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Technical Report

Costing and Financing Analyses of Routine Immunization in Zambia

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30 November 2014

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Acknowledgements

The study team would like to acknowledge the support of staff of the Ministry of Community Development, Mother and Child Health, and of the Ministry of Health, at National, Provincial, District and Facility level in providing guidance and data while dealing with many other demands. In particular we are grateful for the roles played by Dr Penelope Kalesha, Dr Caroline Phiri Chibawe and all other members of EPI team in the MCDMCH.

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.

Acronyms

AIDS	Acquired Immunodeficiency Syndrome
CBoH	Central Board of Health
CHW	Community Health Worker
CHWk	Child Health Week
CIDA	Canadian International Development Agency
CIDRZ	Centre for Infectious Disease Research in Zambia
cMYP	Comprehensive multi-year plan
CSO	Civil Society Organisations
DFID	Department for International Development
DMO	District Medical Offices
DPT	Diphtheria Pertussis Tetanus
EPI	Expanded Programme on Immunization
EU	European Union
EVM	Effective Vaccine Management
FSP	Financial Sustainability Plan
FTE	Full Time Equivalent
GAVI	Global Alliance for Vaccines and Immunizations
GDP	Gross Domestic Product
GRZ	Government of the Republic of Zambia
GSK	Glaxo-Smith Kline
GVAP	Global Vaccine Action Plan
HAHC	Hospital Associated Health Centre
HC	Health Centers
HIV	Human Immunodeficiency Virus
HP	Health Posts
HMIS	Health Management Information System
HR	Human resources
IMCI	Integrated Management of Childhood Illness
JICA	Japan International Cooperation Agency
MCDMCH	Ministry of Community Development, Mother and Child Health
MOH	Ministry of Health
NHA	National Health Accounts
NUVI	New and Underutilised Vaccines
PCV	Pneumococcal Conjugate Vaccine
PHC	Primary Health Care
PMO	Provincial Medical Office
RHC	Rural Health Centre
SIA	Supplementary Immunization Activities
SIDA	Swedish International Development Cooperation Agency
TFR	Total Fertility Rate
TT	Tetanus Toxoid
UCI	Universal Childhood Immunization
UHC	Urban Health Centre
UNICEF	United Nations Children’s Fund
USAID	United States Agency for international Development
WHO	World Health Organisation

Executive Summary

Zambia had a population of just over 13 million in 2010 of which 60.5% lived in rural areas. The total fertility rate is high at 5.9 per woman and higher in rural areas. Zambia is classified as a lower-middle income country (per capita gross national income (GNI) US$1350 in 2012, with 61% of the population living in poverty. Zambia's geographic location, climate, socio-economic profile and demographic characteristics put its population at risk of preventable childhood diseases. Managing efficiency and costs of health care is important to ensure increasing coverage and sustainability.

In 2011 (the year of the costing study) there were 9 provinces[1] and 72 districts. Immunization is predominantly delivered through 409 urban health centres (UHC) and 1 131 rural health centres (RHC). Of these approximately 81% are owned by government and 6% by faith-based organizations, which are largely funded by government and tend to have public sector salary and other inputs.

Zambian government EPI reports indicate national full immunization coverage rates above 90% between 2009 and 2011, although WHO-UNICEF estimates based on national surveys, suggest lower immunization, with DTP3 coverage of 83% in 2010 and 81% in 2011. Sustaining high immunization coverage and resolving uneven performance across districts has been difficult due to shortage of human resources, cold chain challenges and inadequate attention to routine activities. In 2012, Zambia introduced three new vaccines: PCV, rotavirus and measles second dose in a phased manner.

An up-to-date and detailed understanding of routine program costs is important for planning and management of EPI (and other primary health care) services. This study is part of a multi-country EPI costing project to tackle that challenge. The overall purpose of the multi-country project is to generate accurate costing and financing information for the EPI in each country, including consideration of cost implications of new vaccines. This particular study sought to develop an updated, detailed evidence-base around routine immunization program costs to inform planning, management and funding in Zambia.

Specific objectives were to assist the Government of Zambia (GRZ) and other stakeholders to:

1) Replace dated estimates of costs of providing immunization and introducing new vaccines with more accurate estimates of EPI costs.
2) Generate costing estimates, which are methodologically consistent with estimates generated in other countries.
3) Relate delivery costs to output or coverage indicators, and identify cost determinants and factors affecting productivity.
4) Obtain information on patterns of financing by government and other EPI funders.
5) Generate cost and financing data to inform assumptions which underpin estimates of budgets and resource requirements in the cMYP, to enhance resource mobilization.

The findings from the study can also potentially inform the refinement of standard methodologies to estimate immunization costs such as the cMYP, and the tracking of resource flows for immunization.

[1] Muchinga Province was created in October 2011, bringing the total number of provinces to 10 from 2012 onwards. Also the total number of districts was increased to over 105.

Methods

The study followed a Common Approach methodology for assessing costs in all study countries, but this was adapted to reflect Zambia's context and data availability.

The *costing of the routine EPI* examined all recurrent costs related to routine immunization in 2011, including routine Child Health Weeks but excluding supplementary immunization activities. Costs were analysed by line item and standard classifications of immunization program functions. Capital costs were also estimated, including cold chain, other equipment and buildings. Directly attributable management and other overhead costs were included at each level of the system, but there was no step down costing of other indirect costs.

A stratified sampling approach involved the purposive selection of 3 provinces and 9 districts within them that were considered to represent key service delivery contexts in Zambia, based on a number of criteria. A random sample of 53 facilities was selected across the 9 districts, proportional to numbers of facilities within strata of facility types (UHC and RHC).

The assessment distinguished between economic and financial costs. Economic costs annualized capital expenditures using the productive life of assets with a 3% discount rate, while financial costing wrote them off on a straight-line basis. The economic costing also sought to identify costs of volunteer labour and donations in kind, but these proved to be very small. Staff time was costed using new, higher 2012 pay scales to assist interpretation in the current context.

Questionnaires were administered to staff and managers at facility, district, provincial, and national levels to obtain data on EPI activities and associated costs. Data was captured in Excel questionnaires and transferred to a costing database for further cleaning, analysis and production of unit costs. Aggregation of facility costs to produce the total cost of the total national EPI was done by applying the weighted average unit costs of each facility stratum to the total number of doses delivered nationally by facilities in the stratum.

Analysis of productivity and cost determinants started with scatter plots and quadrant analyses, followed by multiple regression analysis to examine associations with supply, demand and environmental variables. Selection of independent variables was guided by the unit cost analysis and existence of plausible explanations of what might impact on cost, as well as previous research findings of associations of costs particularly with utilization and determinants of utilization. Log transformed dependent and independent variables produced the best fit, and these results are presented in this report. Statistical analyses were done in STATA.

Costing of the introduction of the new PCV10 vaccine in Zambia was mostly prospective as the PCV10 implementation only started once the study had commenced, but was able to refined previous estimates by using some actual PCV10 related expenditures and data from the EPI costing, particularly of staff, training and cold chain equipment costs. The costing aimed to estimate only the incremental or extra costs incurred when introducing the new vaccine. The study excluded costs incurred to maintain existing routine services, and also costs incurred to introduce other new vaccines (measles 2^{nd} dose and rotavirus). New vaccine introduction cost estimates were reported in both economic cost and fiscal (cash flow) terms.

The mapping of financial resources for the EPI used top-down data collection, which attempted to determine the levels of funding committed, transferred and expended by partners, government and other cooperating partners. However, data on resources mobilised at District and Provincial levels was also collected during fieldwork. SHA coding was adapted to produce more detailed categories for immunization resource mapping specifically. As far as possible, funding for the EPI was allocated to expenditure line items and functional activities. The cost data was also compared to national EPI cost and resource estimates. Funding data was supplemented by cost estimates from the EPI costing.

Limitations
Several limitations may have affected the accuracy of results, although the main conclusions of the study are likely to be robust unless otherwise noted. In relation to the *routine EPI costing*, there were several data limitations. Allocation of staff time to EPI activities relied on interviewee estimates, not direct observation or time and motion studies. The lack of accurate vaccine stock records also prevented accurate calculation of vaccine consumption and wastage rates and WHO default wastage rates had to be applied. Although budgets gave some details on programs and activities, expenditure records and accounting systems do not differentiate EPI expenses from other programs, which made it difficult to allocate actual costs to the EPI. Estimation of unit and aggregated cost estimates also required HMIS data that had some inconsistencies.

Other components of the study that used various EPI costing outputs were also affected by these limitations. Comparisons of cost estimates generated from the study with other plans such as the cMYP were also made more difficult by inconsistencies in cost categories.

For *productivity and determinants analysis*, it is possible that some significant associations may not have been identified, but would have become apparent with a larger sample. However, the strength of the main associations means that they are likely to be reliable findings. In relation to the *NUVI costing*, prospective costing has inherent limitations as it may not accurately reflect actual expenditures. Definition of the implementation period and uncertainty about actual coverage that would be achieved are the other limitations. The *resource mapping* was limited by data quality and difficulty reconciling some donor and government records of disbursements and expenditures.

Lastly, some caution is required in interpreting immunization cost data as a measure of operational and allocative efficiency. Relatively high costs may be justified to reach certain target groups to achieve herd immunity or equity objectives, or due to considerations of immunization as a public good and positive externalities that are associated with immunizing a child. Results also need to be assessed in the context of broader PHC service planning and management.

Results

a) Routine EPI program costs

The total national program economic cost was estimated to be $38.16 million for 2011. The estimated total routine EPI cost comprises approximately 5.4% of total expenditure on health and approximately 10% of government expenditure on health. Analysis of the total national programme cost by functional area and line item revealed that:

- Most routine programme costs (82%) were incurred at facility level. District level costs (14%) were also substantial, while province and national levels added 2%.
- Total program costs had a similar profile to facility level, although vaccine costs were a smaller proportion of national costs as total program costs add district, provincial and national costs to facility costs, but vaccine costs remain constant.
- The most significant single cost item was labour, which contributed an estimated 49% of total EPI costs. Vaccines contributed 16% while travel and allowances contributed 12%. Together these items comprised 77% of the total national EPI cost. Transport and fuel added a further 6%.
- The most significant functional costs related to facility-based and outreach service provision. Together they contributed 51.8% to total costs and include mainly the cost of salaries, vaccines and travel allowances.

- Total supervision and program management costs amounted to a relatively high 18.6% of the total EPI cost. Significant expansions of the EPI or introduction of new vaccines, should thus carefully consider indirect supervisory and program management capacity requirements.
- Other activities with substantial contributions to total costs included social mobilization and advocacy (10%), and vaccine collection and distribution (9%).
- Recurrent costs contributed by far the largest portion of economic costs. Annualized capital costs contributed 11% of total program costs. Vehicles were the largest capital costs, contributing 5.3%, mainly at district level. Interestingly, the economic cost of cold chain equipment is less than for vehicles and buildings.
- The economic and financial costs of the program generally differed by only 2-4%, so unrecognised economic costs are unlikely to be a major consideration in planning.

The results suggest that efficiency improvement efforts should prioritize the largest cost items, particularly through management of staff productivity and efficiency, travel and outreach activities, and strong management of stock and wastage. Weak stock management, observed at all levels of the system, is a concern.

The study estimated the total cost of the routine EPI for 2011 at $38.16 million, which is higher than the cMYP estimate of $33.18 million for 2010. Further *comparisons with the cMYP, however,* highlighted a number of substantial differences.

Differences in the costs may be attributed to differences in the costing assumptions between the cMYP and those used in the study, and changes in some unit costs such as staff salaries. For example, unlike the study, the cMYP cost categories mix line items and activities (e.g. including activities rather than line items for training, social mobilization and management) which makes some cost comparisons more difficult. There were large differences between major cost items including vaccines, where cMYP costs were higher for reasons which were only partially identified. On the other hand most of the large difference in human resource costs can be explained by the difference between the 2010 salary scales which were used for the cMYP, and the 2012 salary scales which were used for this study.

Furthermore, the cMYP costing model relies substantially on existing (secondary) information as opposed to the study, which used a combination of primary and secondary data. For example, the study used updated estimates of staff time allocated to immunization. Travel and costs for allowances were also substantially higher in the cMYP. Vehicle and fuel costs were $2.439 million compared to only $283 006 in the cMYP, which had not completed the relevant section of the cMYP costing model in full. For cold chain equipment, the cMYP annualized cold chain costs of $583 400 is similar to the study value of $568 066. Although the amount is similar, the underlying assumptions are different.

b) Profile of total and unit costs at facility level

The costing highlighted significant variation in total costs and unit costs of facilities between the rural and urban health centres, and also between facilities of the same type. Important findings include:

- The total weighted average cost of UHCs was higher at $34 441 per annum than that of RHCs at $24 262. This would be expected as RHCs generally have lower facility attendance and facility staff numbers.
- For both urban and rural facilities the activities which account for the highest costs are routine facility-based and outreach service delivery. However outreach is a larger contributor to costs in rural sites.
- Total vaccine costs generally comprise a much lower proportion in rural (16%) than urban facilities (47%). This is mainly due to the larger allocation of staff time to EPI activities per child in rural facilities.

The *unit costs per dose and per DTP3* vaccinated child highlight the variability between urban and rural facilities (see Table below). For example, the national weighted average unit cost per DTP3 vaccinated child was estimated as $65.89, but the total unit cost per DTP3 child was $87.14 in RHCs compared to $33.38 in UHCs. Differences in labour costs account for $32.68 of the variation, and travel related costs account for around $12. The average district unit cost was estimated at $10.24 per DTP3 child and $1.11 per dose, an important consideration in planning and budgeting.

These estimates of unit costs are substantially higher than previous ones for Zambia, as well as average unit costs in many other countries as reported in reviews of cMYPs and other studies. This is largely due to more comprehensive assessment of staff, district-level and various other costs. However, other factors such as wastage, coverage and vaccination completion rates may also be material influences.

Average annual facility statistics and unit costs in Zambia ($2011)

Facility statistics and unit costs	Urban Health Centres	Rural Health Centres	All facilities
Sample (n)	15	36	51
- Total Child Doses	13 325	2 974	7 066
- Total DTP3 Vaccinated Children	1 271	330	702
- Infant population	1 868	319	931
- Total population	44 156	7 536	22 013
- Cost per Dose	3.73	9.43	7.18
- Cost per targeted child	22.85	83.17	59.32
- Cost per DTP3 Vaccinated child	33.38	87.14	65.89
- Cost per capita	0.97	3.52	2.51
Total Delivery Cost (Total – vaccines and injection supplies)	17 910	20 234	19 315
- Delivery Cost per Dose	2.43	8.07	5.84
- Delivery Cost per targeted child	13.79	70.56	48.12
-Delivery Cost per DTP3 Vaccinated child	21.07	74.72	53.51
- Delivery Cost per capita	0.58	2.98	2.04

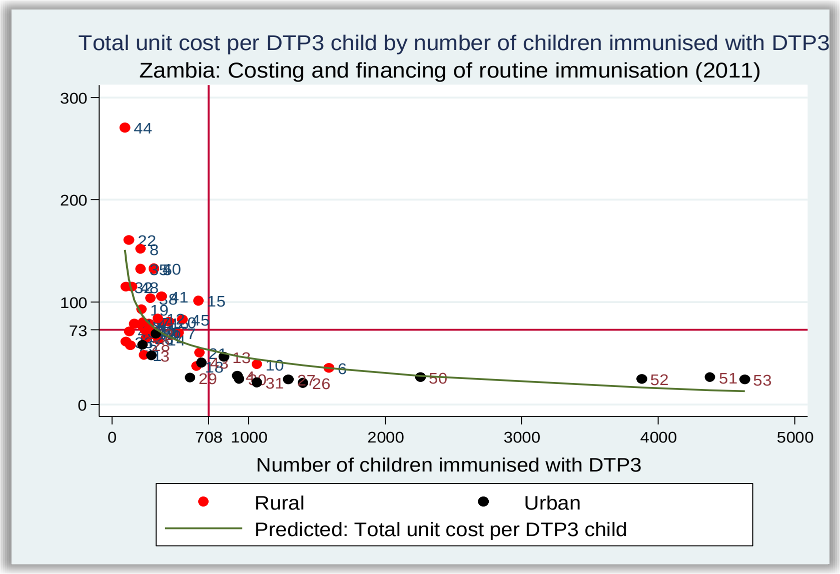
Analysis of unit costs and efficiency indicators

Scatter plots such as the one below showed a clear reduction in unit costs and greater efficiency of facilities, as the total number of doses increases. With some exceptions, UHCs have higher volumes and efficiency, while RHCs have lower volumes and efficiency.

Below a threshold of approximately 10 000 doses or 1000 DPT3 per annum, the unit cost per dose appeared to rise substantially. However, there was wide variation in unit costs within facility types, particularly among facilities with lower volumes. This variation was again mainly due to differences in staff and travel costs. Lower flexibility to adjust staffing and other fixed costs to workloads in smaller facilities is an important contributor to their higher unit costs and variability. As closing low utilization health facilities is usually not an option to increase efficiency, reducing barriers to service uptake becomes a key issue to utilize capacity better.

Similarly, the plot shows that beyond a certain upper limit the increase in number of doses does not result in much further decline in unit costs, as they tend to be closer to full utilization levels. Spare capacity seems likely to be more available in some small, low volume facilities. This may be relevant to assessing capacity needs when new vaccines or other services are introduced. Further analysis also indicated a clear increase in doses per full time equivalent staff (FTE) involved in immunization in facilities with larger number of doses and attendance. High performing facilities with high outputs per FTE did not have obvious different characteristics from low performers.

