit Prices	
Item	Unit Cost (US$)
Cost of Fuel (per litre)	1,54
Cost of Venue hire at central/ National level	192,31
Cost of venue hire at Regional Level	134,62
Cost of venue hire at district level	38,46
Per diem cost for personnel from Central	42,31
Per diem cost for driver from Central	21,15
SDA for District level pesronnel	4,62
SDA for District level Driver/ community mobilizers, VHTs	4,23
Conference package at national/ Central level	23,08
Conference packaage at regional level	13,46
Conference package at district level	7,69
Stationary pack	1,92
Tansport refund for participants at central level	38,46
Tansport refund for participants at district level	3,85
Transport to and from (No of liters estimated per district)	0,04
Transport within district (No of liters per day)	0,01
Cost of printing per page (documents)	0,08
Cost of printing per page(flyers/posters)	0,19
Hotel hire and complimentary meet	-
Light refreshments in inhouse meetings	0,77
Venue hire at district/health sub district level	96,15
Cost of Venue hire at central/ National level	192,31
Ream of paper	3,85
Per diem for district officers (mobilisation)	5,77
Per diem for drivers and escorts(district level)	4,23
Cost of radio talk show (One hour)	307,69
Cost of a radio spot	19,23
Raptouer	192,31
Allowance to drivers (central level)	21,15
Cost of a television talk show (One hour)	961,54
News paper advertsing rates (Half page)	1 153,85

Table 6.3: Details of NUVI Training Cost Estimates and Assumptions

Summary for Cost of NUVI Training			
Item	Total cost (USD)		
Central level training	43 108		
Regional level training	68 794		
District level training	228 738		
Training at the HSD	311 595	Economic Cost	Financial Cost
Total - all Training (US$)	652 235	340 865	326 118

NUVI Training Estimates

Training of trainers - Central level

Length of training (days)	3
Number of participants	38
Number of trainers/facilitators	3
Number of phases for ToT at central level	3

	Quantity	Unit cost	Cost (UGX)
Per diem for all	369	110 000	40 590 000
Venue hire	9	500 000	4 500 000
Conference package	1 107	60 000	66 420 000
Stationary	114	5 000	570 000
Sub-total for national level TOT for PCV			112 080 000

Training at regional level

Number of regions	14
Length of training (days)	3
Number of participants	56
Number of trainers/facilitators per region	3
Drivers from central	1

	Quantity	Unit cost	Cost (UGX)
Per diem for trainers	126	110 000	13 860 000
Per diem for driver	42	55 000	2 310 000
SDA for participants	2 352	12 000	28 224 000
Transport to and from district for trainers	1 400	4 000	5 600 000
Transport refund for participants	2 352	10 000	23 520 000
Venue hire	42	350 000	14 700 000
Conference package	2 478	35 000	86 730 000
Stationary	784	5 000	3 920 000
Sub-total for regional level training for PCV			178 864 000

Training at district level

Number of districts	112
Length of training	3
Number of participants per district	25
Number of trainers per district	3
Drivers from central	1

	Quantity	Unit cost	Cost (UGX)
Per diem for trainers	1 008	110 000	110 880 000
Per diem for driver	336	55 000	18 480 000
SDA for participants	8 400	12 000	100 800 000
Transport to and from district for trainers (fuel)	11 200	4 000	44 800 000
Transport refund for participants	8 400	10 000	84 000 000
Venue hire	336	100 000	33 600 000
Conference package	9 408	20 000	188 160 000
Stationary	2 800	5 000	14 000 000
Sub-total for district level training for PCV			594 720 000

Training at Health Sub-district (HSD)

Number of HSD	214
Length of training	2
Number of participants from HSD	78
Number of district trainers ,supervisors and a driver	5

	Quantity	Unit cost	Cost (UGX)
SDA for all participants	35 524	12 000	426 288 000
Transport within district	4 480	4 000	17 920 000
Transport refund for participants	16 692	10 000	166 920 000
Venue hire	428	250 000	107 000 000
Conference package	428	20 000	8 560 000
Stationary	16 692	5 000	83 460 000
Sub-total for HSD training for PCV			810 148 000

Table 6.3 NUVI Social Mobilization, Surveillance and Monitoring Assumptions

Summary for Cost of NUVI Social Mobilisation and IEC	
Item	Total cost (USD)
Develop and print guidelines for PCV introduction	124 163
Develop and diseminate key messages for PCV introduction	281 096
District level mass mobilisation (including electronic media activities)	336 225
Sensitisation at sub-county level	235 853
National launch of PCV	20 171
Total - all Social Mobilisation and IEC	997 509

Summary for Cost of Surveillance and Monitoring	
Cost Item	Total cost (USD)
Printing of updated AEFI guidelines	17 081
Printing of PCV fridge stickers	7 788
Printing of tally sheets (Redesign)	87 231
Printing of vaccines and injection materials control books (Redesign)	103 846
Printing of child health cards	246 154
Post introduction evaluation	56 975
Total Cost for Surveillance and Monitoring	519 075

Appendix 7: Financial Mapping Codes

The following codes, based on SHA codes, were used to map immunization finances

Table 7.1 Financial Mapping codes

FSR.Source of Source Code	**Source of Source Description**	**FS. CODE**	**FS. Descritpion**
			Transfers from government domestic revenue
FSR.1	Loans	**FS.1**	
FSR.1.1	Loans taken by government	FS.1.1	Internal transfers and grants
FSR.1.1.1	Loans from international organizations	*FS.1.1.1*	*Internal transfers within central government*
FSR.1.1.1.1	Concessional loans	*FS.1.1.2*	*Internal transfers within region/local government*
		FS.1.1.3	*Grants from central government*
FSR.1.1.1.2	Non-consessional loans		
FSR.1.1.1.3	HIPC/Debt relief	*FS.1.1.4*	*Grants from regional/local government*
FSR.1.1.2	Other loans taken by government	FS.1.2	Transfers by government on behalf of specific groups
		FS.1.3	Subsidies
FS.RI.1	Institutional units providing revenues to financing schemes	FS.1.4	Other transfers
FS.RI.1.1	Government	**FS.2**	**Transfers distributed by government from foreign origin**
FS.RI.1.2	Corporations	*FS.2.1*	*Monetary transfers*
FS.RI.1.3	Households	*FS.2.1.1*	*from bilateral organizations*
FS.RI.1.4	Non-profit institutions	*FS.2.1.1.1*	*USG bilateral financial transfer*
FS.RI.1.5	Rest of the world	*FS.2.1.1.2*	*DfiD bilateral financial transfer*
		FS.2.1.1.3	*ICA bilateral financial transfer*
FS.RI.2	Total foreign revenues (FS.2 + FS.7)	*FS.2.1.1.4*	*NORAD bilateral financial transfer*
		FS.2.1.1.5	*Other agency bilateral financial transfer (Specify)*
		FS.2.1.2	*from multilateral organizations*
		FS.2.1.2.1	*from UNICEF direct financial transfer*
		FS.2.1.2.2	*from WHO direct financial transfer*
		FS.2.1.2.3	*from PAHO direct financial transfer*
		FS.2.1.2.4	*from Other multilateral financial transfer (Specify)*
		FS.2.1.3	*from GAVI Alliance*
		FS.2.1.4	*from other sources*
		FS.2.1.4.1	*from BMGF financial transfers*
		FS.2.1.4.2	*from CHAI financial transfers*
		FS.2.1.4.3	*from other external/NGO source financial transfers (Specify)*
		FS.2.2	*Commodity transfers*
		FS.2.2.1	*from bilateral organizations*
		FS2.2.1.1	*USG bilateral commodity transfer*
		FS.2.2.1.2	*DfiD bilateral commodity transfer*
		FS.2.2.1.3	*ICA bilateral commodity transfer*
		FS.2.2.1.4	*NORAD bilateral commodity transfer*
		FS.2.2.1.5	*Other agency bilateral commodity transfer (Specify)*
		FS.2.2.2	*from multilateral organizations*
		FS.2.2.2.1	*from UNICEF commodity transfers*
		FS.2.2.2.2	*from WHO commodity transfers*
		FS.2.2.2.3	*from PAHO commodity transfers*
		FS.2.2.2.4	*from other external/NGO source commodity transfers (Specify)*
		FS.2.2.3	*from GAVI Alliance*
		FS.2.2.4	*from other sources*
		FS.2.2.4.1	*from BMGF commodity transfers*
		FS.2.2.4.2	*from CHAI commodity transfers*
		FS.2.2.4.3	*from other external/NGO source commodity transfers (Specify)*
		FS.3	**Social insurance contributions**
		FS.3.1	Social insurance contributions from employers
		FS.3.2	Social insurance contributions from employees
		FS.3.3	Social insurance contributions from self-employed
		FS.3.4	Other social insurance contributions
		FS.4	**Compulsory prepayment**
		FS.4.1	Compulsory prepayment from households/individuals
		FS.4.2	Compulsory prepayment from employers
		FS.4.3	Other

FS. CODE	FS. Descritpion
FS.5	**Voluntary prepayment**
FS.5.1	Voluntary prepayment from households/individuals
FS.5.2	Voluntary prepayment from employers
FS.5.3	Other
FS.6	**Other domestic revenues not elsewhere classified (n.e.c)**
FS.6.1	Other revenues from households n.e.c
FS.6.2	*Other revenues from communities n.e.c*
FS.7	**Direct foreign transfers**
FS.7.1	**Direct foreign financial transfers**
FS.7.1.1	Direct bilateral transfers
FS.7.1.2	Direct multilateral transfers
FS.7.1.3	Other direct foreign transfers
FS.7.2	**Direct foreign aid in kind**
FS.7.2.1	Direct foreign aid in goods
FS.7.2.1.1	Direct bilateral aid in goods
FS.7.2.1.2	Direct multilateral aid in goods
FS.7.2.1.3	Other direct foreign aid in goods
FS.7.2.2	Direct foreign aid in kind: services (including TA)
FS.7.2.2.1	*Direct bilateral foreign aid in kind*
FS.7.2.2.1.1	*from USG bilateral aid in kind*
FS.7.2.2.1.2	*from DfID bilateral aid in kind*
FS.7.2.2.1.3	*from JICA bilaeral aid in kind*
FS.7.2.2.1.4	*from NORAD bilateral aid in kind*
FS.7.2.2.1.5	*from other bilateral aid in kind (Specify)*
FS.7.2.2.2	*Direct multilateral foreign aid in kind*
FS.7.2.2.2.1	*from UNICEF aid in kind*
FS.7.2.2.2.2	*from WHO aid in kind*
FS.7.2.2.2.3	*from PAHO aid in kind*
FS.7.2.2.2.4	*from other multilateral aid in kind (Specify)*
FS.7.2.2.3	*Other direct foreign aid in kind*
FS.7.2.2.3.1	*from BMGF aid in kind*
FS.7.2.2.3.2	*from CHAI aid in kind*
FS.7.2.2.3.3	*from other direct foreign aid in kind*
FS.7.3	Other direct foreign transfers n.e.c
FS.7.9	***Any other source not elsewhere classified (n.e.c)***
FSR.1	**Loans**
FSR.1.1	Loans taken by government
FSR.1.1.1	Loans from international organizations
FSR.1.1.1.1	Concessional loans
FSR.1.1.1.2	Non-consessional loans
FSR.1.1.1.3	HIPC/Debt relief
FSR.1.1.2	Other loans taken by government
FS.RI.1	**Institutional units providing revenues to financing schemes**
FS.RI.1.1	Government
FS.RI.1.2	Corporations
FS.RI.1.3	Households
FS.RI.1.4	Non-profit institutions
FS.RI.1.5	Rest of the world
FS.RI.2	**Total foreign revenues (FS.2 + FS.7)**