***Total unit cost per DTP3 by number of DPT3 at each facility** (Zambia, 2011)*



Statistical regression analyses confirmed that, apart from being associated with increasing volumes of immunization, lower unit costs and more efficient use of staff capacity for immunization are significantly associated with overall service volumes and urban health centres per se. Some models indicated that having higher numbers of health staff involved in immunization was associated with higher unit costs and less efficient use of staff time. Greater use of outreach for immunization was associated with higher unit costs in some models. No other factors were significantly associated with efficiency, but models could explain over 70% of differences in unit costs.

Initial study of outliers and efficiency drivers suggests that options such as task shifting, and reorganizing outreach or other services to enhance utilization volumes and economies of scale, may enhance efficiency of immunization and other PHC services. The reasons why some facilities cope with similar service volumes with substantially different staffing levels is not completely clear. Future assessments should explore inefficiencies such as vaccine wastage more closely, and help to identify adaptations to service that are both more feasible and improve efficiency of all essential PHC services in an integrated way.

For planning and budgeting purposes, using average total costs of urban and rural facilities as a means of estimating costs of facilities may not be accurate enough for predicting costs, given the spread of total and unit costs. An approach that establishes benchmarks for different facility types, based on both the setting of the facility and expected attendance volumes, has potential to be more accurate.

c) The incremental costs of PCV introduction

PCV costs in the year of introduction are a substantial addition to overall costs of the Zambian EPI program. The estimated incremental economic cost to achieve 60% coverage is in the region of $9.7 million, including staff costs. The economic cost is equivalent to almost 25% of total economic costs of the routine EPI in the introduction year and 19% each subsequent year. This suggests that sustaining the on-going cost of PCV may be a material challenge to Zambia and partners. The fiscal cost of achieving 60% coverage was approximately $7.3 million: although the fiscal cost excluded salaries, this was offset by the including the full cost of start-up items such as equipment and buffer stock.

- The total *incremental* economic unit cost per dose in the year of introduction was estimated at $7.56 including start-up costs, similar to the average total economic costs per dose of $7.86 for the routine EPI. The incremental unit cost fell to $5.55 per dose when start-up costs were removed. The fiscal total unit cost is $5.73 per dose, including start-up costs of $1.95 per dose.

- Estimated service delivery costs of $3.37 per targeted child are significantly higher than the GAVI contribution of 30c per birth (and also the new rate of 80c).
- The largest cost component by far was PCV10 vaccine and safe injection supplies. The estimated cost of the vaccine for 60% coverage in the year of introduction was $5.888 million of which $1.177 million was buffer stock. So reducing vaccine cost is a key issue to enhance sustainability and cost effectiveness of PCV.

A particular challenge for budgeting and costing of NUVI arises from uncertainties around realistic coverage targets and actual implementation timeframes. Over-estimating initial coverage rates may lead to an over investment in vaccines stocks, unnecessary wastage and unnecessary strain on existing cold chain, distribution and other capacity.

There are quite substantial differences between economic and fiscal costs due to the inclusion of salaried labour in economic costs but not in the fiscal cost. The decision by the MOH not to employ additional staff for new vaccine introduction does not necessarily mean that there is not a *need* for additional staff. There are strong indications of human resources constraints in the health system at service and programme levels. The study also found that immunization programme management makes up a substantial proportion of PHC system management costs. There are thus definite opportunity costs of diverting resources from strengthening and increasing sustainability of the broader health system on which immunization depends. More accurate costing of the human resource cost of NUVI will require a comprehensive assessment of staff capacity at PHC facilities.

Uncertainties exist about the true cold chain capacity at facility level, and how much extra capacity is needed for PCV. Much of the recent cold chain equipment purchase was to replace previous capacity rather than for new capacity for PCV (or other NUVI). However, cold chain costs can clearly be a substantial part of fiscal costs, funding applications and NUVI planning. The NUVI process has at least *triggered* significant expenditure in cold chain in Zambia and other countries. NUVI processes therefore need to anticipate reasons for large scale cold chain refurbishment and expansion, and to consider them in terms of overall EPI requirements, not only NUVI needs. The study also highlighted a need to support NUVI planning with accurate assessment of facility cold chain capacity.

The Zambian example suggests that other uncertainties will also affect the rigour and completeness of resource estimates for NUVI. In particular, the complexity of introducing several vaccines at the same time, and having appropriate resource planning for each independently, is evident. There may be limited benefit to trying to isolate introduction plans and costs of separate new vaccines too minutely. Countries may instead benefit from long–term, multi-vaccine plans that cover all the main activities and related costs.

d) Analysis of productivity

The analysis of productivity looked at factors associated with level of facility outputs, including outputs or productivity of staff in different facilities.

Determinants of facility productivity

Regression analyses of total facility productivity, examined associations between total doses or DPT3 doses provided and a number of independent variables. The strongest correlations with productivity were catchment population and total facility attendance, with Pearson correlation coefficients ranging from 0.87 to 0.92. The strong correlation between the two variables also allows planners to use the catchment population for a given area to predict with some degree of accuracy the number of doses provided by a facility. The total number of doses together with the facility type is in turn a good predictor of total facility costs (see determinants analysis below).

The following table illustrates several of the regression models that examined variables that explain between 69% and 74% of variations in the total number of doses delivered by facilities once catchment population and attendance were excluded. The most consistent predictors of total productivity were facility type and setting, and the number of outreach zones supported, which were both highly statistically significant. An increase of 10% in the number of zones supported is associated with an increase in DTP3 children of just over 6% and an increase of total facility doses of between 5.6% and 6.2%. Rural facility type is associated with a decline in the total number of DTP3 children and doses when compared to urban facilities. District poverty was significantly associated with lower facility immunization outputs in several models.

Statistical analysis of facility productivity

	Ln Total number of facility doses		
Variable	**Model - 1 β (std err)***	**Model - 2 β (std err)***	**Model - 3 β (std err)***
Ln FTE Immunisation staff	0.26 (0.16)		0.25 (0.16)
Ln # Community health workers	0.01 (0.03)		0.004 (0.03)
Ln # Zones supported (outreach)	0.57 (0.16) **	0.62 (0.14) **	0.56 (0.16) **
Ln Distance to vaccine collection point (km's)	0.01 (0.07)		
Facility type & Area: - Urban - Rural	- -1.12 (0.34) **	- -0.91 (0.20) **	- -1.06 (0.20) **
Ln District poverty index	-0.14 (0.06)	-0.21 (0.05) **	-0.14 (0.05)
Roads: - Good/Fair - Poor/very poor	- 0.36 (0.20)		- 0.33 (0.16) *
Constant	7.74 (0.36) **	7.70 (0.29) **	7.77 (0.33) **
R – squared	0.74	0.69	0.74
F statistics	F(7, 43) = 18**	F(3, 47) = 35 **	F(6, 44) = 21 **

*Statistically significant at the 5% level; **significant at the 1% level #refers to number of units

Other factors including FTE immunization staff, use of CHWs, distance to depots and road conditions were not significant. Excluding these variables one at a time had no impact on the models' ability to explain variations in productivity between facilities. Removing all of them from the regression (model 2) resulted in a decline in the R-squared from 74% to 69%. However, it is still possible that they and other factors may be important, particularly at the level of individual facilities, but that that this was not evident due to sample size.

e) Determinants of total facility cost

The analysis of determinants explored the determinants of both the total facility cost and of total cost *ex*cluding labour and vaccines, as they are strong cost drivers that could obscure associations with other factors.

Quadrant analysis of scatter plots suggested strong positive relationships between total facility costs and both the total number of doses administered and total number of DTP3 doses administered. Most UHCs had lower total costs when compared to RHCs with similar numbers of doses or DTP3 children, reinforcing the efficiency analysis finding that urban facilities tend to be more efficient. Higher RHC costs for the same level of output appear to be due to their having more outreach immunizations, longer travel times to outreach points, poor road conditions and lower demand for services.

Multiple regression models examined associations of total and service delivery costs with available indicators of; quantity (doses per year - which is highly correlated with DTP3 doses and catchment population); quality (DPT3 per FTE); price (average cost per FTE hour); capital investment (m^2 of both the main site and outreach points); and contextual factors (facility type and setting, distance to vaccine collection points, number of CHW, immunization sessions per week, energy source and the district deprivation index).

In the *total cost models* the main findings were as follows:

- The total number of doses was highly significantly associated with total facility costs in all models that included this variable. A 10% increase in the number of doses administered resulted in an increase in total facility cost of up to 7.5% in models. The close correlation is not unexpected given the relationship between doses, vaccine costs and total HR costs.
- The number of DTP3 children per FTE staff member was negatively associated with total costs at the 1% significance level. This suggests, all else being equal, that higher quality and productivity can be associated with lower total facility costs. However, DPT3 per FTE was only significantly associated with total costs when included with total doses, and was not a strong predictor of total cost on its own.
- Facility size (in m^2) is positively and significantly associated with total facility cost in most models.
- The price per FTE hour was not significantly associated with total cost.
- Of the contextual variables, only the facility type and setting was associated with total costs: rural facilities were associated with statistically significant higher costs in some but not all models.

Models of *total cost excluding labour and vaccine costs* indicated the following.

- Total number of doses was consistently and highly significantly associated with the outcome confirming the importance of volume for costs. A 10% increase in doses was associated with between 3.8% and 4.9% higher costs.
- The second variable consistently and strongly associated with non-HR service delivery costs was facility size (as measured in $m^{2)}$. An increase of 10% in the number of square metres resulted in an approximate increase of between 4.2% and 6.4% in facility total cost. The relatively strong association reflects that facility size is, to some extent, a proxy for outreach visits and zones supported as this variable also included an allocation for outreach points. The variable thus reflects costs such as travel and associated allowances as well as capital items.
- Facility type was positively associated with service delivery costs at the 1% level when models also included the number of doses. Facility type was more consistently associated with service delivery costs than total facility costs. The association suggests an increase in service delivery costs when comparing rural with urban facilities, other factors being equal, and corroborates costing study findings that allowances and travel costs in particular, are higher in rural facilities. However, facility type on its own may not be strongly predictive of facility cost, given high variability of costs within urban and rural strata.

Regression results for total facility cost and costs excluding HR and vaccines – selected models

	Ln Total facility cost (n=51)		**Ln Total cost excl. vaccines and salaries (n=51)**	
	Model 1	Model 4	Model 5	Model 8
Quantity: Ln Dose	0.75 (0.05) **	0.55 (0.07) **	0.38 (0.12) **	0.38 (0.10) **
Quality: Ln DTP3 / FTE	-0.49 (0.06)**		-0.36 (0.14) **	

Price: Ln cost / FTE Hour	0.17 (0.25)	-0.58 (0.34)	-0.63 (0.60)	-1.07 (0.54) *
Capital : Ln SQM	0.19 (0.05) **	0.13 (0.08)	0.58 (0.11)**	0.42 (0.12) **
Facility type & Area: - Urban - Rural		- 0.43 (0.15) **		- 0.78 (0.24) **
Distance to vaccine collection		-0.01 (0.03)		-0.51 (0.05)
Constant	6.00 (0.49) **	5.80 (0.81) **	6.77 (1.18) **	5.54 (1.28) **
R-Squared	0.89	0.76	0.56	0.60
F statistic	F(4, 46) = 89 **	F(5, 45) = 28 **	F(4,46)= 15 **	F(5,45)= 13 **

* Statistically significant at 5% level; ** statistically significant at 1% level

The regression models of determinants of total costs and service delivery costs shown above produced similar patterns, with some exceptions. Service delivery cost models tended to predict a smaller proportion of costs, as shown in the R-squared values of examples in the table above. When models excluded staff and vaccines, the number of doses was still associated with costs but the influence of doses was less than in the total costs models.

When compared to results of other studies, this analysis supports their findings that the total number of doses is strongly predictive of total costs. The association of costs with the facility type (a proxy for facility-based vs. outreach service delivery strategy), is also consistent with findings from other countries. However the number of immunization sessions, highlighted as predictive in other studies, was not statistically significant in regression models for Zambia. This is because it may be adequately represented in other variables such as facility type and number of doses.

The lack of association of other environmental variables with either total cost or non-HR service delivery costs in the basic model may be due to the limitations of sample size or because factors such as distance from the vaccine collection point and poverty are adequately represented by quality and facility type variables. And while there was no strong association of FTE price with total cost, the study shows consistent, negative association with costs, as well as significance in some non-HR cost models. This phenomenon is not fully understood.

A relatively simple regression model that includes only the number of doses, DPT3 per staff member, cost per FTE and facility size predicts total facility costs with a high R-squared (0.89), but service delivery costs with an R-squared of only 0.56. An alternative model which includes the number of doses, facility size, cost per FTE and facility type – which is easier to identify than DPT3 per staff - can also generate estimates of the total cost of facilities (R-squared 0.76) and non-HR service delivery cost (R-squared 0.60).

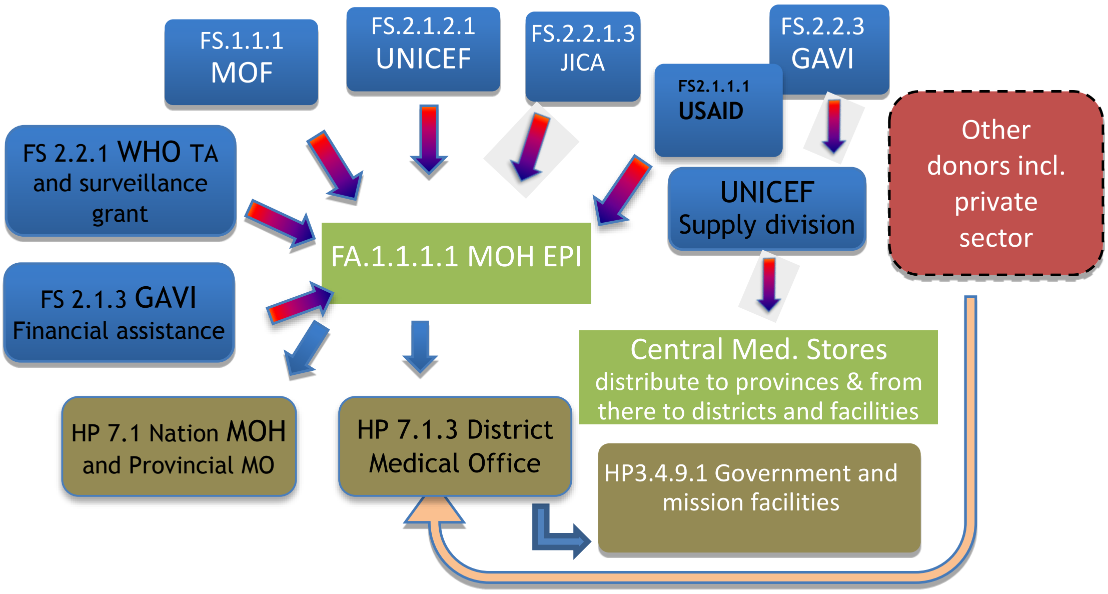
These models could potentially be useful in developing an updated planning and budgeting tool. The high variability of costs around the average, however, suggests that such models are likely to be most useful for estimating costs at program level across a number of facilities. For individual sites, specific characteristics will need to be considered and some flexibility and adjustment will be required in planning, particularly among RHC where variability is greatest.

f) EPI Programme funding and funding flows

The Zambian government made a significant contribution to the EPI which was estimated as $32.1 million or 82% of the EPI routine programme resource requirement in 2011. This exceeds the cMYP estimate of $25 million and 76% for 2012, as well as findings of previous multi-country analyses of FSPs and cMYPs that suggested that governments provided an average of 42% and 56% of immunization costs.

The main funding sources (FS) funding agents (FA) and health providers (HP) identified in the mapping are shown in the following figure.

Map of major funding flows and support



The most important financial flows for the EPI in 2011 included the following.

- The Ministry of Finance (MOF) provided $32.1 million of government funds to the MOH. These transfers provide for staff, vaccine purchases through UNICEF, support services and transfers to provinces and district medical offices. The MOH transfers these funds directly to DMOs which then transfer operational funds to health facilities. The DMOs also pay for some items on behalf of facilities, especially health centres, such as utility costs. In some instances PMOs also transfer government and donor funds to DMOs for special events such as Child Health Weeks.
- GAVI made the largest external contribution estimated at $5.7 million. Most of this was spent on Pentavalent vaccine. The funds are forwarded to UNICEF supply division which then procures vaccines and arranges for delivery to the national central medical stores. In addition to vaccine funds, GAVI provides grants for health system strengthening and to support introduction of new vaccines.
- The UNICEF county office funded certain Child Health Week costs, campaign costs and NUVI costs ($330 943). WHO employs a logistician for the EPI, funds some technical support, and contributes to surveillance and campaign costs.
- CIDA and CIDRZ supported the procurement of additional cold chain equipment for the EPI for $552 847 and $270 000 respectively.
- A number of smaller donors give support directly to DMOs or PMOs. They include private companies which support Child Health Weeks or capacity building.