FA.CODE	FA.Description	HF.CODE	HF.Description
FA.1	**General Government**	**HF.1**	**Government schemes and compulsory**
FA.1.1	*Central Government Agencies*	HF.1.1	Government schemes
FA.1.1.1	Central Ministry of Health:	HF.1.1.1	Central government schemes
FA.1.1.1.1	Central Ministry of Health (EPI programme)	HF.1.1.2	State/regional/local government schemes
FA.1.1.1.2	Central Ministry of Health (other programmes)	HF.1.2	Compulsory contributory health insurance
FA.1.1.1.3	National Medical Stores / Central Cold Stores	HF.1.2.1	Social health insurance
FA.1.1.1.4	National Laboratories	HF.1.3	Compulsory medical savings accounts
FA.1.1.1.5	National Surveillance Agency	**HF.2**	**Voluntary health care payment schemes**
FA.1.1.2	Other Central Ministries and Units	HF.2.1	Voluntary health insurance schemes
FA.1.1.3	National Health Service Agency	HF.2.2	Non-profit institutions financing schemes
FA.1.1.4	National Health Insurance Agency	**HF.3**	**Household out-of-pocket payment**
FA.1.2	*State/Regional/Local Govt Agents*	*HF.3.1*	*Community level financing*
FA.1.2.1	Provincial Level Ministry of Health	**HF.4**	**Rest of the world**
FA.1.2.2	Other Provincial Level Ministries/Departments	**HF.99**	**Not disaggregated**
FA.1.2.3	District Level Ministry of Health		
FA.1.2.4	Other District Level Ministries/Departments		
FA.1.3	Social Security Agency		
FA.1.3.1	Social Health Insurance Agency		
FA.1.3.2	Other social security agency		
FA.1.9	All other general government unit		
FA.2	**Insurance Corporations**		
FA.3	**Other Corporations / Business (other than insurance)**		
FA.4	**Non-Profit Institutions Serving Households**		
FA.5	**Households**		
FA.5.1	*Community organizations/groups*		
FA.6	**Rest of the World**		
FA.6.1	*International Organisations (Multilaterals)*		
FA.6.1.1	UNICEF		
FA.6.1.2	WHO		
FA.6.1.3	PAHO		
FA.6.1.4	Other multilateral agent 1		
FA.6.1.5	Other multilateral agent 2		
FA.6.1.6	Other multilateral agent 3		
FA.6.2	*Foreign Govts (Bilateral Agents)*		
FA.6.2.1	Govt of USA: PEPFAR, CDC, USAID etc		
FA.6.2.2	Govt of United Kingdom:		
FA.6.2.3	Govt of Japan (JICA):		
FA.6.2.4	Govt of Norway (NORAD):		
FA.6.2.5	Other bilateral agency 1		
FA.6.2.6	Other bilateral agency 2		
FA.6.2.7	Other bilateral agency 3		
FA.6.3	*Other Foreign Entities*		
FA.6.3.1	BMGF		
FA.6.3.2	CHAI		
FA.6.3.3	Other International NGO (Sabin vaccine institute)		
FA.6.3.4	Other International NGO (AFENET)		
FA.6.3.5	Other International Foundation (PATH)		
FA.9	**Any other agents not else where classified**		

HP.CODE	HP.Description
HP.1	**Hospitals**
HP.1.1	General hospitals
HP.1.1.1	General hospitals - public
HP.1.1.1.1	*National general hospitals*
HP.1.1.1.2	*Provincial or regional general hospitals*
HP.1.1.1.3	*District hospitals*
HP.1.1.2	General hospitals - social security
HP.1.1.3	General hospitals - NGO/private non-profit
HP.3	**Providers of ambulatory health care**
HP.3.1	Medical practices
HP.3.4	Ambulatory health care centres
HP.3.4.9	All other ambulatory centres
HP.3.4.9.1	*Government facilities*
HP.3.4.9.3.1	*PHC Type 1 (HC IV)*
HP.3.4.9.3.2	*PHC Type 2 (HC III)*
HP.3.4.9.3.3	*PHC Type 3 (HC II)*
HP.3.4.9.3.4	*PHC Type 4 (VHT)*
HP.3.4.9.2	*Social security facilities*
HP.3.4.9.3	*NGO facilities*
HP.4	**Providers of ancillary services**
HP.4.2	Medical and diagnostic laboratories
HP.6	**Providers of preventive care**
HP.6.1	*Country Specific Preventative providers*
HP.6.2	*Research Providers*
HP.6.2.1	*Public research institutions*
HP.6.2.2	*Para-statal (quazi-public) research institut*
HP.6.2.3	*Private research institutions*
HP.7	**Providers of health care system**
HP.7.1	Government health administrative agencies
HP.7.1.1	*National MOH*
HP.7.1.2	*Provincial MOH*
HP.7.1.3	*District MOH*
HP.7.2	Social health insurance agencies
HP.7.3	Private health insurance administrative
HP.7.9	Other administrative agencies
HP.8	**Rest of the economy**
HP8.1	Households as providers of home health care
HP.8.9	Other industries n.e.c
HP.9	**Rest of the world**
HP.99	**Not classified elsewhere**

HC.CODE	HC.Description	FP.CODE	FP.Description
HC.1	**Curative care**	**FP.1**	**Compensation of employees**
HC.6	**Preventive care**	FP.1.1	Wages and salaries
HC.6.1	Information, education and counseling programmes	FP.1.3	All other costs relating to employees
HC.6.1.1	*Social mobilization, advocacy*	*FP.1.3.1*	*Per diem*
HC.6.2	Immunization programmes (not disaggregated)	**FP.2**	**Self-employed professional remuneration**
HC.6.2.1	*Facility-based routine immunization service delivery*	*FP.2.1*	*Volunteer labour*
HC.6.2.2	*Outreach routine immunization service delivery*	**FP.3**	**Materials and services used**
HC.6.2.3	*Training*	FP.3.1	Health care services
HC.6.2.4	*Vaccine collection, storage and distribution*	FP.3.2	Health care goods
HC.6.2.5	*Cold chain maintenance*	FP.3.2.1	Pharmaceuticals
HC.6.2.6	*Supervision*	*FP.3.2.1.1*	*Vaccines and other goods*
HC.6.2.7	*Program management*	FP.3.2.2	Other health care goods
HC.6.2.8	*Other routine immunization programme activity*	*FP.3.2.2.1*	*Injection supplies*
HC.6.5	Surveillance	*FP.3.2.2.2*	*Other supplies*
HC.6.5.1	*EPI Surveillance*	FP.3.3	Non-health care services
HC.6.5.2	*Record-keeping and HMIS*	*FP.3.3.1*	*Transport*
HC.7	*Governance and health system financing and*	*FP.3.3.2*	*Maintenance*
HC.99	**Not disaggregated**	*FP.3.3.3*	*Printing*
HC.RI.3	**Prevention and public health services**	FP.3.4	Non-health care goods
HC.RI.3.3	Prevention of communicable diseases	*FP.3.4.1*	*Utilities and communications*
Cap.Invstmt.	CAPITAL INVESTMENT	*FP.3.4.2*	*Other*
		FP.4	**Consumption of fixed capital**
		FP.4.1	*Cold chain equipment*
		FP.4.2	*Vehicles*
		FP.4.3	*Other equipment*
		FP.4.4	*Buildings*
		FP.5	**Other items of spending on inputs**
		FP.5.1	Taxes and customs duties
		FP.5.2	Other
		FP.99	*Not disaggregated/n.e.c*

Appendix 8: Further Details of Results

A. Costing analysis of Routine Immunization

Table 8.1: Total Uganda Economic Costs of Routine Immunization by activity and facility type (2011)

EPI Estimated Economic Costs (US$, 2011)	HCII Total (N=2215)	HCIII Total (N=1180)	HCIV Total (N=185)	Gen.Hosp.Total (N=127)	DHO Total (N=112)	National level costs	Total Country EPI Costs (US$)	% Share by Line-Item
Activities								
Cold Chain Maintenance	585 207	502 548	172 023	562 696	99 479	179 062	2 101 016	5,3%
Outreach Service Delivery	2 375 462	3 310 946	1 055 171	2 271 695	191 826	1 349 457	10 554 558	26,4%
Program Management	1 144 368	1 101 558	367 380	335 705	183 591	-	3 132 604	7,8%
Record-Keeping & HMIS	244 238	292 246	102 829	95 725	48 502	-	783 539	2,0%
Routine Facility-based Serv-Del.	3 607 698	5 074 820	1 454 387	2 967 151	2 505 456	269 876	15 879 388	39,7%
Social Mobilization & Advocacy	164 561	292 924	88 139	47 938	24 420	-	617 983	1,5%
Supervision	248 888	240 147	160 981	190 980	73 080	587 855	1 501 931	3,8%
Surveillance	161 808	170 738	102 930	17 504	25 993	240 172	719 144	1,8%
Training	21 524	22 868	7 304	789	3 954	1 985 977	2 042 416	5,1%
Vaccine Collectn, Distribn &Storg.	991 181	740 432	403 471	341 523	195 088	-	2 671 695	6,7%
Total EPI Estimated Costs	9 544 937	11 749 226	3 914 616	6 831 707	3 351 389	4 612 399	40 004 275	100%

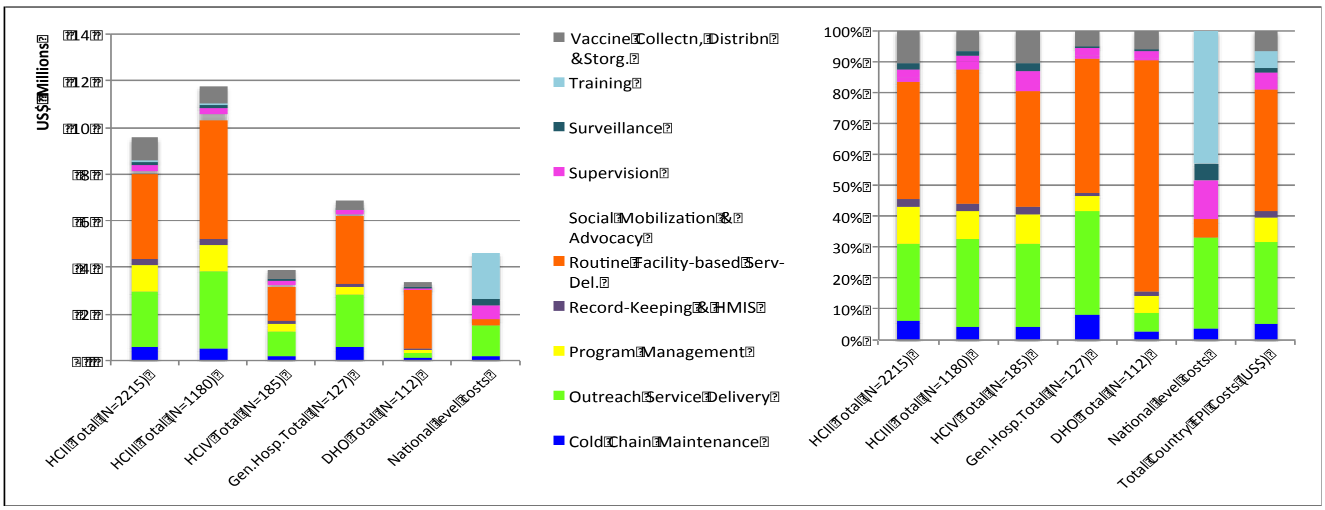


Figure 8.1: Total National Economic Costs for Routine Immunization by activity (%)