These new estimates could influence decisions around benchmarks and targets for provision of funding by government, GAVI and other partners. The Zambia government's large contribution to the EPI points to commitment to the EPI and strong ownership. However, a key sustainability issue is how the cost of additional vaccines will be funded in the short and longer term. If GAVI or other partners cannot fund the required increase, it is uncertain how much of it can be absorbed by GRZ. The cMYP estimates an increase of EPI vaccine and safe injection supplies costs of $8.4 million between 2010 and 2012, and $29 million between 2010 and 2016. This latter increase is equivalent to a 90% increase in the 2011 government contribution to the EPI over five years, and an 8.9% increase in total government funding of health care when compared to the base year. Substantial reliance on partners' contributions seems necessary for the foreseeable future: partners contributed an average of 38% of the total health expenditure between 2007 and 2010, there are competing demands from rapid population growth and other health needs, and there will probably be limited extra resources from economic growth.

Conclusions and Recommendations

The study estimation of routine immunization program costs has provided considerably more detailed information on costs to inform planning and financing of routine and new vaccine programmes. These are likely to be useful for Zambia and its partners, as well as informative to other countries and international initiatives to enhance the impact and sustainability of immunization programmes.

This study indicates that Zambian EPI costs are high compared to previous estimates. More comprehensive costing of human resources is the main reason. The government contribution to routine EPI resource requirements is also larger than previously calculated.

The study provides new details of costs of specific line items and activities, as well as drivers of efficiency and productivity. These can be used to prioritise initiatives to manage costs and sustainability. However, further examination of EPI cost and productivity factors in the context of broader PHC services is desirable, as ability to identify appropriate response strategies is limited when the EPI is only analyzed as a vertical program.

From a planning and budgeting perspective, the location and setting of any facilities or expansions of program coverage should be carefully considered. There are major impacts of the location of the health facility, facility type, catchment population, facility attendance or number of children to be immunized, on the resulting efficiency and immunization unit costs. When developing plans and budgets for facilities below the 10 000 dose threshold, planners should consider basing budgets on total facility costs and specific circumstances, as unit costs vary significantly for low volume facilities. Planning and budgeting of immunization can also not be divorced from those of other PHC services.

The study also highlights challenges in EPI budgeting, expenditure tracking and management, and maintaining records for vaccine stock and doses administered. There is divergence between many study and cMYP estimates, along with reports that EPI managers often have inadequate information to guide planning. This suggests that costing studies, support and sharing of learning may often assist countries to strengthen cMYP cost estimates and program management.

The main recommendations that arise from the study are as follows.

Program and Service Management

1. *The outcomes of this study should be communicated to EPI and general managers and planners* at district, provincial and national levels to inform their practice in relation to routine immunization and new vaccines. Dissemination to district and facility management should use an action-orientated approach with support for immediate use of insights in routine operational planning and implementation. Systematic dissemination is seen as a critical next step by EPI stakeholders.

2. *Explore the potential to incorporate key results into management training and planning programs* to guide future planning and practice. This could enable managers to use M&E and cost data more effectively at each level, and could, in turn, improve efficiency and M&E.

3. *Implementation of more effective stock management at all levels should be prioritized,* in order to operationalize appropriate stock management policies, obtain accurate

wastage rates and manage inefficiencies. This will be increasingly important to manage costs and ensure impact of expensive new vaccines.

Planning and Financing

4. Planners *should revise estimates and mapping of resource needs, finance sources and funding gaps* to ensure sustainability of the program especially as multiple new vaccines are being introduced. A consolidated planning framework, building on existing planning tools, is desirable to consolidate the results of planning initiatives and establish one integrated, long-term plan for the EPI which reconciles outputs of the various tools.
5. *The accuracy of cMYP cost projections can be improved* using data from this study to update assumptions, especially around costs of staff, allowances and transport. It may be necessary to adapt study results to update the cMYP. A task team could examine the detailed results and formulate new inputs for the cMYP.
6. Potential *impact of expanding the EPI* and introducing new vaccines on *supervisory and program management capacity and costs* should be carefully considered.
7. The GRZ should develop a *coordinated, single mechanism which accurately captures all contributions* received from partners and reconciles government reported figures to donor reports. Development partners should explore ways to increase the detail of reporting of EPI support in order to facilitate more informed resource tracking.
8. *GAVI and other partners should consider implications of the study for future planning and funding policies, decisions and systems.* Particularly important findings include: higher than anticipated government contributions to the EPI; high unit costs and differences between facility location, and facility types; high service delivery costs of NUVI in relation to GAVI grants; and the scale of NUVI costs and implications for longer term sustainability in resource constrained health systems. The limitations of current immunization planning and budgeting tools, and their application, should also be considered.
9. *New ways should be explored to plan and budget for immunization services and facilities.* There are important limitations of using average total costs for facility types to estimate facility costs. Benchmarks could be established for different facility types based on the setting/location of facilities and anticipated service volumes, to estimate appropriate costs. Regression models may help to refine estimates. New ways to identify appropriate staffing levels for services is also useful, given their high costs and variability.

Improving information

10. The *number of doses administered during outreach activities should be accurately recorded* and separately reported from the doses administered at the facility. This will enhance information on service delivery patterns and trends and inform development of operational strategies to improve efficiency and service delivery.
11. *Actual costs of implementing PCV (and other new vaccines) should be monitored* to enhance impact and sustainability. Particular emphasis should be given to monitoring the large cost of vaccines and injection supplies, as well as monitoring staff capacity constraints in various settings, and possible “hidden” diversion of capacity from other PHC priorities
12. *More detailed study of sites with particularly high or low productivity* and related efficiencies should be considered. The study could further explore outlier performance, immunization productivity in the context of comprehensive PHC services, and adaptations which may be feasible to improve PHC and immunization productivity and coverage.
13. *Further analysis of immunization productivity and efficiency* should be carried out in

the context of accessible, equitable, comprehensive PHC services, particularly in relation to efficient staffing and managing vaccine wastage.

14. Ways should be explored to *enhance capacity utilization for enhanced efficiency in low volume settings*. Instead of just changing immunization services, a more comprehensive package of cost effective PHC interventions could be provided so that overall capacity is well utilized. For example, Child Health Weeks or other outreach activities should be able to include a wider range of services.
15. *District and higher level financial systems should be reviewed* to establish whether they can be adapted to isolate actual expenditure on immunization and other priority programs to support stronger management and planning.

1 Purpose and Scope of the Study

1.1 Rationale for and purpose of the study

The cost and financing of national immunization programs were evaluated quite extensively in the 1980s, as part of Universal Childhood Immunization (UCI) and as part of the process of developing country Financial Sustainability Plans (FSP). The FSP gave way to the comprehensive multi-year plan (cMYP), a tool and planning process which countries use to estimate current and future program resource requirements, including costs and financing of new and underutilized vaccine introduction (NUVI) programs and Supplementary Immunization Activities (SIA). Few studies have been conducted since 2000 to examine the cost of routine immunization and no known immunization costing studies have been carried out in Zambia. The only estimation of immunization costs that has taken place in Zambia is related to the process of completing the cMYP. National Health Accounts are not sufficiently disaggregated to facilitate the costing of the EPI and some concern has been expressed about the reliability of the NHA.

In 2012 the primary operational responsibility for the Zambia EPI was transferred from the Ministry of Health (MOH) to the Ministry of Community Development, Mother and Child Health (MCDMCH). However, some administrative and support functions remain with the MOH, such as health management information systems (HMIS) and disease surveillance.

Although reported immunization coverage for Zambia is high (DTP3 is reported by the MOH at over 90%), there are geographical areas where coverage is still well below desired levels and efforts continue to improve coverage in these areas. Zambia has now initiated a process to introduce three new vaccines: PCV10; a second dose of measles; and Rotavirus.

The cMYP has been used as the primary planning and costing tool. Completion of the tool has however been difficult without reliable estimates of unit costs and, in particular, of shared costs. In addition the prolonged absence of a logistician in the Ministry to support completion of relevant sections of the cMYP has raised further concerns about the cMYP cost estimates. The new vaccine initiatives are reflected in the cMYP, although cMYPs are not specifically designed to evaluate costs of new vaccine introduction.

Given the above, the need for accurate cost data for routine immunization, introduction of new and underutilised vaccines and improved data on financing is critical to inform policy and facilitate planning of the country EPI and associated service delivery.

Understanding the delivery costs per dose or per child of a new vaccine is also important for updating GAVI Alliance policies on new vaccine introduction grants, and for domestic and external resource mobilization for routine programs. Documented information on financial flows for new vaccines and routine programs, particularly from government sources, will be useful inputs into policy dialogue on sustainability and co-financing of new vaccines. More generally, providing accurate cost information and estimates is increasingly important in the context of intensifying competition for health financing resources.

In response, the Bill and Melinda Gates Foundation, GAVI, WHO and other partners launched a multi-county EPI costing project to address key challenges in relation to costing and financing of national immunization programs, and specifically introduction of new vaccines in low- and middle-income countries. The studies in each country have been guided by development of the Common Approach methodology as part of the project.[2] Zambia is one of the countries participating in the project.[3] The overall purpose of this study in Zambia is to generate accurate costing and financing information which can improve planning of resource requirements and financing needs at the country level; inform GAVI Alliance policies on support for new vaccine introduction and enhance domestic and external resource mobilization for routine programs. More specifically this study will help Government of Zambia and other stakeholders to:

1) Replace outdated estimates of costs of providing immunization and introducing new vaccines with more accurate estimates of EPI costs.
2) Generate costing estimates which are methodologically consistent with estimates generated in other countries.
3) Relate delivery costs to output or coverage indicators.
4) Gather information on patterns of financing by government and other funders of the EPI.
5) Generate costing and financing data which will inform the assumptions which underpin the calculations of budgets and resource requirements in the cMYP and thereby enhance resource mobilization initiatives.

Estimates from the study can also inform costing and financing projections to be done for the Global Vaccine Action Plan (GVAP).

1.2 Scope of the study

The Zambian costing study had three main components: i) the costing of the routine immunization programme, ii) a prospective costing of the introduction of the PCV10 vaccine, and iii) the mapping of financial flows for the EPI from partners and government.

The study was limited to estimating the economic and financial cost of the *routine national programme* in 2011, which includes the national child health weeks but excludes the costs associated with any supplemental immunization activities (SIA). Routine immunization activities include service delivery at facilities and during outreach.

Data collection focused on the costs incurred at health facility level, where EPI services are delivered. However, the costing also included immunization costs incurred at district, provincial and national level. The costing considered both recurrent and capital costs, and financial and economic costs. Estimated costs were reported both by expenditure line item and also by functional activity based on a comprehensive data collection process at 51 facilities.

Cost estimates from the facility sample, district medical offices, provincial medical offices and the national programme unit were extrapolated to estimate the total national cost of the routine EPI. Unit costs were calculated for children immunised and for doses administered. A comprehensive analysis of the estimated cost included both non-statistical and statistical analyses.

The study also attempted to estimate, prospectively, the *cost of introducing the PCV10 vaccine* in Zambia. The objective was to estimate only the incremental cost of introducing the new vaccine. This assessment thus endeavoured to isolate the specific extra costs of PCV introduction from costs incurred to replace and maintain adequate capacity for existing routine services, and also from costs incurred to introduce other new or underutilised

[2] Brenzel L. 2013. Common Approach for the Costing And Financing of Routine Immunization And New Vaccines,

[3] Other studies are being conducted in Uganda, Moldova, Honduras, Ghana and Benin

vaccines. New vaccine introduction cost estimates were reported in both economic cost and fiscal (cash flow) terms.

The third component of the study was the *mapping of the financial flows* which sustain the EPI in Zambia. This mapping comprised a top-down data collection exercise which attempted to determine the levels of funding committed, transferred and expended by partners, government and other sources of finance. As far as possible, funding for the EPI was allocated to expenditure line items and functional activities. A subsidiary objective of the mapping was to use the cost data collected in this manner to corroborate the national EPI cost estimate. In order to achieve this, costs estimates from the costing were not used to try and explain the expenditure of available funding of the programme, with the exception of the human resource costs.

2 Background

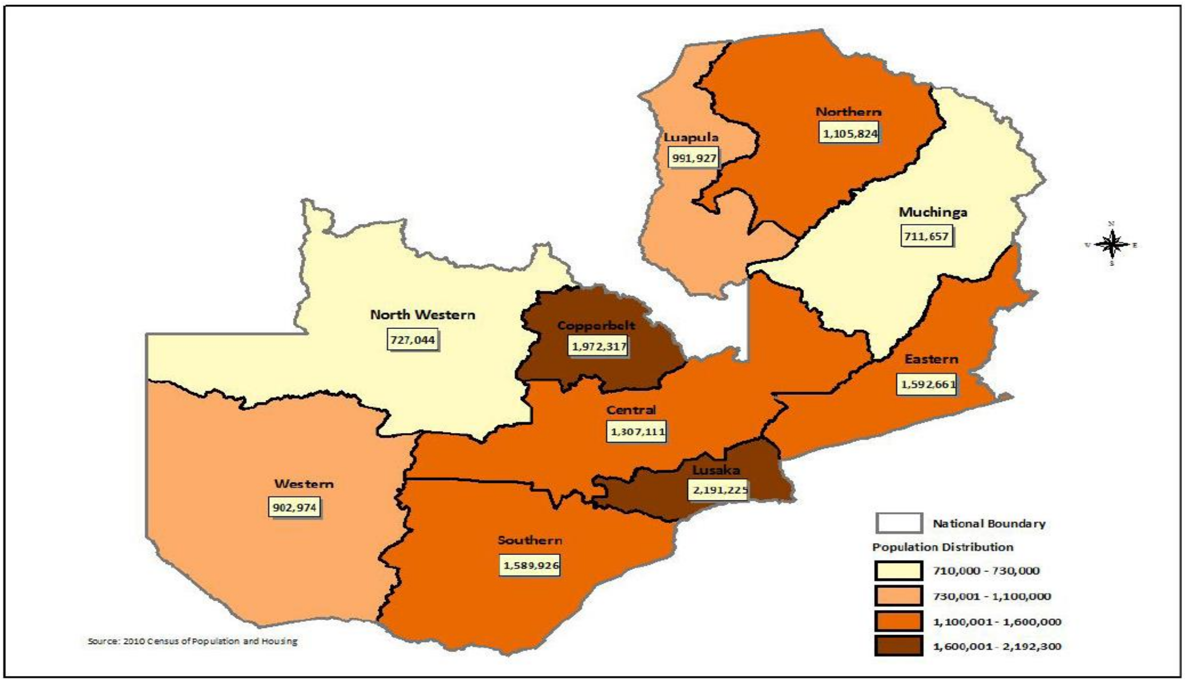
2.1 Country overview

Zambia is a land-locked country in Southern Africa with an altitude of between 1000 and 1500 metres above sea level. It covers an area of 752,614 square kilometres and is surrounded by eight countries. The country has a tropical climate and vegetation with three distinct seasons; a cool dry winter from May to August, a hot season from September to October and a warm wet season from November to April. The day temperatures range from about 20°C to 34°C. Average annual rainfall is between 600 and 1100mm.

According to the 2010 Census, Zambia's population was 13,093,000 in 2010 with an estimated annual population growth of 2.8%.[4] The majority of Zambia's population (60.5%) lives in rural areas, with 39.5% in urban areas. The Total Fertility Rate (TFR) is estimated at 5.9, with each woman having approximately 6 children in her lifetime. The rural population TFR of 7.0 is higher than the urban TFR of 4.6. Zambia has a young population with 45.4% of the total population aged below 15 years. The national literacy rate is 70.2%, but is lower in rural (60.5%) than urban areas (83.8%).

Zambia is a low middle income country with a Gross National Income (GNI) of $1 350 in 2012, with an average annual GDP growth rate of 6% over the past five (5) years.[5] However, despite this strong growth, the overall poverty rate remains high at around 61%, and rural poverty is much higher at 78%.[6]

Figure 2-1: Map of Zambia by provinces and population distribution



Source: 2010 Census of Population and Housing

In 2011 (the year of the costing study) there were 9 provinces[7] and 72 districts. Some

[4] Government of Zambia. Central Statistics Office. 2010 Census on Population and Housing. 2012

[5] Bank of Zambia www.boz.zm 2013.

[6] Central Statistics Office. Living Conditions Monitoring Survey 2010

[7] Muchinga Province was created in October 2011, bringing the total number of provinces to 10 from 2012 onwards. Also the

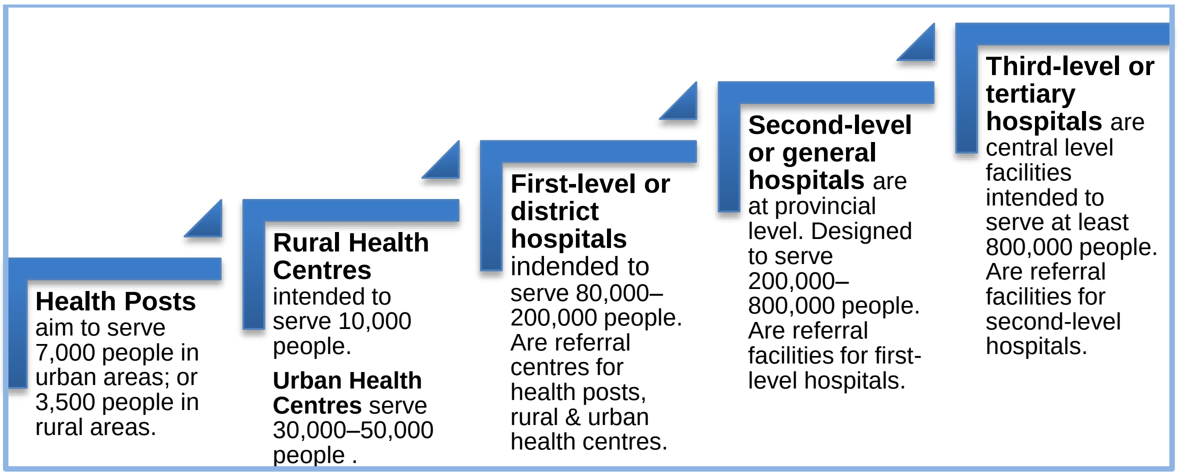
provinces are very sparsely populated, a major factor affecting access and utilization of immunization services. Zambia has an average population density of 17.4 persons/km^2, but population density ranges from 100/km^2 and 63/km^2 in the two most densely populated Provinces of Lusaka and Copperbelt, respectively, down to 5.8/km^2 in North Western Province.[4]

Zambia's geographic location, climate, socio-economic profile and demographic characteristics (growth, composition, distribution) therefore put its population at risk of preventable childhood diseases. Some of these factors also affect demand for, and accessibility of, immunization services. For example, high population growth and fertility rates, low education levels in rural areas, and sparsely populated areas are some of the major factors affecting access and utilization of immunization services. Rainfall patterns can also be erratic and lead to droughts or impassable roads, which ultimately affect the demand and availability of immunization services. The country is surrounded by eight countries and has been affected by diseases originating in neighbouring states including vaccine preventable diseases such as measles.

2.2 Facility types and catchment populations

The Zambian health system has a strong organizational and decentralized structure. Health services are provided through 1,956 health facilities, including 6 third-level or tertiary hospitals; 19 second-level hospitals; 84 first-level hospitals, 409 Urban Health Centres; 1,131 Rural Health Centres; and 307 Health Posts (MOH, 2013). About 81% of existing health facilities are owned by the government, 6% by faith based organizations, and 13% by a small but expanding for-profit private sector. The various health facilities are established based on several elements including the number of people covered, distance, and specialization. The referral flow for patients in the Zambia Health System is shown in Figure 2-2. For curative services, 40% of the cases seen at Health Posts and Health Centres are assumed to be referred to First-level hospitals. An important point to note, however, is that patients are allowed to bypass the referral system at any level – and often do so, particularly for curative care.

Figure 2-2: Facility Types and Catchment Populations



Policy requires all preventive interventions to be done at first referral level (from Health Posts to First-level hospitals). Preventive interventions include five types of services namely (i) Child Health and Immunization, (ii) Maternal Health, (iii) Communicable Diseases, (iv) Epidemic Preparedness, and (v) Information Education and Communication.
Figure 2-1

total number of districts was increased to over 105.

Immunization services are generally provided at Health Centres and through outreach posts. The four main types of facility which represent key service and planning categories are: Urban Hospital Affiliated Health Centres (HAHC – U), Rural Hospital Affiliated Health Centres (HAHC – R), Urban Health Centres (UHC) and Rural Health Centres (RHC).[8] RHCs typically provide services to smaller, more dispersed catchment populations[9] As a result, numbers of FIC and immunization coverage of RHCs is typically lower than for UHCs.

2.3 Stewardship framework

In 1992 the Government of Zambia (GRZ) embarked on reform of the health sector in order to strengthen the health system and improve service delivery and quality. The thrust of the reforms was decentralization, which delegated authority and responsibility for planning, management and decision making to the districts. In line with the structural adjustment program, the units and departments of the MOH were streamlined to manage with minimal staff. A Central Board of Health (CBoH) was created to undertake the Ministry's operational functions, but in 2006 the CBoH was dissolved and its functions assigned to the MOH.[10]

In 2012, the GRZ further re-organized the health sector and realigned roles of Ministries. The MOH assumed the role of policymaking, strategic planning, resource mobilization, regulation, and provision of clinical care (second and tertiary level hospitals). The Ministry of Community Development, Mother and Child Health (MCDMCH) took over responsibility to deliver primary health care through the district level structures (district hospitals, health centres, and health posts). The Expanded Program on Immunization (EPI) has been reassigned from MOH to MCDMCH as a result of the changes.

2.3.1 Strategic Plans and Decision Making Process

Through the Child Health Policy and the Comprehensive Multi Year Plan (2011-2015) (cMYP) on immunization, Zambia outlines the child health situation in the country, including strategies to direct the immunization program.[11] The cYMP is guided by the National Health Policy of 2012, the National Health Strategic Plan (2011-2015), and the Sixth National Development Plan (2011-2015). The cMYP is essentially the Immunization vision and strategy. The cYMP is also a tool for implementing identified strategies and activities in high priority areas, resource mobilization and strengthening partnerships.

2.3.2 Implementation structures

The Child Health Unit responsible for the EPI falls under the Child Health and Nutrition Section of the Department of Mother and Child Health of the MCDMCH (Figure 2-3).[12] The main functions of the Child Health Unit are to initiate and coordinate the development and review of plans, programs and guidelines on child health with particular reference to Integrated Management of Childhood Illness (IMCI) and the Expanded Program on Immunization (EPI); and supervising, monitoring and evaluating child health programs and activities.[13] The specific functions under the EPI program as executed at different level of the health system are outlined in Table 2-1.

[8] The national list of health facilities in Zambia for 2010 shows that, with few exceptions, UHCs are located in urban and peri-urban settings and RHCs are located in rural settings.

[9] MOH. List of Health Facilities in Zambia, 2010. For target populaions of various facilities, see Figure 2.2 above.

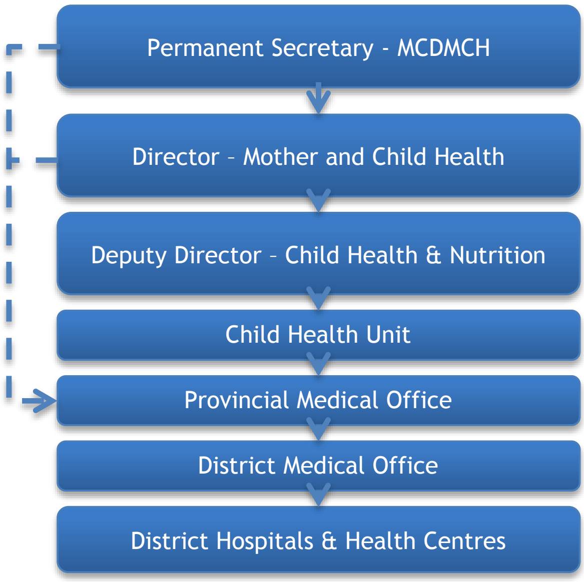
[10] Chansa C. (2009). Zambia's Health Sector Wide Approach (SWAp) Revisted. Köln: Lambert Academic Publishing

[11] MOH (2011). Zambia Comprehensive Multi Year Plan (2011-2015): Immunization Vision & Strategy. Lusaka: Ministry of Health

[12] The MCDMCH structure is: Deputy Director – Child Health and Nutrition to head the Section; 1 Child Health Specialist (Head: Child Health Unit); 1 Chief EPI Officer; 1 Chief Logistician; 2 Chief Cold Chain Officers; 1 Principal EPI Officer.

[13] Neupane R., Njie H., (2007). Zambian Health Sector Support: Mapping Report. London: DFID Health Resource Centre

Figure 2-3: Organization of the immunization program in Zambia



Source: Derived from Ministry informants

Table 2-1: EPI functions performed at the various levels of the health system

Child Health Unit	Provincial Medical Offices	District Medical Offices	Health Facilities
Overall coordination of the EPI; guidelines; supervision and technical support to provinces and districts; capacity building; data analysis and forecasting; budgeting and procurement; managing the central vaccines store/stock; distribution of vaccines to PMOs; cold chain equipping and management; surveillance; Interagency Coordinating Committee (ICC) Secretariat	Coordination, supervision and technical support to districts; capacity building for districts; data analysis and forecasting; budgeting; managing the provincial vaccines store and logistics for districts; issuing vaccines and supplies to districts; support cold chain maintenance; surveillance	Coordination, supervision and technical support to health facilities; capacity building for health facilities; data collection, analysis, and budgeting; managing the district vaccines store/stock; collecting vaccines from the PMO and issuing to eligible health facilities in the district; cold chain maintenance; surveillance	Implementing EPI activities in catchment population; data collection, analysis, and budgeting; collecting vaccines from district office; training and social mobilization at community level; monitoring and evaluation of EPI activities; facilitate cold chain maintenance; surveillance (report/submit samples of suspected outbreak of vaccine preventable diseases)

Source: Derived from various policy documents

Immunization service delivery is organized and offered at all static and outreach posts. During the biannual Child Health Week (CHWk), immunization is offered to children who may have missed their earlier opportunity. The CHWk emerged as a key strategy for vaccines supplementation in Zambia in 1999. By 2004, it was expanded to include a package of maternal and child immunization, diagnosis, and management of illnesses. Since then, the CHWk has been institutionalized as a routine strategy for immunization and delivering high impact interventions biannually in all parts of Zambia. Apart from the CHWk, other key EPI initiatives are: Polio Eradication Initiative, Maternal and Neonatal Tetanus Elimination, Accelerated Measles Control, and Reaching Every District strategy.[14]

[14] MOH 2011. Zambia Comprehensive Multi Year Plan (2011-2015): Immunization Vision & Strategy. Lusaka

In smaller facilities immunization services are provided on immunization days, which may be at the facility or at outreach points, while in most large facilities, immunization services are provided every day. At many facilities community health workers assist with mainly community mobilization. Community health workers do not get paid a stipend but do receive a daily travel allowance when working on the EPI program.

2.3.3 Joint coordination structures

To strengthen implementation, multi-sectoral coordinating structures are also in place. The expanded Maternal Neonatal and Child Health & Nutrition Inter-Agency Coordinating Committee (ICC), and the Joint Child Health Technical Working Group oversee the planning, implementation and monitoring through various sub-committees such as those covering maternal and child health, EPI, IMCI, logistics and paediatric HIV. Membership to these groups is drawn from Cooperating Partners, government, Civil Society Organizations (CSOs), and Health Professional Bodies with the Child Health Unit being the secretariat.

2.3.4 Annual planning and immunization schedule

The district is the basic unit of management and health service delivery. Since the 1992 Health Reforms, all districts have been empowered to do bottom-up planning and implement various activities at local level, in line with national health priorities (Chansa, 2009). The EPI program is fully integrated into the health service delivery system. All provinces and districts plan for, and implement EPI programs. Based on inputs from districts, the provinces provide the information to the Child Health Unit which prepares a consolidated annual forecast for vaccines and supplies based on the immunization schedule. The schedule currently being used in Zambia is shown in Table 2-2. The Immunization program aims to reach all children with the targeted vaccines before they attain their first birthday.

Table 2-2: Zambia childhood Immunization schedule[15]

Antigen	Age	Comments
OPV0	At birth up to 13 days	
BCG	At birth or first contact	
OPV1, DTP-HepB-Hib1	6 Weeks of age	
OPV2, DTP-HepB-Hib2	10 Weeks of age	
OPV3, DTP-HepB-Hib3	14 Weeks of age	
Measles – MCV1	9 Months of age	
Measles – MCV2	18 Months of age	Introduced in 2013
Vitamin A - 1st dose	6 – 11 Months of age	
Vitamin A - 2nd dose	12 months to 6 years	
Pneumococcal Vaccine: PCV10 – 1st dose	6 Weeks of age	Introduced in 2013
Pneumococcal Vaccine: PCV10 – 2nd dose	10 Weeks of age	Introduced in 2013
Pneumococcal Vaccine: PCV10 – 3rd dose	14 Weeks of age	Introduced in 2013
Rotavirus Vaccine: Rota_liq 1st dose	6 Weeks of age	Introduced in 2012
Rotavirus Vaccine: Rota_liq 2nd dose	10 Weeks of age	Introduced in 2012

Source: Derived from MOH data 2009; 2011c; 2011d

2.3.5 EPI Program performance

Zambian government EPI reports indicate national full immunization coverage rates above 90% between 2009 and 2011.[16] Individual antigen coverage rates for the period 2009-2011

[15] Source with modification: Zambia Pneumococcal Conjugate Vaccine Introduction Plan

[16] A child is considered fully immunized after having received: BCG, three doses each of the diphtheria, pertussis, tetanus/hepatitis B/haemophilis influenza type B (DPT-HepB-Hib); four doses of polio (OPV); and one dose of measles by the

also show that the immunization program has been doing relatively well, with BCG, DTP3 and measles coverage rates above 90% for that period. WHO-UNICEF Estimates of National Immunization reports, based on nationally representative surveys, suggest somewhat lower immunization, with DTP3 coverage in Zambia as 81% and 83% for 2011 and 2010 respectively.[17] [18]

Sustaining high immunization coverage has been difficult due to shortage of human resources, weak cold chain and lack of attention to routine activities. The cMYP reports that there has been a steady increase in the number of districts reporting Fully Immunized Children levels of more than 80%. However, some districts have low or declining immunization performance. Problems with establishing population denominators have also lead to some districts having coverage rates above 100%.

In this context, national immunization program objectives are shown in Table 2-3.

Table 2-3: National objectives and related global objectives

National Objectives	Related Global Objectives
98% Penta3 and fully immunized nationally by 2015 80% of districts to have 80% fully immunized by 2013	1. Coverage: By 2014 or sooner all countries have routine immunization coverage at 90% nationally with at least 80% coverage in every district
Sustain certification of polio-free status	2. Polio: By 2014, the world will be certified polio-free
Sustain measles mortality reduction by 90%	3. Measles 90% reduction goal in infant mortality by 2010 compared to 2000
Sustain elimination of MNT by 2015	NT Elimination in every district by 2005
PCV10 introduced by 2012 Rotavirus vaccine introduced by 2013 Measles vaccine second dose introduced by 2012	New Vaccine introduction
Safety: Use only auto-disable syringes Incinerators available in 85% of districts by 2015	Policy developed to protect HCWs against HBV in place

Source: MOH, 2011d

2.4 Introduction of new vaccines in Zambia

Challenges in sustaining high immunization coverage prompted the Zambian Government to apply for 3 years of financial support from GAVI in 2001 for three areas: i) Immunization Services Support; ii) Injection safety; and iii) New vaccines (MOH, 2011d). Consequently, Zambia introduced tetravalent (DPT-HepB) with DPT in 2004, DPT-Hib+HepB (Pentavalent) in 2005, and one dose liquid Pentavalent in 2007.

In 2009, Zambia applied to GAVI for financing of Rotavirus, Pneumococcal (PCV10), and Measles second dose.[19] The pneumococcal and measles second dose application was conditionally approved, but re-submission for rotavirus was required.

The cMYP notes that at the time of submitting the initial 2009 proposal, the country had inadequate cold chain space for new vaccines. According to the Zambian Vaccine Cold Chain Scale-up Strategy, Zambia required US$7.5 million for further cold chain storage capacity at a national, provincial, district and health facility levels to accommodate the introduction

age of 12 months and according to the immunization schedule (MOH, 2013).

[17] http://apps.who.int/gho/data/node.wrapper.IMMUNIZATION0?lang=en

[18] In contradiction to the nationally reported figures, the cMYP base year also reflects a lower coverage figure of 82% for DTP3 but continues to target 90% in subsequent year.

[19] MOH 2009. Expanded Programme on Immunization: Pneumococcal Conjugate Vaccine Introduction Plan 2010.

of new vaccines. The strategy includes full-scale expansion of vaccine storage capacity at all levels, with renovation of existing buildings, installation of new cold rooms with generators, and procurement of 83 refrigerators and 250 cold boxes. Zambia mobilized US$1.6m and the process to upgrade the cold chain capacity commenced at national and provincial levels. An Effective Vaccine Management (EVM) training and assessment in 2011 gave a clear understanding of all aspects of vaccine service delivery, and identified areas that needed improvement before introducing new vaccines.[20]

In addition to the cost of upgrading the cold chain storage capacity, other non-vaccine related costs were estimated at US$1.7 million.[21] The Scale-up Strategy anticipated that GAVI would provide an estimated US$ 107 million between 2012 and 2015, in the form of vaccines and dry supplies if Zambia and its partners invested in cold chain expansion and other non-vaccine costs associated with introducing new vaccines. Zambia re-submitted the proposal for introducing Rotavirus, Pneumococcal (PCV10) and Measles second dose in June 2011. The application was approved by GAVI as Zambia met all the requirements for the introduction of new vaccines.

During the second quarter of 2013, Zambia launched two new vaccines (PCV10 and Measles second dose) countrywide. The rotavirus vaccine was introduced in 3 districts in Lusaka Province (Lusaka in 2012; Kafue and Chongwe in 2013) with Centre for Infectious Disease Research in Zambia (CIDRZ) as the implementing agency.

2.5 Current knowledge of costs and financing of immunization in Zambia

2.5.1 Funding flows

Funds for the EPI programme are disbursed to the health system in a variety of ways. The government pays for personnel, vaccines and injection supplies, cold chain equipment and maintenance, transport and other operational costs.[20] Salaries are disbursed directly from the Ministry of Finance to the individual bank accounts of the health workers. For vaccines, the GRZ pays for routine EPI vaccines (BCG, OPV, HepB, Measles and TT) while the DPT-HepB-Hib vaccine is co-financed by the GRZ and GAVI. All vaccines are purchased with government funds through the UNICEF procurement system, which ships them to Zambia. The budget for cold chain equipment and other capital items is maintained at national level, and procurements are made centrally.