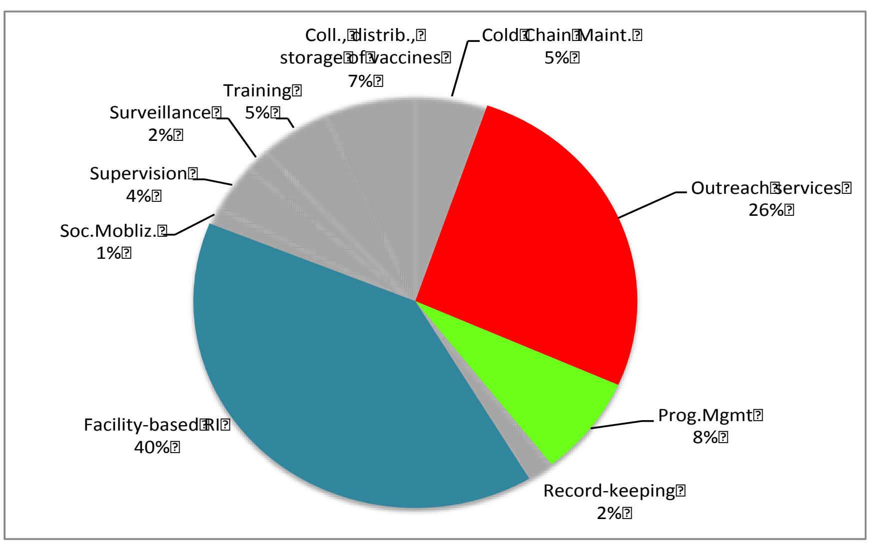


Table 8.2: Weighted Unit Cost per Targeted Child by Line Item and Facility Type (US$, 2011)

FACILITY UNIT COSTS (US$) PER TARGETTED CHILD	HC II W.Unit Cost (per child)	HC III W.Unit Cost (per child)	HC IV W.Unit Cost (per child)	General Hosp. W.Unit Cost (per child)	Across All HC W.Unit Cost (per child)	Distribution for all HC types (per child)
No. of Facilities (n):	18	18	9	4		
Weighted number of target children	536	826	1 208	10 477		
Expenditure Line Items						
Salaried Labor	2,81	3,22	6,13	1,25	3,36	38,4%
Volunteer Labor	-	-	-	-	-	0,0%
Per Diem & Travel Allowances	0,10	0,13	0,18	0,04	0,11	1,3%
Vaccines	1,48	3,83	4,24	1,22	2,69	30,8%
Vaccine Injection & Safety Supplies	0,08	0,20	0,15	0,07	0,12	1,4%
Other Supplies	0,16	0,10	0,09	0,03	0,10	1,1%
Transport/Fuel	0,12	0,18	0,26	0,00	0,14	1,6%
Vehicle Maintenance	0,09	0,09	0,35	0,13	0,17	1,9%
Cold Chain Energy Costs	0,30	0,27	0,33	0,24	0,29	3,3%
Printing	-	-	-	-	-	0,0%
Building overhead, Utilities, Comms.	-	-	-	-	-	0,0%
Other recurrent	-	-	-	-	-	0,0%
Subtotal recurrent	*5,14*	*8,02*	*11,74*	*2,98*	*6,97*	*79,9%*
Cold Chain Equipment	0,20	0,19	0,18	0,02	0,15	1,7%
Vehicles	0,65	0,69	3,04	0,45	1,21	13,8%
Lab equipment	-	-	-	-	-	0,0%
Other Equipment	0,00	0,06	0,01	0,00	0,02	0,2%
Other capital	-	-	-	-	-	0,0%
Building	0,36	0,72	0,43	0,04	0,38	4,4%
Subtotal capital	*1,21*	*1,66*	*3,66*	*0,51*	*1,76*	*20,1%*
Facility Immunization Cost / Child (US$)	**6,35**	**9,68**	**15,40**	**3,49**	**8,73**	**100,0%**
Facility Cost per child (excluding vaccines)	4,87	5,85	11,16	2,27	6,04	
Facility Cost per child (excl. vaccines & salaries)	2,06	2,63	5,03	1,02	2,68	

Table 8.3 : Weighted Unit Cost per Capita (catchment population) (US$, 2011)

FACILITY UNIT COSTS (US$) PER CAPITA	HC II W.Unit Cost/capita	HC III W.Unit Cost/capita	HC IV W.Unit Cost/capita	General Hosp. W.Unit Cost/capita	Across All HC W.Unit Cost/capita	Av.% Distribution for all HC types (per capita)
No. of Facilities (n):	18	18	9	4		
Weighted catchment population	10 984	18 986	28 099	243 643		
Expenditure Line Items						
Salaried Labor	0,14	0,14	0,26	0,05	0,15	38,6%
Volunteer Labor	-	-	-	-	-	0,0%
Per Diem & Travel Allowances	0,00	0,01	0,01	0,00	0,01	1,3%
Vaccines	0,07	0,17	0,18	0,05	0,12	30,7%
Vaccine Injection & Safety Supplies	0,00	0,01	0,01	0,00	0,01	1,4%
Other Supplies	0,01	0,00	0,00	0,00	0,00	1,1%
Transport/Fuel	0,01	0,01	0,01	0,00	0,01	1,6%
Vehicle Maintenance	0,00	0,00	0,02	0,01	0,01	1,9%
Cold Chain Energy Costs	0,01	0,01	0,01	0,01	0,01	3,3%
Printing	-	-	-	-	-	0,0%
Building overhead, Utilities, Comms.	-	-	-	-	-	0,0%
Other recurrent	-	-	-	-	-	0,0%
Subtotal recurrent	*0,25*	*0,35*	*0,50*	*0,13*	*0,31*	*79,9%*
Cold Chain Equipment	0,01	0,01	0,01	0,00	0,01	1,7%
Vehicles	0,03	0,03	0,13	0,02	0,05	13,7%
Lab equipment	-	-	-	-	-	0,0%
Other Equipment	0,00	0,00	0,00	0,00	0,00	0,2%
Other capital	-	-	-	-	-	0,0%
Building	0,02	0,03	0,02	0,00	0,02	4,4%
Subtotal capital	*0,06*	*0,07*	*0,16*	*0,02*	*0,08*	*20,1%*
Facility Immunization Cost / capita (US$)	**0,31**	**0,42**	**0,66**	**0,15**	**0,39**	**100,0%**
Facility Cost per capita (excluding vaccines) (US$)	0,24	0,25	0,48	0,10	0,27	
Facility Cost per capita (excl. vaccines & salaries)	0,10	0,11	0,22	0,04	0,12	

Figure 8.2: Weighted unit cost per Dose by Line Item and Facility Types (US$, %, 2011)

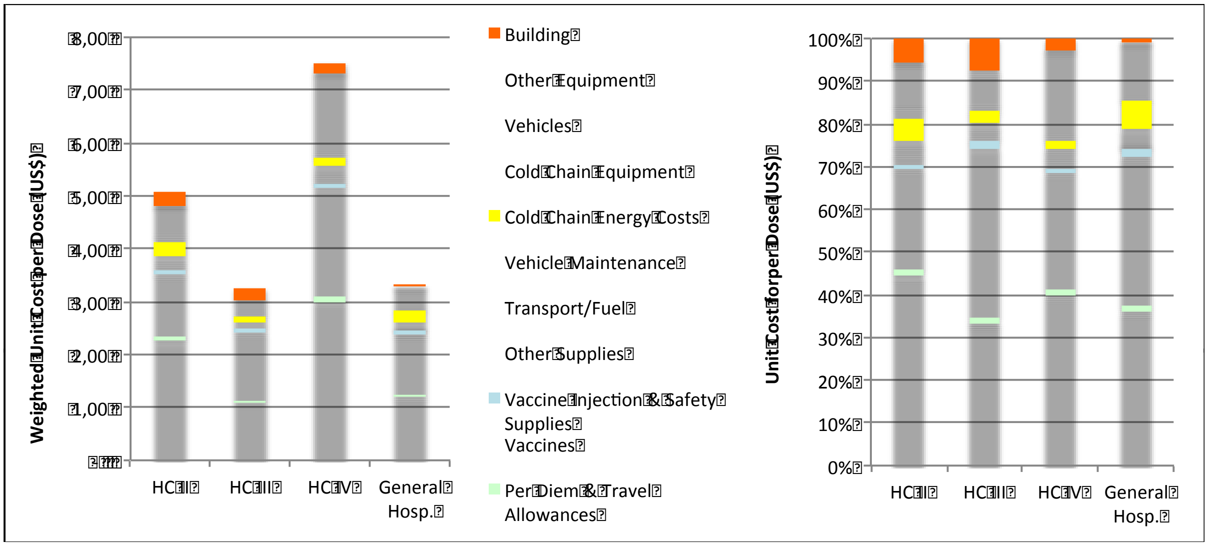


Figure 8.3: Weighted unit cost per Targeted Child by Line Item and Facility Type (US$, %, 2011)

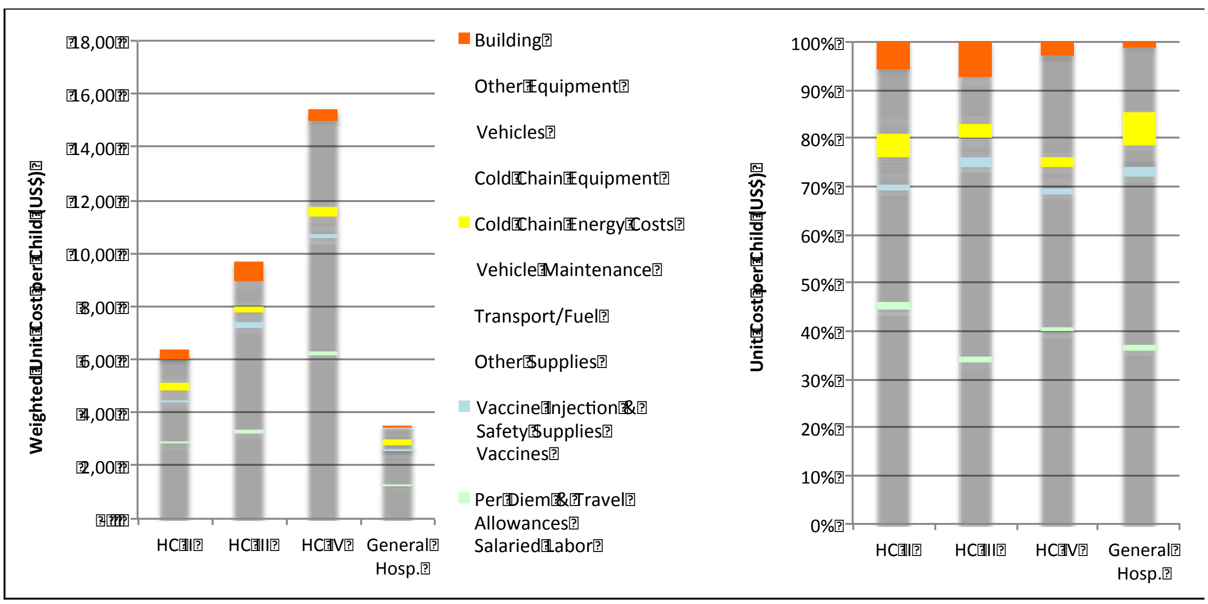
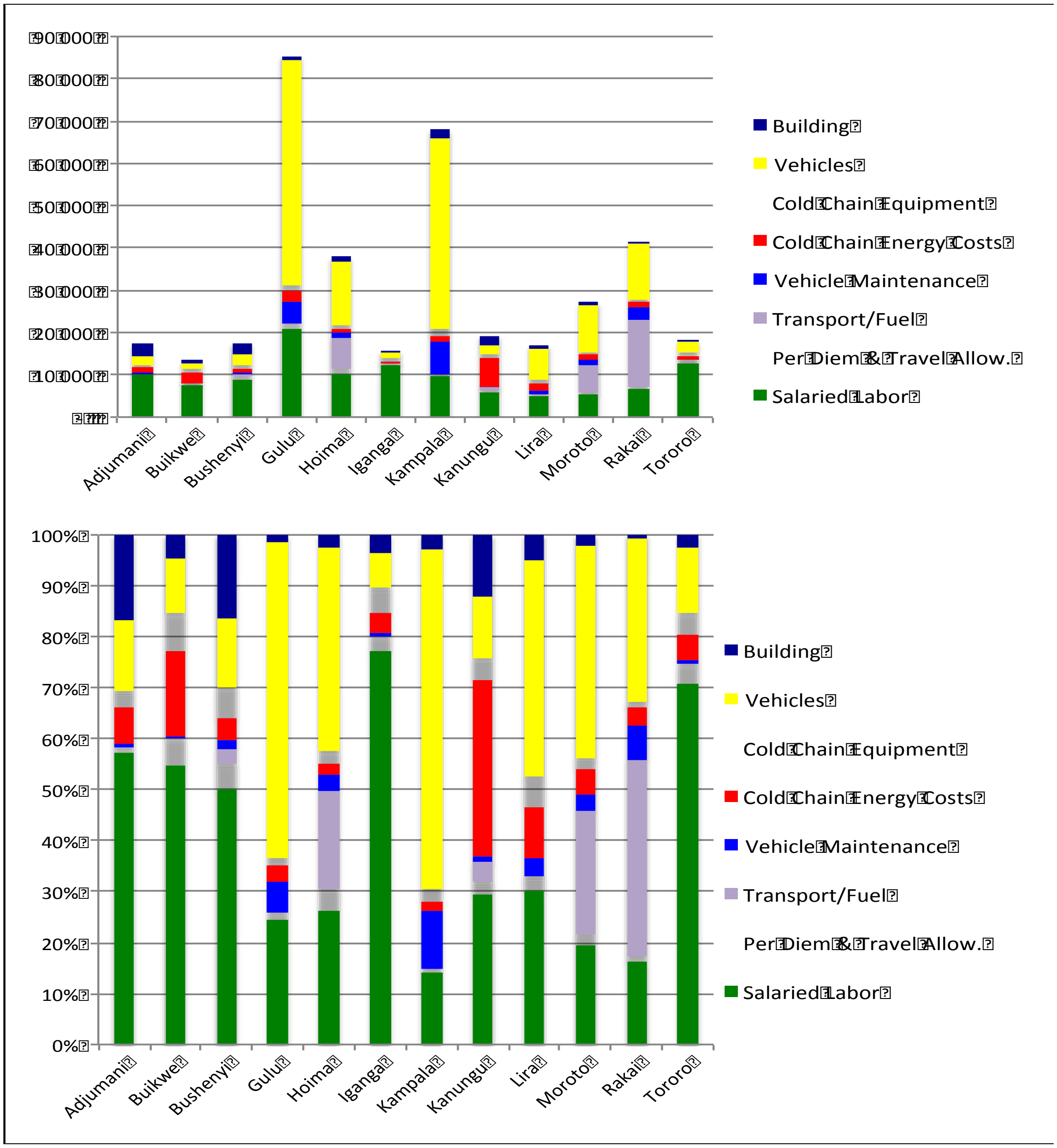