The GRZ also provides operational grants (from own funds and donor basket funds) directly to provinces, districts, and second- and third-level hospitals.[10] Districts disburse the funds to district hospitals, health centres and health posts. The funds allocated to each health centre and health post are disbursed monthly as an imprest that is set according to their catchment population. Health workers usually use over 50% of their GRZ operational grant on allowances during outreach activities.

To revitalize the routine immunization program, and to provide every child with life- saving vaccines, Zambia has been receiving support from GAVI under the Immunization Services Support since 2001. This has provided an opportunity for the country to introduce new injection devices, new vaccines, and to strengthen the health system. To date, funds received from GAVI amount to US$ 46.5 million for pentavalent vaccine (DPT-Hib-HepB), US$ 8.8 million for tetravalent vaccine (DPT-Hib), US$100,000 for new vaccine introduction, US$ 3.9 million for immunization services support, US$ 771,000 for Injection Safety, US$ 6.6 million for Health System Strengthening and $ 2.2 million for high immunization

[20] MOH 2011. Effective Vaccine Management: Towards improving the Immunization Supply Chain Management in Zambia.

[21] This included: planning meetings; training of health workers; community orientation; printing of updated cards, guidelines, and stickers; development of DVDs and training materials; updating of monitoring tools; distribution of vaccines and supplies; social mobilization; supervision; Post Introduction Evaluation; and administrative costs for UNICEF

performance.[14]

In addition to the government and GAVI budget allocations, the EPI enjoys support from various bilateral and multilateral partners such as UNICEF, WHO, JICA, USAID (through CIDRZ), CIDA, SIDA, EU, World Bank, DfID, and GSK. The majority of the partners in the health sector provide their support for non-salary recurrent expenditures such as operational costs, vehicles, cold chain equipment, CHWks, and supplemental immunization activities. Funds are disbursed through general budget support at the Ministry of Finance; basket funding at MOH; and vertical projects. Some of the partners pay salaries for technical assistance posts directly to the recruited individuals, usually on contractual arrangements.

2.5.2 Existing cost estimates of routine immunization

There is very limited documentation of the immunization cost per child in Zambia. Estimates on the cost of immunizing a child are based on program-specific spending on routine immunization services. The WHO estimated that Zambia spent $1.7 million to deliver routine immunization services and $1.3 million on supplementary immunization activities in 2000, before support from GAVI was mobilized in 2001. The program-specific spending on routine immunization services was estimated at about $5.50 per DTP3 vaccinated child or $0.16 per capita.[22]

The total estimated cost of the cYMP 2011-2015 is US$ 181 million for 2012 to 2015. Out of this amount, US$ 169 million was expected to be secured from the GRZ and GAVI, leaving a funding gap of US$ 13 million. However, traditional financiers of the EPI program in Zambia (JICA, WHO, and UNICEF) will probably meet the funding gap and some cooperating partners may contribute funds through the MOH basket funding. More details of cMYP unit costs are discussed below along with study results.

2.5.3 Resource requirements and sustainability

The main challenges in the EPI program are inadequate human resources, inadequate financing, weak community support mechanisms and poor cold chain equipment.[13] Zambia anticipates that resource requirements of the program will increase with increasing expenditures on new vaccines. The cMYP highlights that the financing gap between available government funding and resources required for the EPI, is expected to increase. The overall government financial sustainability strategy is to have GRZ resources increasingly used for vaccine purchases, with the bulk of the remaining program operational costs covered by additional support mobilized from other sources. The GRZ also plans to increase program efficiency.

[22] World Health Organization. (undated). Zambia's immunization costing and financing situation. Retrieved online on 4th August 2013 from *http://www.who.int/immunization_financing/countries/zmb/about/en/*

3 Cost Analysis of Routine Immunization

3.1 Methods

Key aspects of the methodology for the cost analysis are set out below. They were based on the Common Approach developed for the study, but adapted to address priorities identified by Zambia and to tackle various data and practical limitations.[2]

3.1.1 Perspective and key assumptions

The study collected data for the 2011 financial year (January-December 2011), and results are reported in 2011 US$.

Government program perspective to costing

The study focused on the costs incurred, primarily by government, to implement the EPI program in government and mission facilities. In an ideal scenario the study would attempt to measure the comprehensive societal perspective, reflecting all costs, regardless of who incurs them, including service users and others(e.g. transport and productive work time lost).

Economic vs. financial costs

In this study both economic costs and financial costs are calculated and presented. Economic costing reflects the true economic or opportunity costs of an intervention, even if they have not actually been paid for by the program. In Zambia, the valuation and inclusion in costs of volunteer time is an example. Economic costing also includes the discounted, annualized cost of assets.

Financial costing reflects cash outflows or expenditure directly incurred by the program and tends to be most useful for assessing short to medium term resource and budgetary requirements. Using the example above, no value is attached to volunteer time. Asset costs are annualized but without discounting, i.e. this method is similar to a straight-line depreciation of assets.

Description of expenditure line items

Cost measurement refers to the quantification and valuation of resources consumed during service-delivery for the purposes of the EPI. This section briefly describes the expenditure line items used to calculate and report costs in this study. Table 3-1 summarizes the quantification method and the approach to valuation for each line item.

For capital cost items, in the economic costing a discount rate of 3% was used to calculate the annual cost. In the financial costing the discount rate was set to zero, resulting in an even spread of the capital cost over the useful life of the asset.

It should also be noted that although an attempt was made to allocate indirect costs to the EPI, the costs of support units, located mainly at the national level, were not 'stepped-down' to the immunization programme and these costs are therefore excluded from the costing and the table below.

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

Expenditure line item - recurrent costs	Quantification method	Valuation method
Salaried labour	Quantification comprised the total time taken to provide immunization and related services. Immunization staff was required to allocate hours to various immunization activities over the period of a month. Where non-clinical staff directly supported the EPI, their time spent was also included and quantified on the basis of hours allocated to EPI per month. Human resource costs of administrative services were *not* allocated to the EPI.	Annual remuneration defined by the total cost to the employer (MOH) of the employee including benefits. In Zambia there was a significant increase in 2012 salary scales. Even though the study year was 2011, it was decided to use the 2012 scales for costing to improve the relevance of the output for planning purposes.
Volunteer labour	In Zambia the volunteer cadre is referred to as Community Health Workers. Costs were based on time spent on immunization related activities such as participation in meetings and social mobilization. Relatively little time was allocated to the EPI by CHW.	Volunteer time is difficult to value in settings where most volunteers are unemployed and an employment market does not exist. In discussion with MCDMCH it was agreed to use a rate of ZK100 000 (approx. $20) per day.
Travel allowances	Travel allowances were quantified on the basis of days or nights spent away from the facility.	GRZ rates for travel allowances were used. Rates differ for day and overnight allowances and for different staff.
Vaccine costs	Vaccine stock records at all levels were poorly maintained so calculating vaccine consumption on the basis of reported stock levels was unreliable. Cost of vaccines was thus calculated on the basis of doses administered and WHO wastage factors[23] with one exception. The wastage factor for OPV was also assumed to be 50% based on research carried out on 20 dose vials and review of stock records in some districts.[24]	Unit costs for vaccines were obtained from the in-country UNICEF office. These included a specific % for freight costs added to each vaccine unit cost.[25]
Vaccine injection and safety supplies	Vaccine injection and safety supplies were quantified on the basis of doses administered for the reason described above. A wastage factor of 5% was used.	Unit costs for supplies were obtained from the UNICEF office. A % for freight costs was added to each unit cost.
Other supplies	Other supplies included expenditures that did not fit in other line items. Costs were based on actual expenditure.	Other supplies were valued at the actual expenditure reported.

[23] WHO wastage factors for various vaccines and GAVI NUVI application form section 6.3.3. WHO does not have specific estimates of Zambian wastage rates.

[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 and for OPV in a 20 dose vial the average wastage rate was calculated at 47%)

[25] Vaccine prices and wastage rates that were used are reported in Annex 7.

Expenditure line item - recurrent costs	Quantification method	Valuation method
Transport and fuel	Transport and fuel included bus and taxi fares, and fuel consumed by vehicles. Bus and taxi fares were based on responses to questions in questionnaires. Fuel costs were based on estimated fuel consumption for different types of vehicles given the allocation of total kilometers travelled for the EPI. There are very few vehicles at facility level.	Values for bus and taxi fares were provided by each facility. The price of fuel is controlled by GRZ and the costs per litre are the same throughout Zambia. Diesel and petrol were included at $1.58 and $1.7 per litre respectively.
Vehicle maintenance costs	Quantification was based on actual reported maintenance costs. Where these were not available an assumed annual service unit cost was developed with national management based on actual service costs for similar vehicles. 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
Cold Chain energy costs	Calculation of energy consumption by facility cold chain is complex. Electricity charges are split into a fixed availability charge and a consumption charge. Both are paid at district level. Using the PQS[26] consumption of electricity by cold chain equipment was calculated for each facility (Kwh). In a small number of cases kerosene or gas was used. For these, purchases of gas or kerosene were used to quantify costs.	A standard price for electricity consumption from ZESCO was used to value electricity usage. Prices for kerosene are government controlled for all facilities but gas prices were obtained from each facility.
Printing	Quantification on the basis of actual expenditure. There was no printing expenditure reported at facility level.	Printing expenses were valued at the actual expenditure reported.
Building overhead, Utilities, Communication	Building and grounds overhead costs, sundry utilities and maintenance and communication costs are budgeted, incurred and reported at district level, not facility level. When possible actual expenditure was used for allocating costs to the EPI. (See 'District & provincial costs' below)	Overhead costs were based on an allocation of reported actual expenditure at mainly district level. No overheads were included at facility level.[27]
Training costs	Training costs are quantified in terms of days needed for delivery of the standard training module. This includes venue hire, facilitation, allowances and travel costs, development and supply of training materials.	Actual expenditure incurred by EPI programme
Expenditure line items - Capital costs		
Cold chain equipment	Cold chain equipment was listed in a specific question in the questionnaire. Where uncertainty existed about the exact model/size of equipment verification was attempted with reference to the national facility cold chain equipment list.	Valuation of cold chain equipment was based on the PQS list. The basic prices were increased by 20% to cover freight, in-country transport and installation

[26] PQSEquipment Inventory 09_10_12

[27] The district level overhead was difficult to separate from the facility level overhead. Keeping district administered EPI overhead costs at the district level was expected to be more accurate and useful to planners and comparisons in future studies. A second layer of allocations to facilities using further utilization based assumptions was unlikely to enhance validity or interpretability. Poor quality of district data may have distorted facility costs.

Expenditure line item - recurrent costs	Quantification method	Valuation method
Vehicles	Vehicles were listed in response to a specific question in the questionnaire. Most urban facilities did not have vehicles and some rural facilities had motor cycles.	Current replacement costs for vehicles were obtained from dealers in Zambia, deflated to 2011 prices.
Buildings	Space used was based on allocation of facility space to the EPI and measured in square metres. Most outreach services are provided in built structures. A standard of 16 m^2 was assumed per outreach zone. Cost was based on number of visits per month, once a month in almost all cases.	Each square meter was valued at $500, representing the replacement cost of health facility type buildings as provided by the MOH.

Allocation to functional activities

In this costing, expenditure was allocated to ten standard EPI functional areas or activities based on the expenditure line item matrix provided for in the Common Approach (see Annex 5). Although this study was not designed as an activity based costing, the allocation of costs to activities provides a valuable indicator of which activities consume the majority of resources. This can be used by planners and management to guide their efforts to improve operational efficiencies and productivity.

Table 3-2 gives an overview of functional activities and the expenditure items that were allocated to each activity. For all personnel costs, staff were initially asked to estimate the number of hours per week they allocate to the EPI program. Once this allocation and a monthly total number of hours had been agreed, staff were asked to allocate the monthly total to the pre-defined activities.

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 in the questionnaire. In the absence of accurate records, recording doses administered during outreach, immunization staff were asked to estimate which portion of total immunizations were carried out during facility vs. outreach activities. This ratio at each facility was used to allocate vaccine costs, injection supplies and wastage between outreach and facility based service provision.
Record keeping / HMIS	This activity reflects 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 and travel allowances.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with supervision.

Activity name	Expenditure items included in the activity	Allocation method
Outreach services	Time allocated by EPI staff, vaccines and injection supplies for outreach immunizations, outreach zones building costs and a portion of waste disposal costs.	Staff were asked to allocate their time to activities in the questionnaire. Immunization staff were asked to estimate which portion of total immunizations were carried out at the facility vs. during outreach activities. This ratio was used to allocate vaccine costs, injection supplies and wastage between outreach and facility based service provision.
Social mobilization	Staff time, and in some cases instances transport and fuel costs, and travel allowances. Cost of community health workers is included in this activity.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with social mobilization.
Cold chain maintenance	Cold chain maintenance includes staff time, the cost of operating the cold chain (energy costs) and the cost of any repairs.	Staff time as above. Energy costs for cold chain were specifically calculated. Repair costs were included where these were reported. An imputed maintenance cost for cold chain was not included if no repairs were reported.
Vaccine collection, distribution and storage	Staff time, transport & fuel costs, and travel allowances. Capital cost of cold chain equipment is allocated here.	Staff time as above. Respondents were asked to identify any travel costs specifically associated with vaccine collection.
Program management	Staff time, CHW time, the cost of office equipment, travel allowances and transport and fuel costs.	Staff time as above. CHW allocated their time to specific activities and respondents were asked to identify any travel costs specifically associated with program management.
Training	Mainly staff time associated with attending trainings. Travel costs for training are incurred at district level. (see comment below)	Staff time as above.
Other	This covers the few, small expenditure items that cannot easily be allocated to other defined activities.	Where the allocation is unclear the amount has been allocated to 'Other' in its entirety.

Calculation and allocating vehicle costs

Vehicles are not often used at the facility level, but all districts use vehicles, mainly Land Cruiser pick-up trucks, motorcycles and, in some instances, a pool of motorcycles maintained for use by facilities. At district level vehicles are used to fetch vaccines, undertake supervision visits, support social mobilization and facilitate activities related to program management. A portion of the cost of owning and operating vehicles needs to be allocated to the EPI and its activities.

Accurate log-books were not maintained for most vehicles. Where log-books were not maintained an assumption was made that pick-up trucks travelled 40 000 km per annum. This was based on the number of annual services carried out (required every 10 000 km) and was consistent with annual km assumed in the cMYP. For motorcycles a similar approach resulted in an estimated annual utilization of 11 000km. Staff at the facility were asked to allocate a portion of this utilization to the EPI program for each vehicle. The next step required the allocation of this (EPI) portion to various activities, and log-books were inadequate for this purpose. Distances of trips between the district and the provincial office, round trips to facilities for supervision and the number of trips undertaken for various activities were reviewed to arrive at an estimation of vehicle costs for activities.[28].

Training costs

Training costs at the facility level include the time spent by staff providing or attending training. Estimates were based on respondents' allocation of their time to training and training-related activities. Training for facility staff is however coordinated by district offices, with travel allowances and travel costs paid from the district budget. Thus travel and allowance costs for training were estimated at district level from actual district expenditure reports or budget records. In order to avoid duplication of these non-staff training costs, the data were captured at district level only, not at facility level.

District and provincial expenditure records

In Zambia, funding for health facilities is channeled through the district medical office (DMO). As described above, facilities, districts and provincial offices prepare action plans to inform the annual budget. These plans contain detailed calculations related to planned activities and resource requirements. A line item summary budget is prepared once the action plan is approved and the Accounting System captures expenditure and allocates it by budget line items. However, the line item expenditure data does not reflect whether it was expended for hospital, district office or other program purposes. In this study therefore the estimated costs for the district office and health facilities, reflected in the action plan, were frequently used as a starting point for allocating overhead expenses to the immunization program. In only a few cases did district accountants provide amounts from the actual expenditure records which could be allocated to the EPI.

The main costs incurred at the district level include staff, travel for supervision and program management, cold chain equipment, overhead items and non-staff training costs. Performance assessment and supervisory visits, are conducted bi-annually (4 visits in total) by the DMO. The visits are to all district hospitals, health centres and health posts in the district. A portion of these district level costs are therefore allocated to the EPI.

At provincial level relatively little expenditure is incurred which affects the facilities and the EPI. Performance assessment and supervisory visits at provincial level also occur biannually but are aimed mainly at Level 3 (tertiary) hospitals, training institutions, general hospitals and DMOs in the province. As few immunizations take place at hospitals, the supervisory costs have not been included in the EPI costing. Provincial costs therefore comprise mainly staff, cold chain equipment and overhead costs.

The cost of Child Health Weeks

Twice a year the MOH conducts child health week (CHWKs) campaigns, which are preceded by social mobilization activities. The budget for these campaigns is developed at national level and covers mainly travel costs for staff, drivers and social mobilisers. The budget allocates CHWk expenses to districts, provinces and the national EPI office. At facility level the use of social mobilizers (or community health

[28] This method indicates where the majority of vehicle costs should be allocated, but has limited accuracy. However sensitivity of overall cost estimates to these assumptions is likely to be very small given the low value of vehicle and fuel costs at facility level. No facilities had motor vehicles and only some had motorcycles.

workers) was recorded and costed. Similarly, district level respondents were asked for social mobilization data which captured the activities (and costs) mainly for health workers.