Figure 8.4: Weighted DHO Level Total Economic Costs for Immunization by Line item excl. Vaccine Costs (US$,%, 2011)



B. NUVI Introduction Cost Analysis

Table 8.4: Estimated costs of PCV by line item and activity (Economic, Financial & Fiscal, US$, 2013): 60% coverage

Expenditure Line Items	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Salaried Labor (33% of HR per dose)	1 037 504		1 037 504	6,1%	1 037 504	6,1%		0,0%
Vaccines	13 342 591		13 342 591	79,0%	13 342 591	79,1%	13 342 591	64,0%
Vaccine Injection & Safety Supplies	253 611		253 611	1,5%	253 611	1,5%	253 611	1,2%
Transport/Fuel			No additional costs anticipated					
Vehicle Maintenance			No additional costs anticipated					
Cold Chain Energy Costs			No additional costs anticipated					
Printing	462 100	462 100		2,7%	462 100	2,7%	462 100	2,2%
Building overhead, Utilities, Comms.			No additional costs anticipated					
Other recurrent (Soc.Mob & PIE)	1 054 484	997 509	56 975	6,2%	1 054 484	6,2%	1 054 484	5,1%
Waste management	182 333		182 333	1,1%	182 333		182 333	
Subtotal recurrent	*16 332 624*	*1 459 609*	*14 873 015*	*97%*	*16 332 624*	*96%*	*15 295 120*	*72%*
Cold Chain Equipment	222 419	222 419		1,3%	215 747	1,3%	4 908 798	23,5%
Training	340 865	340 865		2,0%	326 118	1,9%	652 235	3,1%
Vehicles			No additional costs anticipated					
Building			No additional costs anticipated					
Subtotal capital	*563 285*	*563 285*	*-*	*3,3%*	*541 864*	*3,2%*	*5 561 033*	*26,7%*
Total NUVI Estimated Costs	16 895 908	2 022 893	14 873 015	100%	16 874 488	99%	20 856 153	99%
		12%	88%					
Total NUVI Cost/ Month	938 662							
Total Delivery Costs (excl. Vaccines & Supplies)	3 299 705	2 022 893	1 276 812		3 278 285		7 259 950	
		61%	39%					
Total NUVI Delivery Cost/ Month	183 317							

Activity	Tot.Economic Costs (US$)	Economic Start Up (US$)	Economic Ongoing (US$)	%	Financial (US$)	%	Fiscal (US$)	%
Cold Chain Equip (investment)	222 419	222 419		1,3%	215 747	1,3%	4 908 798	23,5%
Outreach Service Delivery	5 623 778		5 623 778	33,3%	5 623 778	33,3%	5 438 481	26,1%
Program Management	178 721		178 721	1,1%	178 721	1,1%		0,0%
Record-Keeping & HMIS	89 059		89 059	0,5%	89 059	0,5%		0,0%
Routine Facility-based Serv-Del.	8 463 373		8 463 373	50,1%	8 463 373	50,2%	8 157 722	39,1%
Social Mobilization & Advocacy	1 042 604	997 509	45 095	6,2%	1 042 604	6,2%	997 509	4,8%
Supervision	106 739		106 739	0,6%	106 739	0,6%		0,0%
Surveillance	560 637	462 100	98 537	3,3%	560 637	3,3%	519 075	2,5%
Training	343 212	340 865	2 347	2,0%	328 464	1,9%	652 235	3,1%
Vaccine Collectn, Distribn &Storg.	83 034		83 034	0,5%	83 034	0,5%		0,0%
Waste management	182 333		182 333	1,1%	182 333		182 333	
Total NUVI Estimated Costs	16 895 908	2 022 893	14 873 015	100%	16 874 488	99%	20 856 153	99%
NUVI Cost/Month	938 662							

Table 8.5: Unit costs of PCV (Economic, Financial & Fiscal, US$, 2013): 60% coverage

Anticipated Outputs	60% Coverage Achieved		
Total number of doses	3 812 169		
Total number of target children	965 749	(60%)	
Total population	35 081 678	(cMYP estimate 2013)	

1. Salaries estimated at 33% of cost of HR per dose			
NUVI Unit Costs (incl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 4,43	$ 4,43	$ 5,47
Unit cost/ PCV Imm. Child	$ 17,50	$ 17,47	$ 21,60
Unit cost/ capita	$ 0,48	$ 0,48	$ 0,59

NUVI Delivery Costs (excl.Vaccin	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 0,87	$ 0,86	$ 1,90
Unit cost/ PCV Imm. Child	$ 3,42	$ 3,39	$ 7,52
Unit cost/ capita	$ 0,09	$ 0,09	$ 0,21

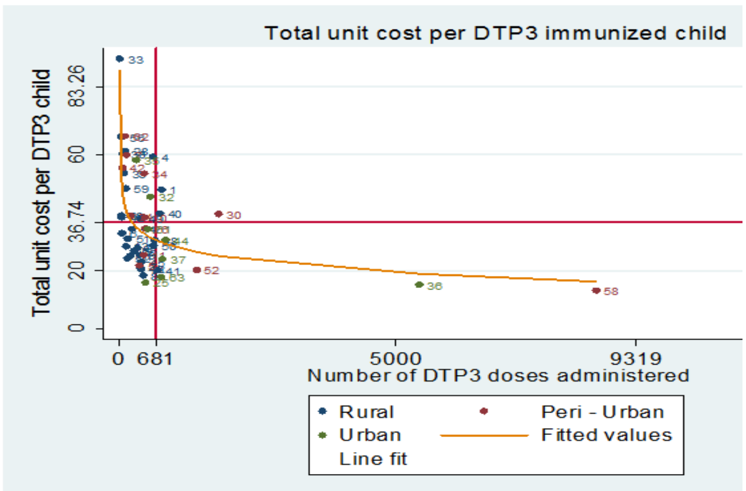
2. Salaries estimated at 10% of cost of HR per dose			
NUVI Unit Costs (incl.Vaccines)	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 4,24	$ 4,24	$ 5,47
Unit cost/ PCV Imm. Child	$ 16,75	$ 16,72	$ 21,60
Unit cost/ capita	$ 0,46	$ 0,46	$ 0,59

NUVI Delivery Costs (excl.Vaccin	Economic Costs	Financial Costs	Fiscal Costs
Unit cost/ PCV dose	$ 0,68	$ 0,67	$ 1,90
Unit cost/ PCV Imm. Child	$ 2,67	$ 2,65	$ 7,52
Unit cost / capita	$ 0,07	$ 0,07	$ 0,21

C. Productivity and Determinants Analysis – Scatter Plots

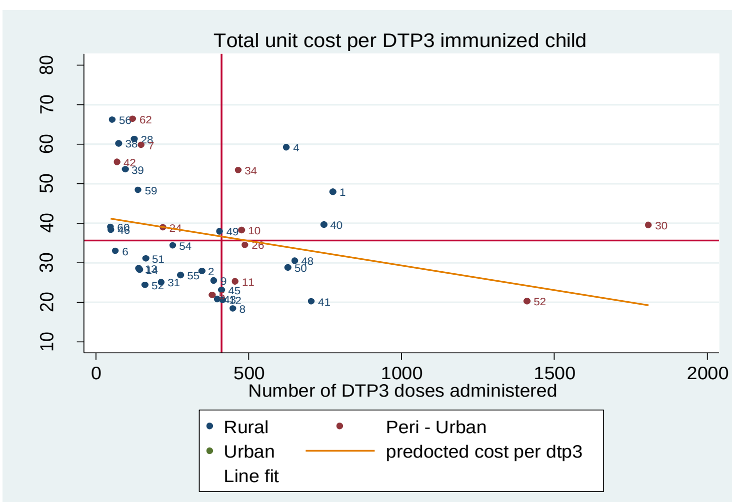
Scatter plots of *un-transformed and ln-transformed* facility data are provided below to supplement the untransformed plots shown in Section 3.2.1 and Section 5. [75]

Figure 8.5: Unit Cost per DTP3 Child vs. Number of DPT3 doses (Rural, Urban & Peri-urban sites)[+]



+ Outlier site 29 (low unit cost, high volume) not shown

Figure 8.6: Unit Cost per DTP3 Child vs. Number of DPT3 doses (Rural, Urban & Peri-urban sites) - high volume outliers removed*



* Sites 36, 58, 29

[75] In graphing several variables after Figure 8.5, four outlier facilities were identified and excluded to better show patterns of other facilities. The sites were Kidoko (HCII #33), Kiswa (HCIII #36), Pachara (HCII #56) and Rakai hospital (#58). They are however included in the log-transformed graphs. Reasons for their outlier performance are discussed above. Tests were run to ensure they were not skewing regression results.

Figure 8.7: Unit Cost per Dose vs. Facility Attendance (by facility location)

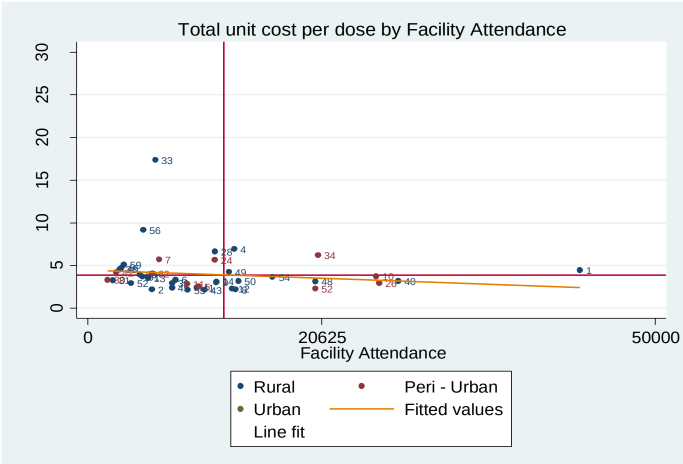


Figure 8.8: Number of doses per health FTE by facility attendance

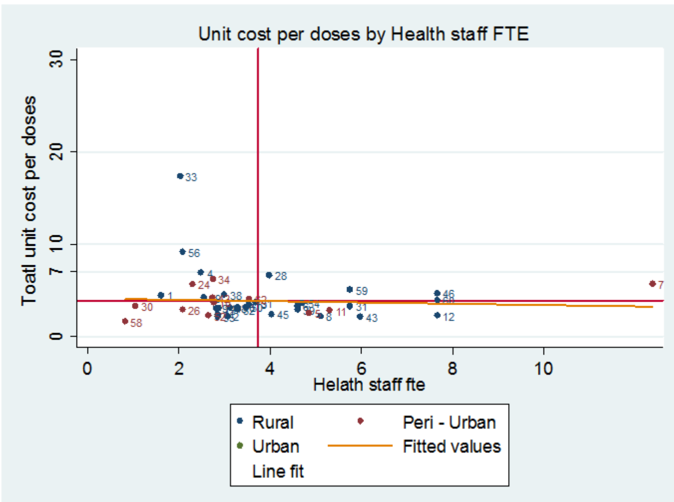


Figure 8.9: Total Unit Cost per Dose vs. Number of Doses (Facility type)

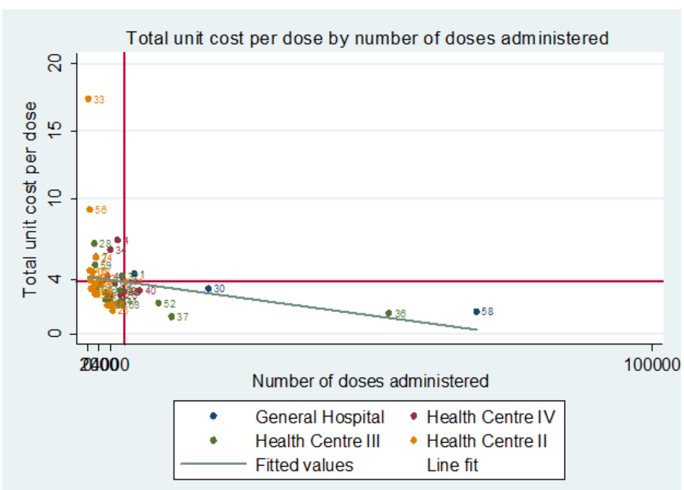


Figure 8.10: Total Facility Cost vs. Doses Administered (Facility Type)

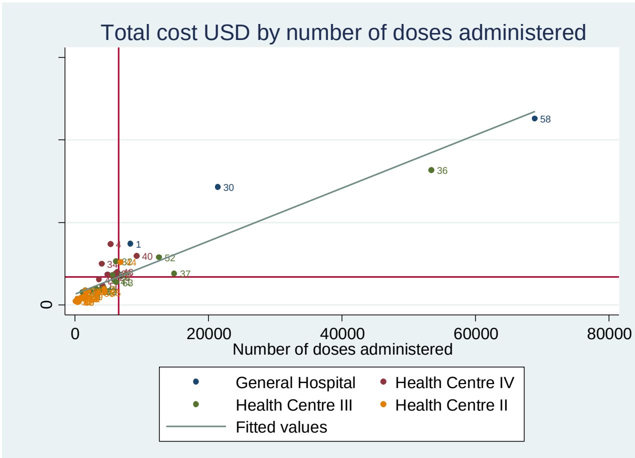


Figure 8.11: Unit Cost of DTP3 by Total DTP3 doses

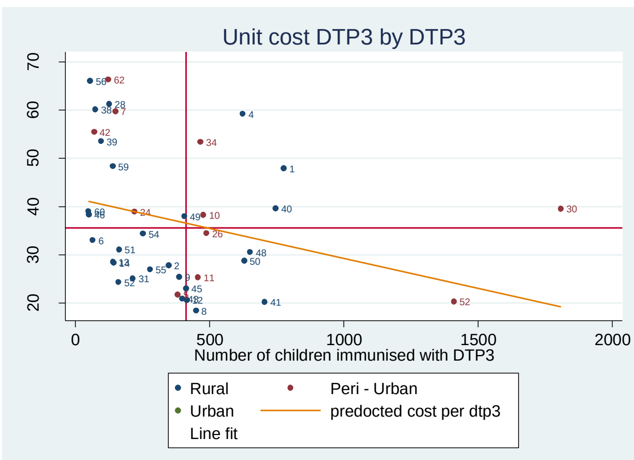
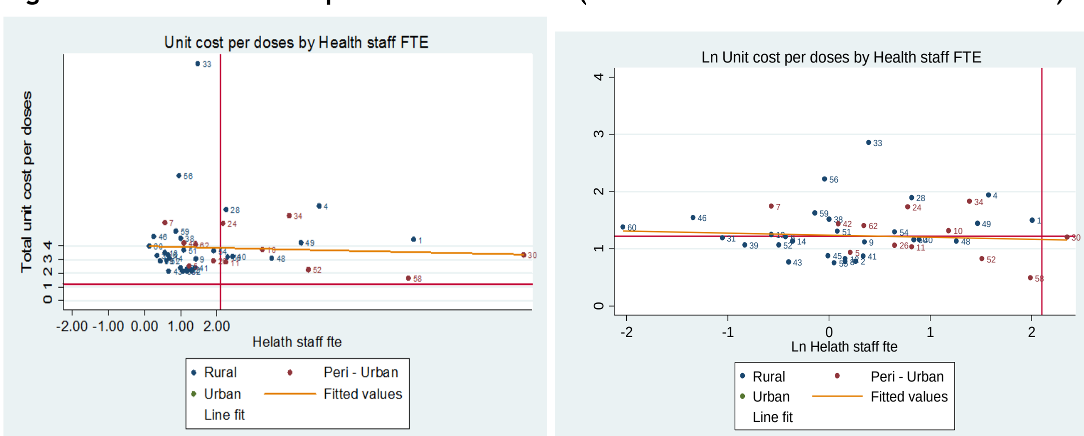


Figure 8.12: Unit cost per Dose vs FTEs (Untransformed and Transformed)



D. Productivity and Determinants Statistical analyses: Correlation coefficients

Table 8.6: Pearson Correlation Coefficient Matrix for Variables Considered in the Productivity Analysis (ln transformed)

	DTP3	No. of doses	Dose per FTE	Doses staff day	Doses staff session	# health staff	FTEs	Village health workers	# immzn sessions per week	Zones support ed	Facility atten-dance	Catchmt Pop.	DTP3 coverage	Poverty
No. of doses	0.98*													
Dose per FTE	0.62*	0.66*												
Doses staff day	0.82*	0.85*	0.83*											
Doses staff session	0.35 *	0.33*	0.55	0.62*										
# health staff	0.63*	0.62*	0.02	0.11	-0.30*									
FTEs	0.73**	0.71	-0.05	0.36	-0.07	0.81*								
Vill. health workers	-0.11	-0.10	-0.06	0.04	0.05	-0.20	-0.08							
# immzn sessions week	0.52**	0.55*	0.24*	0.35*	-0.36*	0.51*	0.50*	-0.02						
Zones supported	0.06	0.08	0.24	0.11	0.14	-0.01	0.09	0.64*	-0.18					
Total # outpatient visits	0.66**	0.64*	0.02	0.51	0.42*	0.43*	0.60	-0.03	0.21	0.06				
Catchment pop.	0.74*	0.74*	0.27	0.62*	0.31*	0.47*	0.62*	0.02	0.37*	0.12	-0.26			
DTP3 coverage	0.04	0.06	0.06	0.07	0.06	0.004	0.03	0.02	0.08	-0.05	-0.11	-0.26		
Poverty	-0.16	-0.19	-0.18	-0.25	-0.30*	0.02	-0.08	-0.01	0.10	-0.08	-0.28*	0-32	0.31	
Distance to facility	-0.04	-0.01	-0.01	-0.003	0.08	0.001	-0.003	-0.003	-0.05	-0.18	0.04	-0.11	-0.01	-0.01

* Statistically significant at 5 % level of significance ** Statistically significant at 1 % level of significance

Table 8.7: Correlation matrix of the costing variables (ln transformed; Pearson coefficients)

	Total cost incl vaccines	Total cost excluding Vaccines	Total Cost excluding vaccines and salaries
Doses	0.7940*	0.7499*	0.6784*
DTP3	0.86*	0.7530*	0.6599*
Dose per FTE	0.7790*	0.1161	0.2878*
Doses per staff day	0.2553	0.4104*	0.4625*
Doses per staff per session	0.6037*	-0.1849	-0.1375
# health staff involved	0.7582*	0.7804*	0.5732*
FTEs	0.6542*	0.8717*	0.6212*
Village health workers	-0.1504	-0.1251	-0.1513
# immunization sessions per week	0.7214*	0.6298*	0.6268*
Zones supported	-0.0051	-0.0038	-0.0734
Facility attendance	0.4106	0.5617*	0.4304*
Catchment population	0.7615*	0.6730*	0.5746*
DTP coverage	0.1301	0.0457	0.1158
Poverty	0.2433	0.0364	0.0843
Distance to vaccine collection point	0.0854	0.0674	0.0748

* Statistically significant at the level of 5% or lower level.

E. Scatter Plot and Statistical analysis of performance (efficiency) indicators

The following analysis sought to identify what determines efficiency at the facility level. Of particular interest was why some facilities and types of facilities appear to be more efficient and generate much lower unit costs per dose and per DTP3 child.

The methodology involved scatter plot analyses and then multiple regression modelling with the same overall approach to analysing associations as set out for the productivity analysis in Section 5. Variations were tested where there was a plausible underlying economic logic which suggested that there might be associations between dependent and independent variables. For example, facilities that provide mostly facility-based services might be expected to have higher efficiencies than facilities which provided most immunizations through outreach activities due to logistics-related costs.

In the analysis of performance indicators, cost per DTP3 and doses per FTE were selected as dependent variables. There was high degree of correlation between cost per DTP3 and cost per dose. The regression analysis explored the relationship between performance indicators, (unit costs per DTP3 child, and doses per FTE staff) and a set of independent variables that were identified as possible determinants of performance. These independent variables included: total number of FTE immunization staff; number of community health workers; percentage of immunizations delivered at the facility; number of zones supported; and total facility attendance. Environmental variables such as facility location (rural or urban), poverty index, road conditions, were also considered.

Results: scatter plot analyses of performance

Figure Figure 8.13 indicates some relationship in the sample between the total cost per dose and number of doses administered. The outliers with higher costs were those facilities with small outputs, while those with lower costs were the facilities with larger outputs. The HC IIs tended to be in the upper left quadrant suggesting lower efficiency. However, they also tend to be below the fitted line suggesting that this type of service has somewhat lower costs for given volumes. HC IVs and hospitals tend to be above the line suggesting somewhat higher cost per dose (lower efficiency) for given levels of doses.