In some cases travel costs based on questionnaire responses may have included CHW travel costs included in the budget for the district. The district travel budget for Child Health Weeks was however also included in the district EPI costs. This approach seemed to be appropriate, as the national budget for the CHWKs, including transport, was disbursed in full. However it may result in some overstatement of travel costs associated with the child health week campaigns.

3.1.2 Sampling

The costing of the immunization program was based on a sample of health facilities. The stratified, random sampling strategy stems from that developed for the Common Approach for the multi-country study (see Brenzel 2013).

A national sampling frame of all facilities providing immunization services in Zambia was obtained and analyzed (see summary in Table 3-3).

Table 3-3: Number of facilities by type of facilities (2010)

Facility Type	Government	Private	Mission	TOTAL	Proportion*
	A		B	A + B	
HAHC – U	10		6	16	0.2%
HAHC – R	14		16	30	3.4%
RHC	930	22	77	1007	79.6%
UHC	206	53	6	212	16.8%
HP	162	8	2		
TOTAL	1322	83	107	1265	

A number of HC's support Health Posts (HP). National health plans foresee an increasing roll out of HP to improve service coverage, and also conversion of various HPs to HCs. However, HPs typically do not provide immunization independently of HCs. Most are effectively an outreach service of HCs rather than stand-alone facilities, and outreach/HP immunization statistics tend not to be reported separately from those of the supporting HCs.[29] In view of these features, HP were not included as a separate stratum in the sample.[30] The productivity and costs of HP are thus reflected in the costs of HCs responsible for the HP.[31]

A stratum of non-government sites was also not defined in the sample. In Zambia almost all HCs which implement the EPI are government-owned, with a relatively small number of mission district hospitals, HCs and HPs. In addition, staff and commodities in mission facilities are typically provided by government, with staff remunerated at government rates. So the cost of immunization services at these facilities is likely to be similar to those at government facilities. The study focus on

[29] Typically, on a specific day of the week, a nurse travels from the HC to the HP with vaccines, provides immunization and then return at the end of the day. CHW at the HP may provide some supporting services mainly to improve attendance.

[30] A minority of HPs have evolved and expanded their services over time to function as HC but these effectively represent HC rather than HPs and were excluded from the sample.

[31] Both urban and rural Hospital Associated health centres were included in final samples but were not specifically analysed, both because of their small numbers and because they are functionally very similar to other urban and rural health centres.

government HCs, given the relatively small sample, was thus considered to be most likely to provide planners with information that can best assist them to expand the number of health centres, primarily in rural areas.

a) Sampling approach

In line with guidelines in the Common Approach on sampling of facilities, a stratified, random sampling approach was used.[2] [32] The sampling frame was developed using the following approach.

1. *Purposive sampling of three Provinces* in consultation with the EPI managers, planners and study Reference Group given the following criteria which were thought to be potential influences on immunization costs:
   - Ability to reflect the range of immunization activity and service performance in Zambia.
   - Presence of typical urban, peri-urban[33] and rural settings
   - Variation in population density across the provinces, to be able to explore the possible effects of density on costs.
   - Accessibility and logistics, including a spread of distances and logistical challenges between sites and provincial and national capitals.
   - Support from government for the initial selection.
2. For each of these provinces, there was *purposive sampling of three districts* expected to include facilities deemed, by EPI managers and planners, to be 'typical' of services and common settings elsewhere in Zambia. Districts were thus not selected for their representiveness of *districts* per se but for ability to yield a representative sample of *sites*. District selection was guided by criteria similar to those for provinces:
   - Presence of urban, peri-urban and rural settings and typical facilities and services for those settings
   - Presence of sites with a range of service performance levels.
   - Districts which include densely and sparsely populated areas
   - Accessibility of sites
   - Absence of atypical service contexts that may distort the sample such as facilities close to international borders with cross-border movement of people to access services.
3. *Random sampling of service sites, within the defined strata, across the selected districts* (not within each district) of facilities involved in immunization service delivery (UHC and RHC).
4. The sample size in each stratum broadly reflected the proportion of all national facilities falling into each main type of facility. HAHCs were slightly over-sampled to ensure they were adequately represented. There was also effective over-sampling of rural sites with lower patient volumes compared to high volume large sites.[34]

[32] Measure Evaluation. 2010. Sampling Manual for Health Facility Surveys. Washington, D.C. http://gametlibrary.worldbank.org/FILES/665_Sampling%20Manual%20for%20Health%20Facility%20Surveys.pdf

[33] In Zambia Peri-urban areas refer to large densely populated compounds located in the outskirts of urban areas.

[34] The Common Approach recommended some over-sampling of rural/remote facilities compared to urban/peri-urban ones. The reason for over-sampling rural sites is that costs are not normally distributed but are right-skewed. In this case, it would be useful to have a sample that would include more observations of facilities that would be associated with the right tail in order to have a greater probability of selecting them in the sample. Simple random sampling was preferred over probability proportional to size (PPS). PPS sampling based on number of doses would tend to favor large urban facilities with a large number of doses which was not desirable. Large sites also do not represent the majority of sites in which coverage of EPI will need to be extended.

5. *Review of the sample* of facilities in terms of patient loads, number of vaccinations delivered, catchment population and coverage for FIC, to ensure that the overall sample was representative of 'typical' urban, peri-urban and rural sites elsewhere in Zambia and did not seem biased or to include a disproportionate number of atypical facilities.[35]
6. Approval of sample by stakeholders and district management.

Some flexibility in the final sample had to be maintained to respond when district managers identified atypical, outlier sites which were not representative of a substantial number of sites, or when selected sites could not be accessed or used for practical reasons. Replacement sites were identified from oversampled sites in the random sampling or from District manager recommendations of sites in similar settings.

b) Sample size

A stratified random sampling approach was used with the aim of being representative of all government health facilities in Zambia. 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 that is present in the population (assumed 0.5)
q = 1-p (0.5)
e^2 = desired level of precision (assumed 10%)

Resulting sample size is = 96 .

2. Stage Two (Finite correction for proportions)

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

$$n = \underline{n_0 N/(n_0 + (N-1))}$$

Where:
n_0 = initial sample size and N = population size

There were 1 265 health facilities in Zambia at the time of the survey (N). Thus, a total of 90 facilities would ideally have been sampled for the study to achieve a precision of 0.1 for an indicator with an initial value of 0.5.

[35] See also diagnostic tests used in Chapter 5 and 6 and Annex 10.

Because of budgetary constraints, 53 facilities were eventually sampled. This sample size would however still give a precision of 0.13 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 approach aimed to somewhat over-sample rural facilities so they were not under-represented, as explained above.

The sampling approach and summary of the resulting sample are shown in Figure 3-1 and
Table 3-4 . Further details of the sampled Provinces and districts are given in Annex 2.

Key productivity data from two rural sites was judged to be too incomplete to be usable at analysis stage, resulting in a final sample of 51.The final sample of 51 facilities included 15 (29%) urban health centres and 36 (71%) rural health centres.

Figure 3-1: Summary of sampling approach

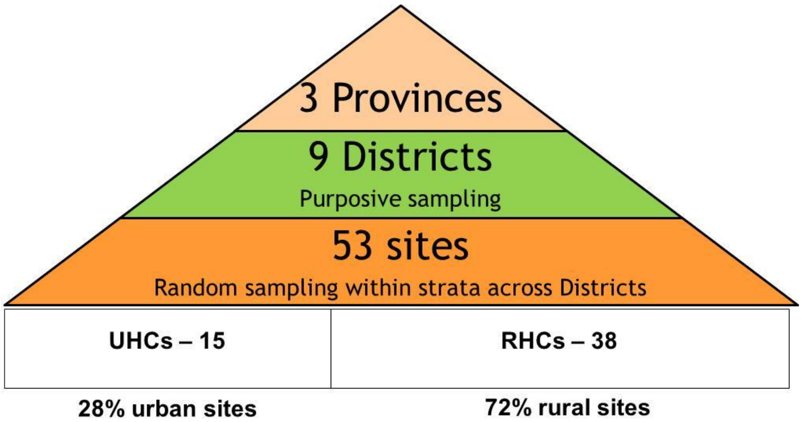


Table 3-4: Summary of sample

District	Sampled Urban facilities	Total Urban Facilities in District*	% of Total Urban Facilities Sampled	Sampled Rural facilities	Total Rural Facilities in District*	% of Total Rural Facilities Sampled
Kabwe	3	15	20%	1	1	100%
Mkushi	0	0		8	16	50%
Serenje	1	1	100%	8	15	53%
Lufwanyama	0	0		4	11	36%
Ndola	6	18	33%	0	1	0%
Masaiti	0	0		6	17	35%
Chongwe	0	0		4	22	18%
Lusaka	4	18	22%	0	0	
Kafue	1	6	16%	7	10	60%
Total for 9 districts	15	58	25%	38	93	41%

*Note: These totals exclude facilities run by uniformed services or which for other reasons were not accessible.

3.1.3 Data collection

Data collection involved an initial phase of 12 health facilities, followed by data collection from a further 41 health facilities. Data collection visits to each health facility were usually spread over two days. Collecting data from district, provincial and national offices took place over several months.[36] Training and Pre-testing of data collection tools was carried out during the week starting 8 October 2012. Data collection started on 25 October and was completed on 10 January 2013. Follow-up and quality assurance related activities commenced in the field and were completed by August 2013.

In order to facilitate the collection of EPI costing and qualitative data, an Excel data collection tool was developed, based on a generic version developed for the Common Approach. The first version of the tool was reviewed by in-country staff and several changes were made to facilitate data collection in Zambia. The revised version was then used for training and pre-tested at two facilities in Lusaka by the data collectors. After both the pre-testing and the first phase of data collection (12 facility sites), further amendments were made to the tool, resulting in a final data collection tool for facilities. The data collection tool used for districts, provinces and national data collection, was substantially the same as that for facilities, with minor changes to accommodate activities specific to the higher administrative levels. Expenditure records at districts, provinces and national levels did not facilitate the completion of the 'budget and sources' component of the questionnaire. Overhead and other expenditure and budget estimates were later captured in a separate Excel workbook.

The data collection team consisted of a Zambian senior researcher and four Zambian researchers who collected and captured the data. The senior researcher developed data collection work plans and supervised the team to coordinate collection of data from facilities, district and provincial offices. Researchers worked in teams of two that visited the facilities and interviewed staff.

Data was collected using a hard copy questionnaire, and then captured, as soon after data collection as possible, into an Excel workbook with the same format as the hard copy data collection tool. This process highlighted missing data or inconsistencies which could be addressed by staff while still in the field. A survey control sheet was maintained to monitor progress of surveys completed.

Once data in the workbooks had been reviewed and cleaned (see data quality section below), the data was captured into the Excel database and costing tool and subjected to further quality assurance reviews to ensure integrity of the data in the database.[37]

Given the complexity associated with the collection of data around funding and financing of the national EPI, as well as prospective costing of the introduction of PCV, this data collection was undertaken by the senior researchers with support from the technical experts in the team. Specific data collection tools were designed for collecting data on funding flows and introduction of the PCV vaccine. This data was typically not available in the format required in the questionnaire, and required

[36] Provinces had initiated their performance assessment visits and this, together with the activities related to the introduction of new vaccines, frequently resulted in non-availability of key informants. The re-structuring of the EPI also contributed to a longer than anticipated data collection process

[37] Immunization Economic Costing Database, Zambia Edition, Developed by Darwin Young with support from the Bill and Melinda gates Foundation, May 2013

extensive manipulation and further analysis before being captured in a separate Excel workbook.

3.1.4 Data quality and verification process

The following quality assurance (QA) approach was used to help to prevent poor practices and to minimise errors in data collection and capture.[38] Standard operating procedures for QA were outlined at the beginning of a survey and QA was an on-going process throughout the life of the project.

Quality assurance procedures
The following steps were taken in response to risks identified in order to mitigate the risk of poor data quality:

- Experienced senior researchers and skilled data collectors were recruited to administer the questionnaire
- The questionnaire was reviewed and revised in an iterative process involving senior researchers, data collectors and technical leads.
- Data collectors were trained using the questionnaire as the main training tool.
- A pre-test of the tool was conducted which assisted in further refining the tool and clarifying questions and data requirements.
- All completed questionnaires (Excel version) were reviewed by the senior researcher and by other team members using a structured checklist.
- Data collectors at HDA captured the approved Excel questionnaires into the database and costing tool.
- Costs generated by the tool were compared to manual calculation of costs by senior technical team members. When inconsistencies were identified, a thorough process reviewed formulae in the tool and corrected them when required.
- The database and costing tool included a number of validation checks which prevented processing of data until the errors are corrected.

Finally the results for all facilities were compared with each other. Where unit costs and other values appeared to divert significantly from the average, the data were re-examined to ensure that it had been accurately captured from source.

3.1.5 Data entry and analysis

A common generic Immunization Costing Database Tool was developed in Excel for the study and customized to correspond to the data availability and collection in Zambia.[37] The data collected from facilities and districts was first captured on hard copies. Once these had been verified as complete, they were transferred to Excel. After several rounds of checking and error-fixing, the data were copied manually to Survey Sheets which were imported back into the Costing Tool, which then generated outputs.

The outputs of the Costing Tool aggregated 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 cost analysis was then undertaken manually in Excel. Later statistical analyses were performed in STATA.

[38] Adapted from: United Nations Statistics Division. Household Sample Surveys in Developing and Transition Countries

Facility-based cost estimates were analyzed to estimate total costs, costs by line item, costs by activity, and unit costs. Unit costs included cost/dose of vaccine, cost per child vaccinated, and cost per fully immunized child, which in Zambia is equivalent to children vaccinated with the third dose of DTP. Estimates are reported in $2011, and average estimates are weighted averages based on sampling probabilities.

3.1.6 Aggregation of costs from facility to national level estimates

The aggregation approach was developed in the context of the specific sampling method applied in Zambia, which was designed to reflect as best as possible the immunization costs for rural and urban health centres for the whole country (see section 3.1.2 above).

The aggregation method aimed to reflect this approach by first calculating weighted average unit costs for each expenditure line item for rural facilities and urban facilities. Weighted average unit costs were calculated based on the number of doses delivered by each facility. The doses for each facility were expressed as a proportion of the total doses of the sampled facilities in the strata. The proportions for each facility were then applied to the specific expenditure or activity unit cost for each facility. The sum of the results generates the weighted average unit cost for the given line item or activity. These unit costs were then applied to the total number of doses for the country, but within the rural and urban strata.[39] In this way the unit costs of facilities which immunize more children are allocated a heavier weight than facilities which account for a smaller number of immunized children.

For district, provincial and national costs a similar approach was followed except that the rural-urban strata were not applicable. The unit cost for districts was weighted by number of doses and a weighted average calculated for each expenditure line item for all districts and similarly for the selected provinces. National costs were simply divided by the total number of doses for the national program. Thus, the amount of district, provincial and national level costs which was added to the weighted unit costs for rural and urban facilities was the same for both of these strata.

3.1.7 Limitations of the approach

A number of limitations should be taken into account when interpreting the results of the costing exercise, although the 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 sample size. The most important of these limitations were as follows:

1) Costing estimates were based on a set of assumptions. These were considered reasonable given the available data but may have limitations. In particular:
    - *Salaried labour,* which comprises a significant portion of total immunization costs, was based on estimates of time allocations. Care was taken during data collection and facility staff interviews, but the allocation of time to the EPI and specific activities reported by staff during interviews was not based on records or observation. The cumulative effect of any systematic over or

[39] This approach was felt to be more robust than calculate total average district costs which are subsequently aggregated to national level, although the raw data exists to do this calculation.

under-allocation of time at facility level might be significant.

- *2012 salary scales* were used for the costing, which otherwise relates to the 2011 year. Salaries were increased on average by 171% in 2012, albeit from a very low base. If 2011 salary scales had been used the salaried labour costs would be less than half of the values reflected in this report.
- *Wastage rates* which were used to calculate the total cost of vaccines. The lack of *accurate* vaccine stock records at all levels of the health system prevented the calculation of accurate wastage rates. The default WHO wastage rates were adapted and used in calculating vaccine costs.
- Estimation of use of *vehicles*. Both total annual use and the allocation of vehicle usage to the EPI and activities, had to be estimated in the absence of detailed vehicle log books.
- The *allocation of expenditure* at the district, province and national levels to the EPI. Many items were allocated on the basis of the ratio between total number of doses and outpatient visits to the facility. Various tracing factors were used to apportion other costs. Some inaccuracy in allocations of shared costs to the EPI may have resulted.

2) The *sampling approach*. This purposively selected both provinces and districts, resulted in a sampling universe which comprised all the facilities in the nine selected districts. Care was taken to select provinces that stakeholders agreed were representative of the range of service contexts in Zambia, and districts which represented the key service contexts in their provinces. This arguably reduced potential for sampling biases that could have arisen from a small, random sample of Districts. Although care was taken to select facilities which reflect facility composition throughout the country, differences between the facilities in the nine districts and facilities in the rest of the country may exist which are not reflected in the results of this study.

   Other limitations of the *sample size and possible biases* may have been material. Of note, there tended to wide standard errors, indicating that sample size may explain absence of statistically significant associations between some factors. Possible biases such as oversampling of large sites within the urban health centre stratum are examined in the Discussion section below.

3) The aggregation method *assumes that the weighted average unit costs derived from the sample* are representative of all the facilities in rural and urban health centre strata in Zambia. If unit costs calculated in this way differ from actual average unit costs for the whole country, this would affect the estimated total national EPI cost. Also it was assumed that national HMIS data on the total number of doses for all facilities is sufficiently accurate despite inconsistencies identified in the review of routine HMIS data.

4) The *ingredients based (or bottom-up) approach* to the EPI costing may have resulted in inaccuracies, mainly in the allocation of indirect costs. This is less likely in a 'step-down' allocation of all facility costs to the full range of facility services as provided for in conventional activity based costing.

3.1.8 Ethical issues

The study did not involve use of individual patient records or interviews with staff (or patients) on sensitive or personal issues. The University of Zambia Research Ethics Committee reviewed and approved the study protocol. Permission to access health facilities, staff and health statistics was obtained from the MOH and MCDMCH at each level of the system.

3.2 Results - total and unit costs

3.2.1 Facility level

Total costs by expenditure line items

Table 3-5 summarizes total economic costs of urban and rural health facilities by expenditure line item in the sample.[40] On average the weighted annual total economic costs of providing immunization services in urban health facilities ($34 441) is higher than in rural health facilities ($24 262). The weighted average total cost per facility in Zambia is estimated at $28 286. The higher total cost of urban facilities is almost entirely due to larger numbers of children being immunized in these facilities when compared to most rural facilities, which are typically smaller.

Table 3-5: Total Routine Immunization Economic Costs by Line Item by Facility Type ($2011)

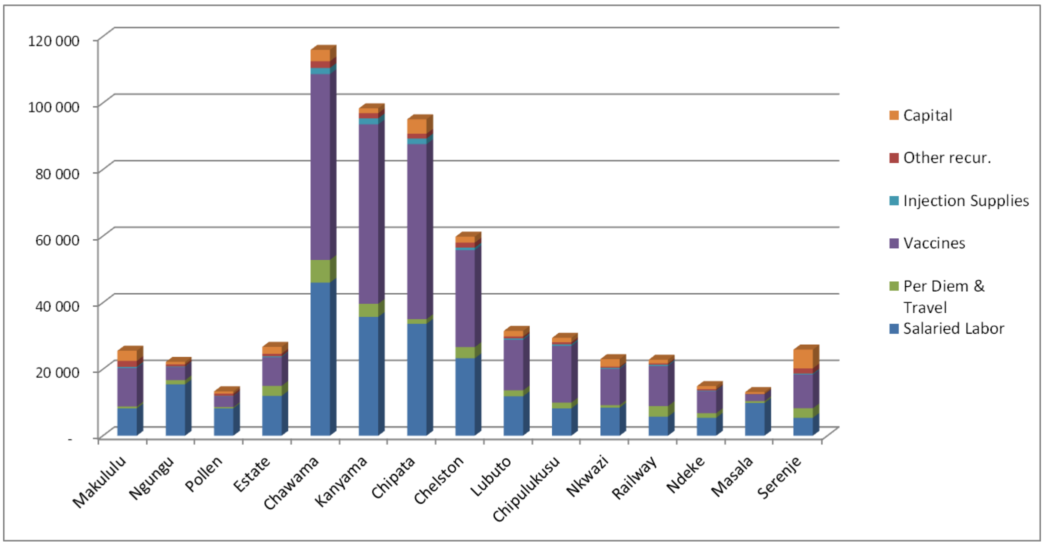
Line Items	Facility Type Urban	Percent Distribution	Facility Type Rural	Percent Distribution	Total Facility	Percent Distribution
Sample (n)	15		36		51	
- Salaried Labor	13 381	38.9%	13 209	54.4%	13 277	46.9%
- Volunteer Labor	0	0.0%	0	0.0%	0	0.0%
- Per Diems	1 907	5.5%	2 671	11.0%	2 369	8.4%
- Vaccines	16 044	46.6%	3 912	16.1%	8 708	30.8%
- Injection supplies	487	1.4%	116	0.5%	263	0.9%
- Other supplies	275	0.8%	64	0.3%	147	0.5%
- Transport & fuel	361	1.0%	1 454	6.0%	1 022	3.6%
- Vehicle maintenance	1.69	0.0%	194	0.8%	118	0.4%
-Cold chain energy costs	142	0.4%	72	0.3%	99	0.4%
- Printing	0	0.0%	0	0.0%	0	0.0%
- Building overheads	0	0.0%	0	0.0%	0	0.0%
- Other recurrent	0	0.0%	0	0.0%	0	0.0%
Subtotal recurrent	32 598	94.6%	21 692	89.4%	26 004	91.9%
- Cold chain equipment	379	1.1%	363	1.5%	369	1.3%
- Vehicles	3	0.0%	1 066	4.4%	646	2.3%
- Lab equipment	0	0.0%	0	0.0%	0	0.0%
- Other equipment	735	2.1%	389	1.6%	526	1.9%
- Other capital	0	0.0%	0	0.0%	0	0.0%
-Buildings	726	2.1%	752	3.1%	742	2.6%
Subtotal capital	1 843	5.4%	2 570	10.6%	2 283	8.1%
Total Facility Immunization Cost	34 441	100.0%	24 262	100.0%	28 286	100.0%
Total Facility Immunization Cost Range	13 102, 115 938		6261, 64 019		6 261, 115 938	

There is nevertheless high variability within the two strata. In the urban strata the total cost of immunization services varied widely between sampled sites, from $13 102 to $115 938 (see Figure 3-2). The four largest facilities in the sample represent particularly large facilities, all in Lusaka, which provide services to large, highly urbanised catchment populations. Many of the smaller urban facilities are not larger

[40] See Section 3.2.2 for discussion of the relatively small differences between economic and financial costs.

than rural facilities, but their setting in urban areas results in subtle differences in the distribution of costs and unit costs as described more fully below. In sampled rural health facilities, total annual economic costs varied from $6 261 for the smallest facility to $64 019 for the largest facility.

Figure 3-2: Total immunization facility economic cost for urban facilities in Zambia by line item ($2011)



The urban health facilities reflected in Figure 3-2 are located in five of the nine sampled districts. What is immediately apparent is that the EPI program cost is highest in those facilities located in Lusaka district (Chawama, Kanyama, Chipata and Chelston). This is not unexpected as these facilities are all located in or near the capital of Lusaka where the catchment population and facility attendance is high and the total number of doses administered is substantially higher than in other facilities, which are located in more rural districts.

With the exception of the three smallest facilities, there is a reasonably high degree of uniformity with respect to the total cost of the other facilities which all have an estimated cost of between $22 163 and $31 489. In the two smallest facilities (Pollen and Masala) salary costs are higher than vaccines costs. This seems to reflect both a fixed allocation of staff time to weekly immunization sessions combined with low numbers of children presenting for vaccinations.[41]

Distribution of costs – expenditure line items

As shown in Figure 3-4, in *urban facilities* the largest expenditure items were vaccines and salaried labour which contribute 46.6% and 38.9% of the total cost respectively. Together they represent 85.4% of the total cost. Travel allowances comprise a further 5.5% of the cost. In *rural facilities*, salaried labour is a higher proportion of total costs (54.4%) with vaccines contributing only 16.1% of the total. Together with travel allowances, staff-related costs make up 65.5% of total facility costs. With vaccines, these three line items comprise 81.6% of total costs.

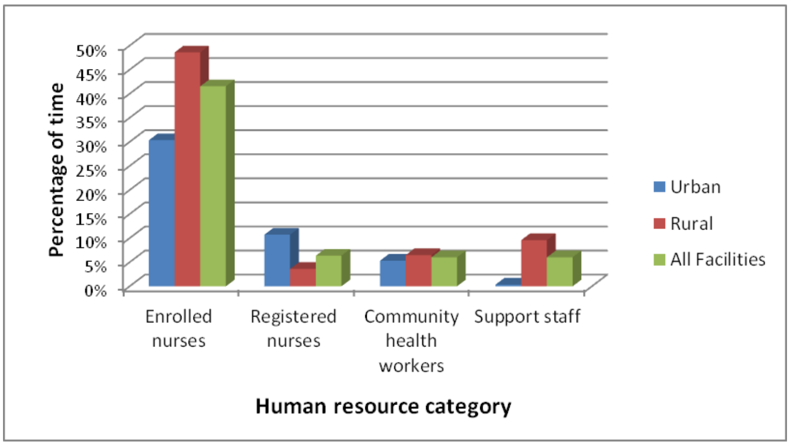
The absolute value of salaried labour in urban and rural facilities is however

[41] In Pollen, 3978 doses were administered (52% DTP3 coverage) with five staff members allocating significant time to the EPI. Masala has a similar pattern with 1 319 doses administered (36% DTP3 coverage) and four staff members allocating time to the EPI.

surprisingly similar ($13 209 rural vs. $13 381 urban). The most significant difference between the two facility types is vaccine costs which amount to $16 044 for urban facilities, much higher than the $3 912 for rural facilities. Vaccine costs are driven by the number of children immunized, which is considerably higher on average in urban facilities. This relationship is examined in more detail in Section 6 of the report.

The salary costs can also be analyzed in terms of the time allocated by facility staff to immunization services. In Figure 3-3 below, the average share of time allocated by different staff categories is shown together with the average time to deliver a dose. Enrolled nurses in rural facilities have allocated a larger portion of their time to immunization (48.6%) than their counterparts in urban facilities (30.4%). Conversely, registered nurses allocated 10.7% of their time in urban facilities compared to only 3.6% in rural facilities. This indicates a proportionately higher participation of more senior nurses in direct immunization service provision in urban facilities, while the senior nurses in rural facilities may be spread more thinly across service components performed mainly by less skilled staff. Community health workers (CHW) spend on average between 5% and 6% of their time on immunization, which comprises primarily social mobilization and attending meetings.

Figure 3-3: Allocation of time to immunization by staff category (Zambia)



The total number of Full Time Equivalents (FTE) staff in both urban and rural facilities is similar at 1.83 and 1.78 FTEs respectively (Table 3-6). Of this FTE, CHW make up just less than one FTE at 0.78 and 0.7 FTEs for urban and rural facilities respectively. CHW therefor comprise a significant proportion of time invested in immunization service. The figure above however confirms that the CHW FTE is made up of relatively large numbers of CHE (usually one per outreach zone) contributing relatively little (less than 10%) of their time to immunization. The time spent per dose varies significantly between urban and rural facilities. In urban facilities a total time of 31 minutes is required inclusive of CHW time and 20 minutes excluding CHW. In rural facilities the time per dose is substantially higher at 85 minutes with CHW and 54 minutes without CHW. The large difference may point to low patient volumes during dedicated immunization days and outreach visits during which nurse and CHW time cannot easily be diverted to other health services. This much higher time per dose in rural facilities is also reflected in the total number of doses delivered per FTE; only 1977 doses per FTE compared to 8673 doses per FTE in urban facilities. These observations corroborate the significant difference in unit costs per dose reviewed elsewhere in this report.

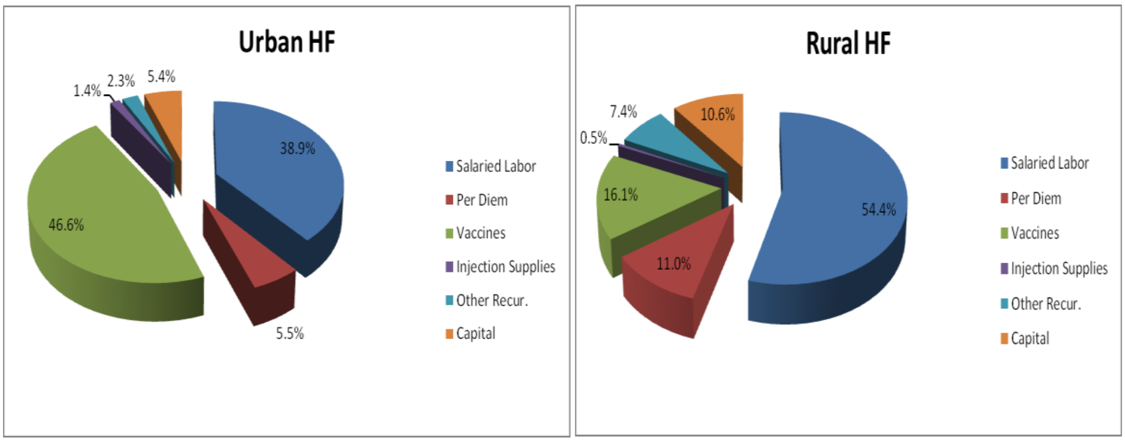
Table 3-6: Summary of full time equivalent staff and time per dose (Zambia)

Line Items	Facility Type Urban*	Facility Type Rural	All Facilities
Sample (n)	14	36	50
Total FTEs	1.83	1.78	1.80
Total FTEs excl. CHWs	1.05	1.08	1.07
Doses/FTE	8673	1977	4562
Doses/FTE excl. CHWs	11542	3118	6370
Time spent /dose delivered (min)	31	85	64
Time spent / dose delivered excl. CHWs (min)	20	54	41

'* One urban facility (Chipata) was not included in this FTE analysis due to an unconventional use of CHW which distorted the results for urban facilities

As one might expect, rural facilities have higher travel costs, as they are further from vaccine collection points and outreach sites. This reflected in the higher proportion of travel allowances in rural facilities (10.6%) when compared to urban facilities (5.5%). Urban facilities reflect no vehicles and insignificant vehicle maintenance costs, as urban facilities did not have vehicles and at most had a bicycle. Some rural facilities used motor cycles.

Figure 3-4: Total immunization economic costs by line item in urban and rural facilities in Zambia ($2011)



Total costs by functional activities

Table 3-7 below shows total costs of urban and rural facilities by functional activity. The weighted average costs by activity show that the most costly activities are routine facility-based service delivery and outreach service delivery, which contribute 34.2% and 34.1% of total facility cost respectively. Other activities that contribute large amounts to total cost include social mobilization, vaccine collection and storage, supervision and training. Almost all facilities collect vaccines from the DMO once a month. Only three facilities reported higher frequencies with one reporting collection of vaccines six times a month.

The average value of routine facility-based service delivery and outreach service delivery is substantially higher in urban than rural sites. The largest contributors to these activity costs are salaried labour, vaccine and travel allowance costs. Together the two activities account for most of the difference in total costs between urban and rural facilities. Of note, the cost of vaccine collection is higher in rural ($2 207) than urban facilities ($621). This is because more staff time and transport are needed as rural facilities are typically further from collection points.

Table 3-7: Total Routine Immunization Economic Costs by Activity by Facility Type ($2011)

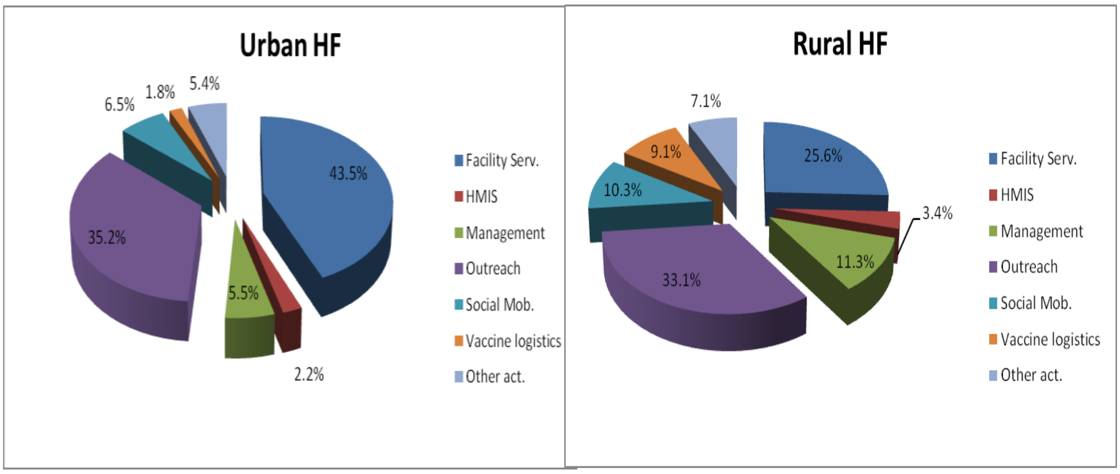
Activities	Facility Type Urban (Range)	%	Facility Type Rural (Range)	%	Total Facility (Range)	Percent Distribution
Sample (n)	15		36		51	
- Routine Facility-Based Service Delivery	14 985	43.51%	6 216	25.62%	9 683	34.23%
- Record-Keeping/HMIS	746	2.17%	833	3.43%	799	2.82%
- Supervision	1 023	2.97%	1 372	5.66%	1 234	4.36%
- Outreach Services	12 116	35.18%	8 035	33.12%	9 649	34.11%
- Social mobilization	2 236	6.49%	2 501	10.31%	2 396	8.47%
- Cold chain maintenance	651	1.89%	611	2.52%	627	2.22%
- Vaccine collection and distribution	621	1.80%	2 207	9.09%	1 580	5.59%
- Program management	858	2.49%	1 380	5.69%	1 174	4.15%
- Training	970	2.82%	576	2.38%	732	2.59%
- Other	25	0.07%	50	0.21%	40	0.14%
- Surveillance	210	0.61%	480	1.98%	374	1.32%
Total Facility Immunization Cost	34 441	100.00%	24 262	100.00%	28286	100.00%
Total Facility Immunization Cost range	13 102, 115 938		6261, 64 019		6 261, 115 938	

Note: Vaccine costs are included in both facility based and outreach service delivery.