Figure 8.13: Total Unit Cost per Dose by the Number of Doses Administered

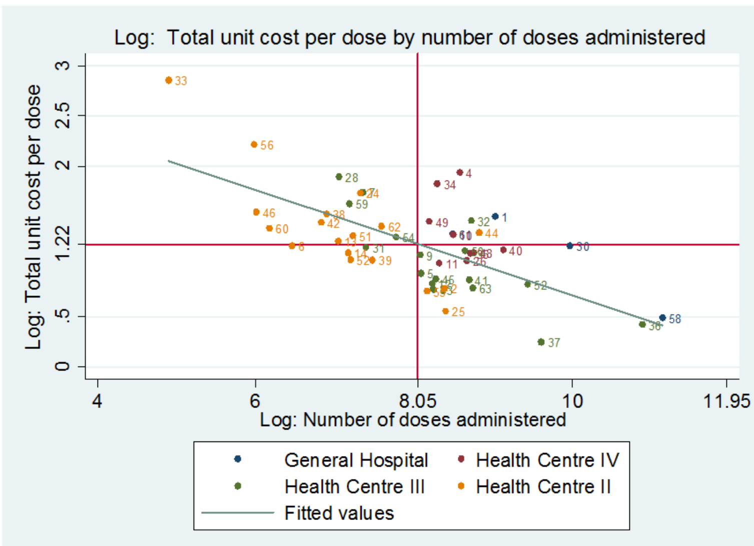
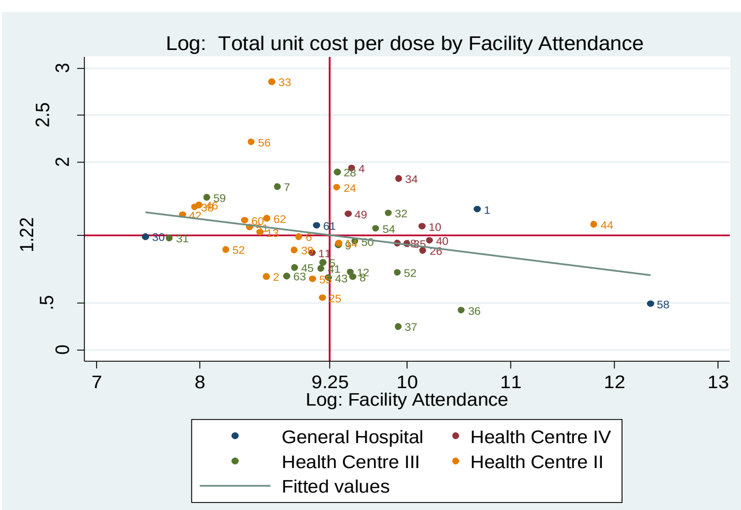


Figure 8.14 suggests a relatively weak relationship between the number of attendees, and unit costs.

Figure 8.14: Total Unit Cost per Dose by the Number of Facility Attendances



Results: regression analyses of performance

The final models including variables that were predictive are show in Table 8.8. Models of unit cost per DTP3 showed relatively consistent patterns of associations, while those of total doses per FTE suggested few strong associations as illustrated by model 5 below. Relatively low R-squared values were produced by all of the models indicating that other factors not adequately captured by the independent variables in these models were important determinants of performance.

Table 8.8: Statistical analysis of performance indicators

	Ln total costs per DTP 3#				Ln total doses per FTE#
Variable[76]	Model - 1 β (std err)	Model – 2 β (std err)	Model – 3 β (std err)	Model 4 β (std err)	Model – 5 β (std err)
Facility type Hospital Health facility IV Health Facility III Health Facility II	 0 (reference) 0.97 (0.51) -0.15 (0.43) 0.40 (0.42)	 0 (ref) 0.93 (0.49) -0.22 (0.39) -.33 (0.38)	 0 (ref) 0.95 (0.51) -0.14 (0.40) 0.32 (0.39)		 0 (ref) -1.14 (1.09) 0.70 (0.94) 0.10 (0.96)
Ln # Community health workers	0.10 (0.03) **	0.10 (0.03) **	0.09 (0.03) **	0.05 (0.04)	-0.19 (0.07)
Ln # Zones supported	-0.12 (0.05) *	-0.11 (0.04) *	-0.11 (0.0)*	-0.06 (0.05)	0.21 (0.10) *
Ln Distance to collection point	0.07 (0.03) *	0.07 (0.03) *	0.07 (0.03) *	0.05 (0.03)	
Ln immunization days per week					0.58 (0.16) **
Ln facility attendance size	-0.22 (0.11)	-0.23 (0.11) *	-0.28 (0.11) *	-0.28 (0.12) *	0.28 (0.23)
Ln poverty index	0.17 (0.09)	0.16 (0.09)		0.04 (0.10)	
Energy source - cold chain Electricity Other sources[&]	 0 (ref) -0.11 (0.25)				 0 (ref) 0.13 (0.53)
Constant	5.68 (1.01) **	5.74 (1.00) **	5.90 (1.02) **	6.18 (1.02) **	4.28 (2.25)
R – squared	50	50	0.46	20	50
F value	F(9, 39) = 4.34**	F (8, 40) = 4.96 **	F(7, 41) = 4.92 **	F(5, 43) = 2.2	F (8, 40) = 5.05**

represents absolute number [&] Other sources of energy include gas, kerosene, solar
* Statistically significant at 5% level ** significant at the 1% level

From the models above, the number of community health care workers, the number of zones supported for immunization and the number of patients seen at a facility were quite consistently predictive of cost per DTP3 child.

The *number of zones* supported also had significant and consistent association with unit costs, with lower unit costs for facilities that supported more zones. Of interest, urban and rural location was not strongly associated with performance. However, distance to vaccine collection points, an indicator of remoteness was significantly but

[76] Specific variables considered but left out of the final cost per DPT3 models because they were not predictive include: FTEs, catchment population, rural/urban area, road conditions, number of staff involved in immunization and number of days immunization occurred per week. For the doses per FTE model the same variables were consider but in final models, immunization days/week was predictive and included while Distance to collection point was omitted as it was non-predictive. Ln FTEs was also omitted due to its direct relationship with the dependent variable definition.

not very strongly associated with performance. The correlation between *total facility attendance* and the unit costs per DTP3 child was negative, suggesting lower unit costs with higher attendance as might be expected. The coefficients indicate that a 10% increase in facility attendance is associated with a decrease of approximately 2 - 3% in the unit cost per DTP3 child the models. Higher attendance was relatively strongly associated with more doses per FTE. *Remoteness,* reflected in distance to collection point, was significantly associated with higher unit costs.

While increasing numbers of community health workers was significantly associated with increased unit costs in some models, other *staffing-related variables* such as number of FTEs and number of health staff involved in immunization were not associated with variations in unit costs in various analyses.

Facility type was not a strong predictor of both cost per DTP3 and doses per FTE. However, when facility type was excluded from the cost per DPT3 model (model 4 vs model 1), the R-squared falls markedly but attendance still has an association with total cost per DPT3. This suggests that facility type captures a substantial amount of variation that is not accounted for by attendance.

Although there was a correlation between facility type and proportion of doses delivered through *outreach or facility based services,* the average proportion was similar across types of health facility (55-65%) and the effect of the outreach variable was weak, suggesting that other aspects of the service delivery models and context are more dominant.

Catchment population was also found to not be predictive of unit costs and thus excluded from final models. Other factors related to the service environment such as road conditions and poverty index were not significantly associated with performance.

Discussion: determinants of facility unit costs

The quadrant analysis suggested associations between facility performance or efficiency (indicated by the unit cost per DTP3 child and doses per FTE staff members providing immunization services) and the volume of immunization doses provided. There were also indications that different types of facility may tend to be more or less efficient. Some facility types have higher unit costs than others at given levels of output - particularly HCIV, even though they had relatively high dose outputs per staff member. There is however, wide variation within facilities of the same type and at the same levels of output.

Multiple regression modelling of unit costs above found that performance in terms of unit costs per DP3 child (and per dose) was most strongly and consistently associated with use of more CHWs and Distance to vaccine collection point (positive association), number of zones served and facility attendance volumes.

However, facility type has a very strong influence on the predictive value of models (R-squared) suggesting that the facility type indicator captures a substantial amount of variation related to delivery models and context that is not accounted for by attendance or other specific independent variables which were assessed. The strong association with facility type may represent significant differences in the service delivery model, such as the particular staffing, equipment, transport functions and typical locations of different HC types. Of note, the proportions of immunization provided through outreach or facility based service models did not seem to be a strong influence on performance.

The finding that performance is strongly and significantly associated with facility patient volumes in most models, supports a number of other studies where higher volumes are strongly associated with lower unit costs, through more efficient use of available staffing capacity and other resources. At the primary health care level, many small facilities such as HCII are staffed by a minimum number of staff, without which the facility would not function. For various reasons including the need to provide services in remote and less densely populated locations, staff inputs (and travel in the case of outreach) are often inflexible in smaller facilities, and cannot be adjusted to align with demand and thereby improve overall efficiency. The limited significance of the association between performance and patient volumes in Uganda in some models may therefore indicate that a variety of other factors may be modifying the association of volumes with efficiency in different facilities.

Overall, models using available performance indicators were not able to account for large proportions of performance. However, there appeared to be substantial consistency in the pattern of variables that were associated with performance.

The difficulty in identifying a range of independent variables that are strongly predictive of performance may be due to the fact that the vast majority of facilities in Uganda are both rural and small. This could create a high degree of variability in a range of factors which could obscure associations that would become apparent if there were more large facilities in less diverse contexts. For example, the average number of DTP3 children, doses and facility attendance in Uganda was about half that found in Zambia during the study conducted there using similar methodology. [77] Both rural location and small size (below the mean) were found in Zambia to be associated with high levels of variability in performance. However, the limited number of significant independent variables may also relate to the limited sample size, which could result in some variables that are in fact important not reaching levels of statistical significance.

Conclusions: facility performance and efficiency

Facility efficiency and total facility productivity in immunization services were associated with a similar set of independent variables. The strongest and most consistent associations were with total patient volumes and number of zones supported and facility type. Less consistently significant or strong associations were found with several other factors such as number of staff and village health workers, and distance to vaccine collection point. These may however have been shown to be statistically significant if a larger sample of facilities had been studied.

The strong and consistent association of facility type with performance suggests that facility type may be both representative of particular service models (though not

[77] Schutte et al. 2014. Costing and Financing Analyses of Routine Immunization in Zambia. EPIC study. Bill and Melinda Gates Foundation

specifically outreach and facility based services) and a varying mix of other factors that are associated with efficiency and output and which cannot be readily identified from the independent variables available from this study. Of interest, urban/rural location seems to be a proxy for several factors affecting productivity but not efficiency.

The association with facility type, and somewhat separate association of both efficiency and productivity with attendance in Uganda, suggests that there may be a high degree of variability in the significance of various factors between facilities. This high variability may be due to the small size and (diverse) rural settings of most Ugandan immunization facilities.

From a planning perspective, there is limited ability (low R-squared) to predict unit costs of any new facility or program expansion with a combination of independent variables such as expected total outpatient load, number of zones supported and the facility type. Thus particular facility features and local contexts will be important to consider in planning, given the variability between facilities performance.

Further investigation of underlying causes of outliers and variations, and differences between facility types, would be useful to increase understanding of determinants of performance and efficiency, and thus inform program management and planning.

F. Finance Mapping

Table 8.9: Financing Source x Health (Immunization) Care Activity (2009/10 and 2010/11), US$

US$	Immunization Activity																									
	Immunisation not disaggregated		*Social mobilization, advocacy*		*Facility-based routine immunization service*		*Outreach routine immunization service*		*Training*		*Vaccine collection, storage and distribution*		*Cold chain maintenance*		*Supervision*		*Program management*		*EPI surveillance*		*Record-keeping and HMIS*		***CAPITAL INVESTMENTS***			
HC Code:	*HC.6.2*		*HC.6.1.1*		*HC.6.2.1*		*HC.6.2.2*		*HC.6.2.3*		*HC.6.2.4*		*HC.6.2.5*		*HC.6.2.6*		*HC.6.2.7*		*HC.6.5*		*HC.6.5.2*		***Capital investment***		**TOTAL (US$)**	
Financial Sources (US$)	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**	**2009/10**	**2010/11**
FS.1. Transfers from government																										
FS.1.1.1 Internal transfers within centra	1,155,634	715,432	-	-	593,387	775,852	395,591	349,345	38,443	-	-	-	23,331	-	78,914	-	287,983	437,432	6,181	-	-	-	-	-	2,579,463	2,278,061
FS.1.1.3 Grants from central governmen	1,016,515	1,070,016			6,829,556	7,189,006	4,553,037	4,792,671																	12,399,108	13,051,693
FS.2. Transfers distributed by government from foreign origin																										
Bilateral organizations																										
FS.2.1.1 USG bilateral financial transfer	-	-	-	-	-	-	-	-	234,073	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	234,073	-
Multilateral organizations																										
FS.2.1.2.1 UNICEF direct fin.transfer	914,306	854,882	52,545	-	6,844	-	7,417	-	13,512	78,993	-	-	55,165	-	-	43,323	21,791	203	10,702	-	-	-	-	-	1,082,282	977,401
FS.2.1.2.2 WHO direct fin.transfer	-	711,601	33,000	-	4,691	-	-	-	10,282	-	-	-	-	-	60,507	-	28,177	-	205,827	70,742	-	-	-	-	342,484	782,344
FS.7.2. Direct foreign aid in kind																										
Bilateral organizations																										
FS2.2.1.1 USG bilateral commodity transfer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	684,629	-	684,629	-
FS.2.2.1.3 JICA bilateral commodity transfer	-	-	-	-	-	-	-	-	-	-	-	-	-	191,378	-	-	-	-	-	-	-	-	-	4,374,936		4,566,313
Multilateral organizations																										
FS.2.2.3 GAVI Aliiance commodity transfer			-	-	4,777,725	4,780,561	3,185,150	3,187,041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,962,874	7,967,602
FS.7.1. Direct foreign financial transfers																										
FS.7.1.3 AFENET/PATH/ RCS/SABIN direct fin.transfer	-		86,890	44,017	-	-	12,342		105,844	100,000	6,266	-	-	-	14,446	-	5,925	-	-	-	2,809	-	-	-	234,522	144,017
Total (US$)	3,086,455	3,351,931	172,435	44,017	12,212,202	12,745,419	8,153,538	8,329,056	402,154	178,993	6,266	-	78,496	191,378	153,867	43,323	343,876	437,635	222,709	70,742	2,809	-	684,629	4,374,936	25,519,435	29,767,431
% of Total HC per year	12%	11%	1%	0%	48%	43%	32%	28%	2%	1%	0%	0%	0%	1%	1%	0%	1%	1%	1%	0%	0%	0%	3%	15%	100%	100%

Appendix 9: Variables used in statistical analysis & diagnostic tests performed

Table 9.1: Summary Statistics for Productivity Variables

Variable	Obs	Mean[¤]	Std. Dev	Min	Max
DTP3 child Ln DTP3 child	49	298 5.0	674 1.1	25.0 3.2	8602 9.1
Total number of doses Administered Ln Total number of doses Administered	49	2894 7.3	5849 1.2	134 4.9	68920 11.1
Doses per FTE Ln Doses per FTE	49	2054 7.2	1521 1.1	90 4.5	11814 9.4
Doses per staff per day Ln Doses per staff per day	49	2.1 0.3	3.4 1.0	0.2 -1.8	44.2 3.8
Doses per staff per session Ln Doses per staff per session	49	9.7 1.9	7.3 1.0	0.6 -0.5	44.2 3.8
# health staff involved in immunization Ln # health staff involved in immunization	49	4.7 1.4	2.7 0.5	1.0 0.6	12.0 2.5
FTEs Ln FTEs	49	1.4 0.1	1.5 0.7	0.1 -2.0	10.5 2.3
# VHW involved in immunization Ln # VHW involved in immunization	49	15.6 1.8	15.5 2.7	0.0 -13.8	86.0 4.5
# of immunizations days per week Ln # of immunizations days per week	49	1.7 0.0	2.0 1.0	0.3 -1.4	7.0 1.9
Zones supported Ln Zones supported	49	13.0 2.0	19.8 2.0	0.0 -13.8	150.0 5.0
Facility attendance Ln Facility attendance	49	9754 8.9	17681 0.6	1760 7.5	230991 12.4
Catchment Population Ln Catchment Population	49	21548 9.1	68315 1.0	2700 7.9	500000 13.1
DTP Coverage Ln DTP Coverage	49	0.7 -0.8	0.8 1.1	0.0 -13.8	3.2 1.2
District poverty Index Ln District poverty Index	49	0.2 -1.7	0.2 0.7	0.0 -3.2	0.8 -0.3
Distance to collection point Ln Distance to collection point	49	10.1 1.8	9.3 2.0	0.0 -13.8	60.0 4.1

* The second row of each variable is ln transformed, thus the mean shown is a geometric mean

Table 9.2: Weighted Variable Summary Statistics - other variables (US$; n=49)

Cost variable	mean	sd	min	max
Total Cost	834651	21002	1912	112753
Total cost without vaccines	5181	6401	1311	46867
Total cost without vaccines and salaries	2332	3081	218	18853
HR cost	2849	3761	460	28014
Per diem	144	152	0	1132
Vaccine	3435	7356	212	89946
Vaccine supplies	156	319	0	3801
Other supplies	133	35	127	316
Fuel	153	286	0	1703
Vehicle maintenance	141	485	0	3805
Energy	325	964	0	8011
Recurrent costs	7337	11384	1539	110642
Cold Chain equipment	159	134	0	509
Vehicle	816	1665	0	14968
Other equipment	10.1	85.0	0.0	1216.4
Building	450	604	14	4708
Capital costs	1435	2019	32	15541

Cost variable	mean	sd	min	max
Weighted Total cost	8772	12291	1912	112753
Vaccine per fully immunized child	10.12	3.13	8.07	23.22
Vaccine per doses administered	1.24	0.18	0.83	1.69
HR cost per FIC	19.64	21.36	1.44	75.55
HR cost per no. of doses administered	2.69	4.16	0.15	14.09
Unit cost per FIC	44.17	23.42	13.11	93.10
Unit cost per dose	5.17	4.56	1.29	17.37
Total cost per DTP3	44.17	23.42	13.11	93.10
HR cost per DTP3	19.64	21.36	1.44	75.55
Per diem cost per DTP3	0.87	0.91	0.00	2.81
Vaccine cost per DTP3	11.93	3.13	8.07	23.22
Vaccine supplies per DTP3	0.55	0.22	0.00	1.06
Other supplies per DTP3	1.40	1.47	0.02	5.06
Fuel per DTP3	0.92	1.21	0.00	5.03
Vehicle maintenance per DTP3	0.49	0.93	0.00	3.52
Energy per DTP3	1.01	1.36	0.00	6.29
Recurrent per DTP3	36.82	21.96	12.86	91.71
Cold Chain equipment per DTP3	1.10	1.63	0.00	6.37
Vehicle per DTP3	3.65	7.35	0.00	24.21
Other equipment per DTP3	0.02	0.15	0.00	2.09
Capital costs per DTP3	7.35	9.96	0.25	32.84
Ln total cost	8.69	0.81	7.56	11.63
Ln total cost per DTP3	3.65	0.52	2.57	4.53
Ln cost per dose	1.41	0.62	0.25	2.85
Ln HR cost	7.61	0.72	6.13	10.24
Ln recurrent cost	8.51	0.77	7.34	11.61
Ln weighted total cost	8.69	0.81	7.56	11.63
Ln total cost without vaccines	8.21	0.75	7.18	10.76
Ln total cost without vaccines and salaries	7.13	1.14	5.38	9.84
Buildings per DTP3	2.58	3.63	0.01	13.99

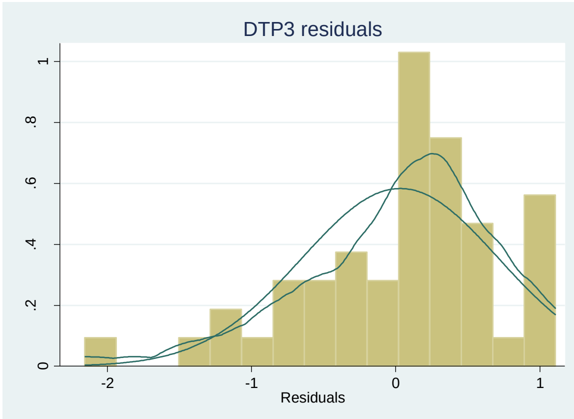
A. Regression Diagnostics for productivity analysis

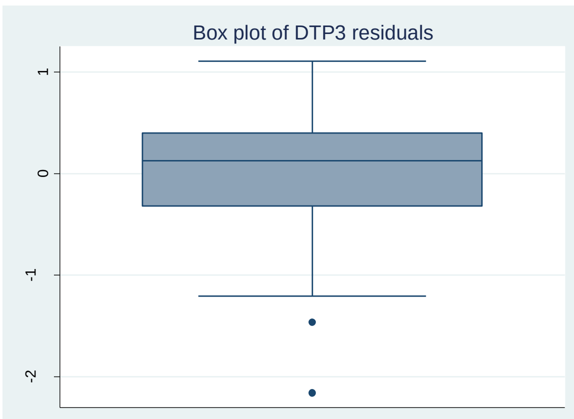
Regression diagnostics for model $\ln(DTP3) = \beta' X + \varepsilon_i$ where X is a vector of independent variables. X = (ln health staff, ln zones supported, ln # of patients seen, ln poverty index, ln distance to pharmacy, dummy for roads, dummy for energy, dummy for area, and three dummies for facility type)

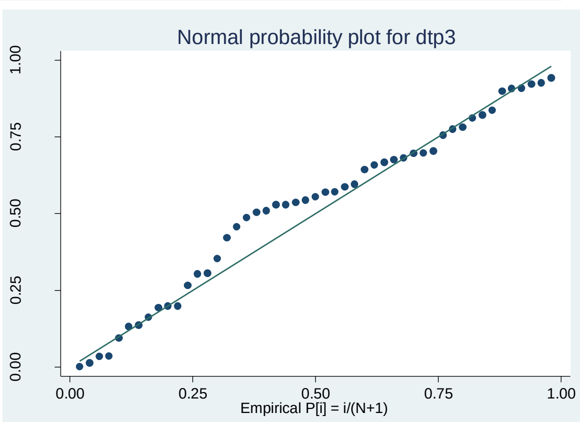
Assessing the normality assumption

Histograms, box and whisker plots, and standardized normal probability plots were used to assess graphically whether the normality assumption was meet.

```
. summ res_dtp3, det
                          Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -2.158406      -2.158406
 5%    -1.207865      -1.465447
10%    -.8673285      -1.207865       Obs                  49
25%    -.3200985      -1.202711       Sum of Wgt.          49
50%     .1251822                      Mean           .031091
                        Largest       Std. Dev.     .6837962
75%     .3988426       .9458697
90%     .9385249       1.001507       Variance      .4675773
95%     1.001507       1.024836       Skewness      -.891042
99%     1.109312       1.109312       Kurtosis      3.944285
```








```
                   Shapiro-Wilk W test for normal data

    Variable |    Obs       W           V         z       Prob>z
-------------+--------------------------------------------------
    res_dtp3 |     49    0.94512      2.540     1.986    0.02352
```

The mean of the residuals was slightly lower than the median, showing negative skewness. The three plots above suggest that the normality assumption is generally reasonable, although the more stringent Shapiro-Wilk test for normality suggested that the distribution of residuals was not normal.

Test for heteroskedascity (unequal variance):

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of dtp3_log

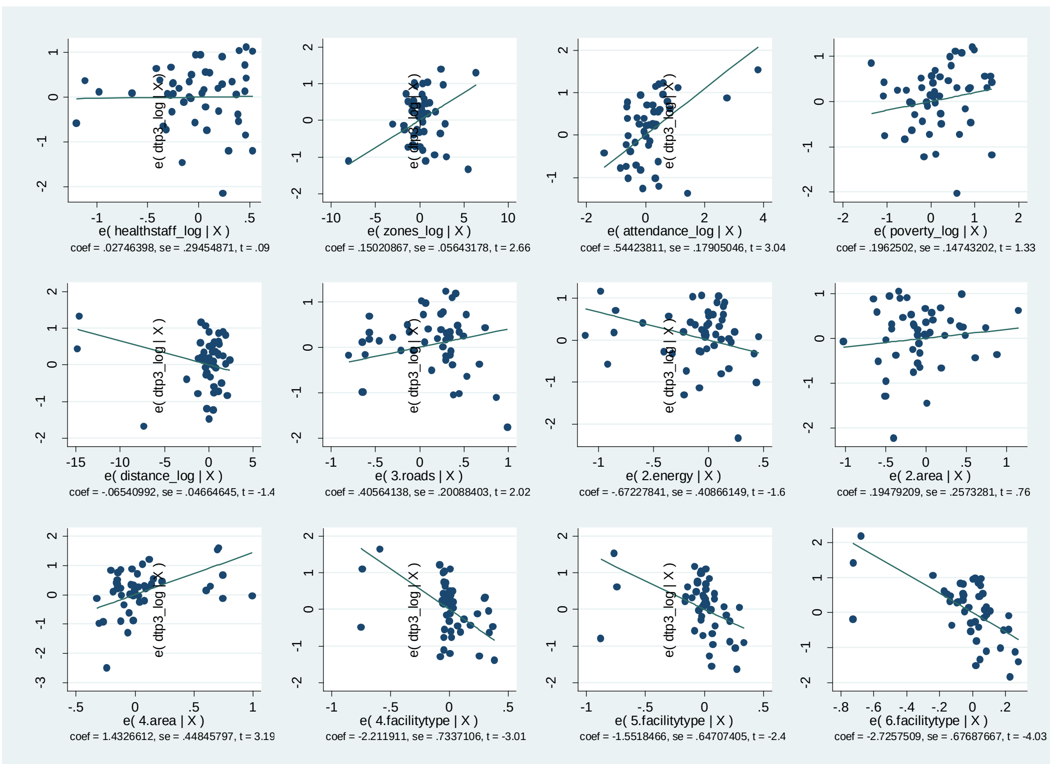
chi2(1) = 0.44
Prob > chi2 = 0.5083

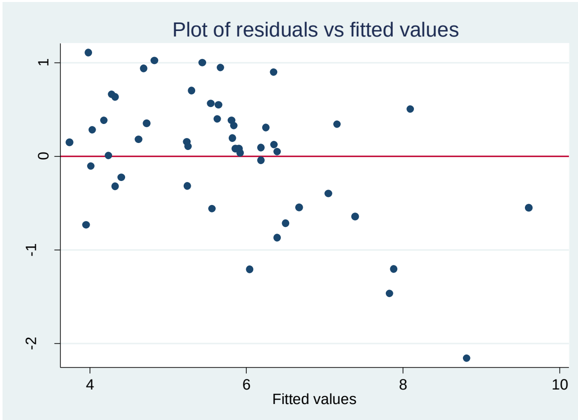
The Breusch-Pagan/ Cook-Weisberg test for non-equality of variance suggests that equal variances can be assumed for this model.

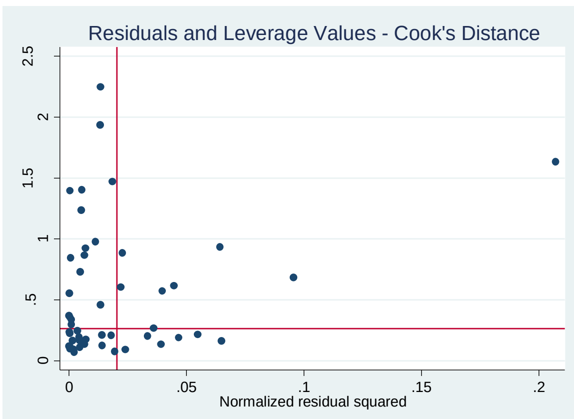
Ramsey RESET test using powers of the fitted values of dtp3_log
Ho: model has no omitted variables
F(3, 33) = 3.15
Prob > F = 0.0378

There was suggestion that higher order polynomial terms could have improved the fitted model.

Assessing linearity between log (DTP3) and fitted independent variables using Added Variable plots







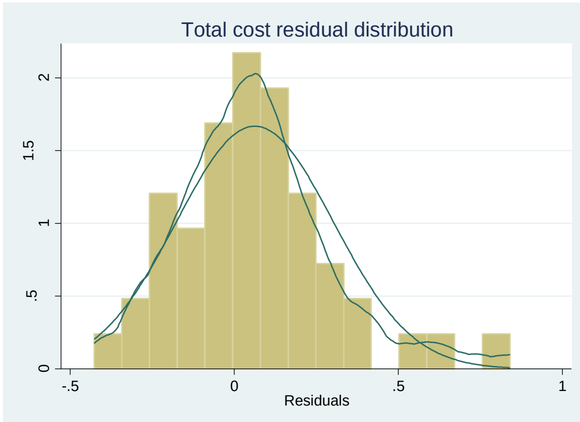
A review of residuals against fitted values plot, supports the equal variance assumption and the linearity assumption, since there are no clear patterns evident and the residuals seem to be randomly distributed above and below the 0 residual line. From the Cook's Distance plot, there is one high leverage value (value higher than 2). The added variable plots show observations with high influence between the dependent variable and each of the fitted variables. It also shows graphically whether there seem to be linear relationships between variables.

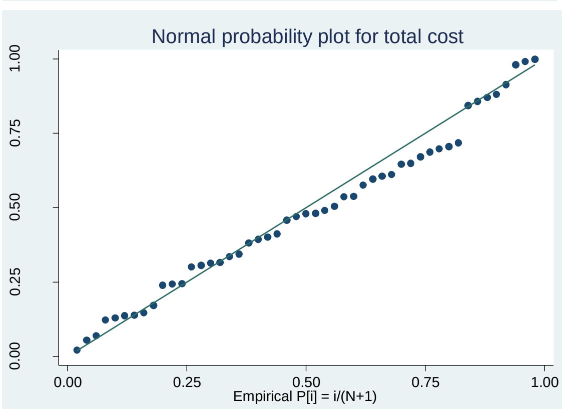
B. Regression diagnostics for Cost models: Total cost

Assessing the normality assumption

Distribution of residuals after fitting a multiple regression model with total cost as the dependent variable is shown below.

```
                           Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -.4272005      -.4272005
 5%    -.2919932      -.3216348
10%    -.2084482      -.2919932       Obs                  49
25%     -.062097      -.2153479       Sum of Wgt.          49

50%     .0506816                      Mean           .0629635
                        Largest       Std. Dev.      .2392318
75%     .1687663       .3890816
90%     .3450214       .5561329       Variance       .0572319
95%     .5561329        .624134       Skewness        .828468
99%     .8409866       .8409866       Kurtosis         4.4344
```

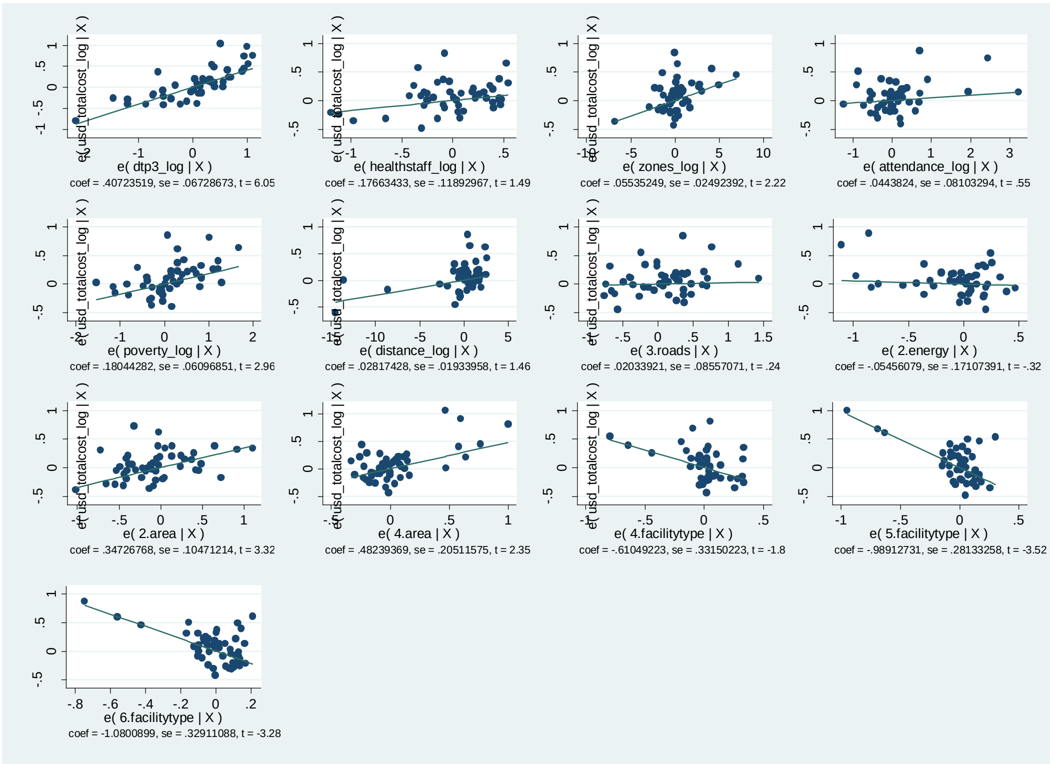


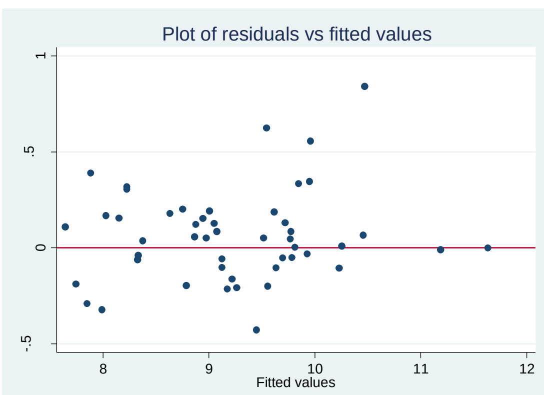


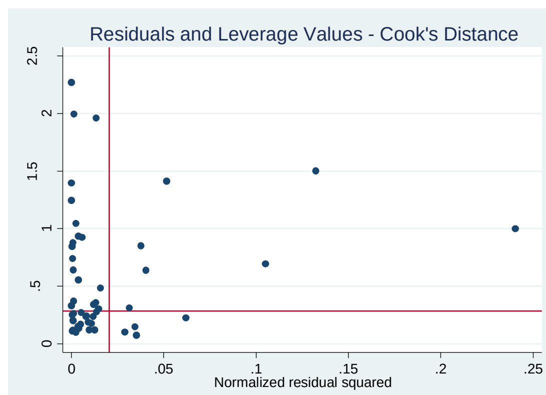

```
                  Shapiro-Wilk W test for normal data

    Variable |    Obs        W           V          z       Prob>z
-------------+-----------------------------------------------------
    res_cost |     49    0.95510      2.078      1.558    0.05961
```

The plots, summary statistics and the Shapiro Wilk's test indicate that it is reasonable to assume that the normality assumption is met.

Added variable plots to assess high influence observations







The plot of the residuals versus fitted values does not show any particular pattern of the residuals thus confirming homogeneity of variances as well as the linearity assumption. As in the productivity model, there is one high influence value with a leverage value above 2.

Testing for constant variance

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of usd_totalcost_log

         chi2(1)      =     0.74
         Prob > chi2  =   0.3890

Ramsey RESET test using powers of the fitted values of usd_totalcost_log
       Ho:  model has no omitted variables
                 F(3, 32) =      0.07
                 Prob > F =      0.9759
```

Appendix 10: Final questionnaires

Please see atached Excel Workbook