Figure 3-5 below shows the proportional contribution of activity costs to total facility costs. In urban health facilities routine facility based service delivery comprises 43.5% of total cost, much higher than the 25.6% for this activity in rural facilities. Outreach service provision contributes a similar proportion to total cost in both facility types (35.2% in urban; 33.1% in rural). Considering facility based and outreach together, these proportions reflect that in rural facilities approximately 60% of immunization services were delivered though outreach whereas in urban facilities the majority of services were delivered at the facility.

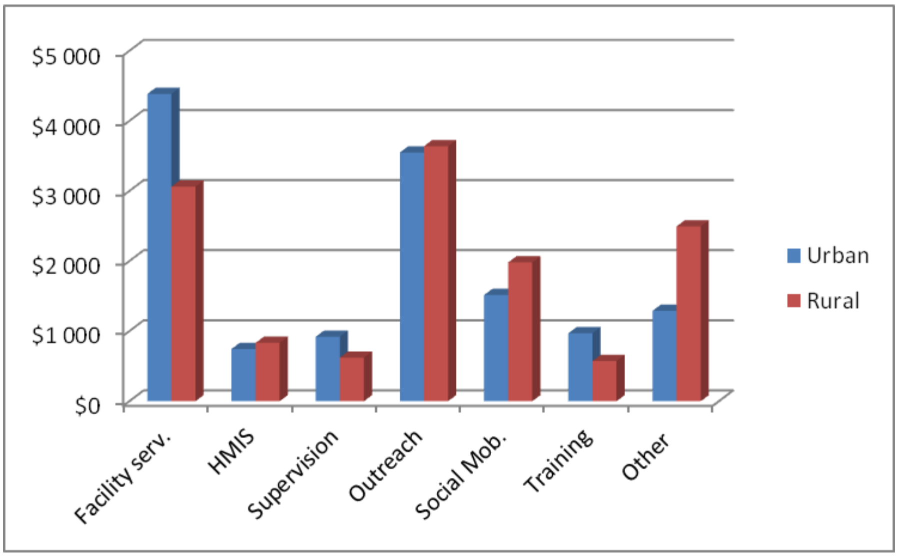
In rural facilities, vaccine collection, social mobilization, program management and supervision account for a higher proportion of total costs than in urban facilities. Higher vaccine collection costs would be expected in more rural sites. Higher contributions of social mobilization and supervision seem to reflect greater time and other resource requirements associated with supervising community health workers and mobilizing communities in more extensive outreach services.

Figure 3-5: Contribution of activities to immunization economic costs in rural and urban facilities in Zambia ($2011)



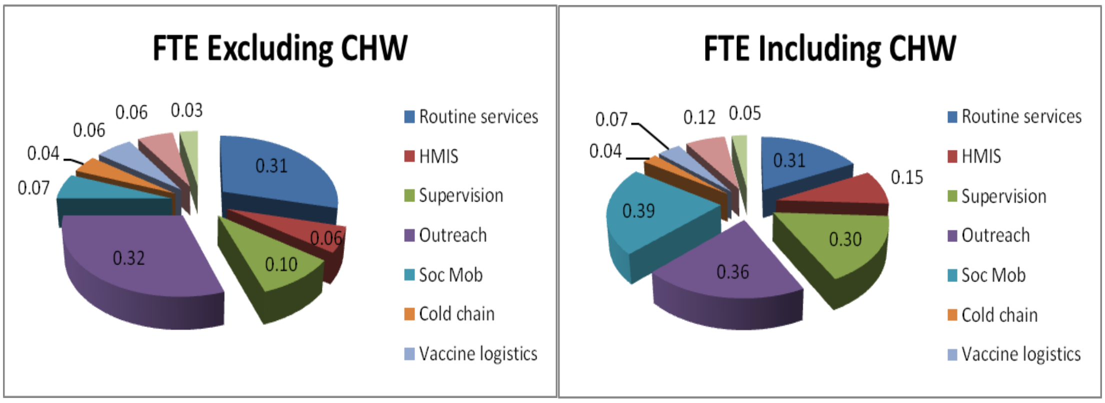
The allocation of salary costs to activities (Figure 3-6 below) differs between rural and urban facilities. In urban facilities a bigger proportion of salary costs are allocated to facility-based services when compared to outreach services. In rural facilities, more staff time has been allocated to outreach services than facility based services. This is consistent with the allocation of doses administered in facilities when compared to outreach, reported by urban and rural facilities. It is also interesting to note that the cost of salaries allocated to other activities, which include vaccine collection, cold chain maintenance, program management and surveillance are all marginally higher than in urban facilities. Given the logistical challenges faced by most rural facilities, this is not unexpected. Lastly it is interesting to note that staff training costs are higher for staff in urban facilities than their counterparts in rural facilities.

Figure 3-6: Total salaried labour economic cost for urban and rural facilities in Zambia by activity ($2011)



The pie charts in Figure 3-7 below show the distribution of the average facility-level fulltime equivalent (FTE) human resources by activity, including and excluding community health workers. The average FTE per facility is 1.07 excluding CHW and 1.8 including CHW. When not considering CHW just over 0.3 FTE are allocated to both facility based services and outreach services delivery. Thereafter supervision attracts 0.1 FTE with smaller amounts allocated to other activities. Including the CHW FTE values results in a significant increase in social mobilization from 0.07 to 0.39 FTE. Supervision increases from 0.1 to 0.3 FTE. Given that a core function of CHW is to mobilise communities, the increase in community mobilization is expected. The increase in supervision relates mainly to coordination and planning meetings attended by CHW. (Supervision and program management has been combined in the chart below). What the charts do highlight is the important role that CHW play in routine service delivery even if the financial cost to the program is very low.

Figure 3-7: Distribution of facility FTE by activity in Zambia



A comparison of unit costs

Table 3-8 highlights several stark differences between urban and rural facilities. For the sampled facilities, the weighted average number of child doses in 15 urban facilities is more than four times the number of child doses in 36 rural facilities. Four facilities sampled in Lusaka were particularly large and together accounted for 179 563 child doses. The ratio of the number of children vaccinated with a 3rd dose of DTP3 in Urban and Rural Health Centres is similar. The weighted average catchment population of the urban health centres is almost six times the size of the catchment population of the rural health facilities. These significantly higher catchment populations, numbers of children vaccinated and doses administered in total and per facility have a significant impact on unit costs as is shown below.

Of note, the *weighted average reported* DTP3 coverage rate differs from the coverage rate calculated from catchment data, especially for urban facilities. The weighted average DTP3 coverage rate is 75% but the calculated coverage rate for some urban facilities in the sample is much lower, with an average coverage rate for urban facilities in the sample of 68% based on targeted children. This anomaly arises because the number of children under 1 year of age, reported at the facility is lower than the standard 4.7% of catchment population assumed to be surviving infants. For example in the Chelston urban facility, the reported number of infants under one year is 1.6% of the catchment population which consequently generates a much higher reported coverage rate. Depending on actual fertility and survival rates, the cost per-child figures in the urban facilities could therefore be understated. Similarly, the calculated infant population may be an underestimate for many RHCs, where the proportion of infants in the target population is higher than the standard 4.7%, resulting in an average DPT3 number that is higher than the average infant population for RHCs.

Urban facilities have substantially lower total facility level unit cost per child with a third dose of DTP, and the unit costs per dose administered, than those of rural facilities. The unit cost per DTP3 vaccinated child is $87.14 per child in rural facilities compared to $33.38 per child in urban facilities, a $53.76 difference.

Table 3-8: Total Routine Immunization Economic Unit Costs by Facility Type ($2011, Weighted Average)

	Urban Health Centres	Rural Health Centres	All Facilities
Sample (n)	15	36	51
- Total Child Doses	13 325	2 974	7 066
- Total DTP3 Vaccinated Children	1 271	330	702
- Infant population	1 868	319	931
- Total population	44 156	7 536	22 013
- Cost per Dose	3.73	9.43	7.18
- Cost per child	22.85	83.17	59.32
- Cost per DTP3 vaccinated child	33.38	87.14	65.89
- Cost per capita	0.97	3.52	2.51
- Delivery Cost* per Dose	2.43	8.07	5.84
- Delivery Cost per child	13.79	70.56	48.12
- Delivery Cost per DTP3 vaccinated child	21.07	74.72	53.51
- Delivery Cost per capita	0.58	2.98	2.04

* Delivery costs = total facility cost *less* vaccines and vaccine supplies

The delivery unit costs (which exclude vaccines and vaccine supplies) tend to be substantially below the total cost per dose. The vaccines and vaccine supplies make up a larger proportion of unit costs in UHCs than in RHCs. In RHCs, the delivery costs are a much larger contributor to total costs. Table 3-9 shows total facility costs and unit costs, and illustrates that delivery costs, and particularly human resources, tend to be an even larger influence on unit costs than vaccines. Together vaccines and human resources account for around three quarters of average national unit costs.

Table 3-9: Facility Level Total and Unit Costs with and Without HR costs (Weighted Averages)

Indicator	Total Facility Cost	Facility Non-Wage*	Delivery Cost**	Delivery Non-Wage***
Total Economic Cost	$28 286	$15 009	$19 315	$6 038
Cost/capita	$2.51	$1.19	$2.04	$0.72
Cost/dose	$7.18	$3.22	$5.84	$1.89
Cost/child (infant)	$59.32	$28.19	$48.12	$16.99
Cost/FIC (DTP3)	$65.89	$29.92	$53.51	$17.54

* Facility Non-wage costs = facility cost *less* salary costs ** Delivery costs = total facility cost *less* vaccines and vaccine supplies ***Non-wage delivery costs = facility cost *less* vaccines, vaccine supplies and salary cost

Table 3-10 shows the weighted average unit costs by line item for facilities in the sample. A review of the weighted average unit costs below shows that the difference is almost entirely due to the difference in four expenditure items:

- Salaried labour which is $48.89 in a rural facility compared to only $16.21 in urban facilities, accounting for $32.68 of the difference,
- Travel allowances which are $6.72 higher in rural facilities,
- Transport and fuel costs, $5.53 higher in rural facilities, and
- Capital cost of vehicles and buildings, $3.37 and $2.29 higher respectively.

The salary unit cost appears to be particularly high, reflecting that volumes (doses and DTP3 children) are much lower in rural than in urban facilities, with lower utilization of staff capacity. In addition, outreach services in rural areas are more labour-intensive and less productive. Staff time is lost in travel to and from the outreach zones, and it is likely that the number of children immunized on outreach days in remote locations is lower than total doses administered in urban facilities on immunization days. These two factors, combined with the fact that outreach immunizations are a higher proportion of total immunizations in rural than urban facilities, are the likely cause of much higher labour unit costs in rural facilities.

Travel allowances are higher in rural facilities. Staff are more likely to be paid allowances for vaccine collection and outreach activities, as there is more travel associated with outreach and social mobilization, and longer distances between facilities, vaccine collection points and outreach zones. On average urban centres are 7km from vaccine collection points, while rural facilities are just over 70kms from theirs. Similarly, travel and fuel costs are higher in rural facilities.

Minor differences in vaccine unit costs occur due to the fact that the mix of doses administered (different antigens) varies from one facility to the next.

Capital costs are generally low when compared to recurrent costs. The capital cost of vehicles is higher in rural facilities because some of them had motorcycles whereas no urban facilities had motorized vehicles and only a few used bicycles. Building unit costs are higher in rural facilities mainly due to lower volumes of children immunized but also as a result of the slightly higher number of outreach zones per facility serviced by rural facilities.[42]

Table 3-10: Weighted average facility unit economic costs per DTP3 child by expenditure line item

Facility type	UHF	% of total	RHF	% of total	Difference
Expenditure line items	Weighted average unit costs (DTP3)		Weighted average unit costs (DTP3)		
Number of facilities (n)	15		36		
Salaried labour	16.21	48.57%	48.89	56.10%	32.68
Volunteer labour	0.00	0.00%	0.00	0.00%	0.00
Per Diem & Travel Allow	1.96	5.86%	8.68	9.96%	6.72
Vaccines	11.95	35.81%	12.06	13.84%	0.11
Vaccine Injection Supplies	0.36	1.06%	0.36	0.41%	0.00
Other Supplies	0.28	0.84%	0.27	0.31%	-0.01
Transport/Fuel	0.41	1.24%	5.95	6.83%	5.53
Vehicle Maintenance	0.005	0.01%	0.65	0.75%	0.65
Cold Chain Energy Costs	0.18	0.54%	0.36	0.42%	0.19
Sub-total recurrent	**31.36**	93.94%	**77.23**	88.62%	**45.87**
Cold Chain Equipment	0.47	1.41%	1.51	1.73%	1.04
Vehicles	0.01	0.03%	3.74	4.29%	3.73
Lab equipment	0.00	0.00%	0.00	0.00%	0.00
Other Equipment	0.77	2.30%	1.60	1.84%	0.83
Other capital	0.00	0.00%	0.00	0.00%	0.00
Building	0.77	2.32%	3.07	3.52%	2.29
Sub-total capital	**2.02**	6.06%	**9.92**	11.38%	**7.89**
Total facility immunisation unit cost	**33.38**	100.00%	**87.14**	100.00%	**53.76**

Figure 3-8 below plots the total unit costs per DTP3 child against the total number

[42] As noted above, each outreach zone was assumed to use $16m^2$ for at least a full day during the outreach visit.

DTP3 children immunized.[43] Each point on the graph represents a facility in the sample and red points are rural facilities while urban facilities are black. The number of each point is the identification study number used for the facility. Figure 3-9 plots total unit costs per dose against total doses at each facility.

Figure 3-8: Total unit cost per DTP3 child by annual number of DTP children for each facility (2011)

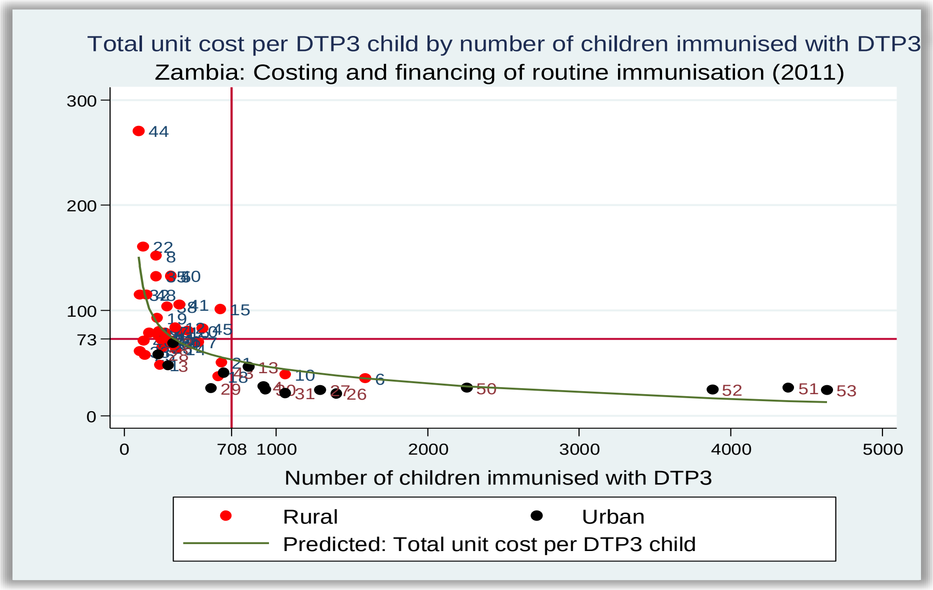
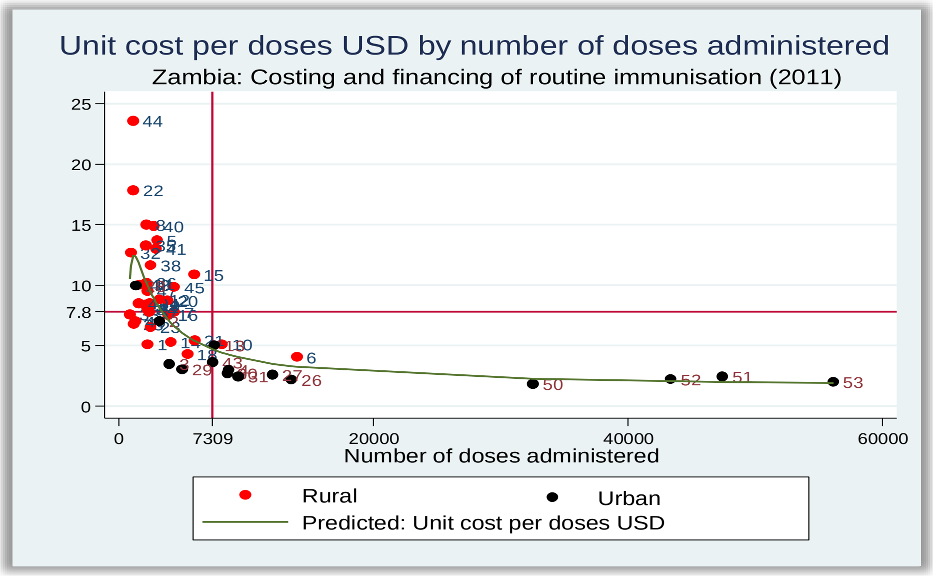


Figure 3-9: Total unit cost per dose by number of doses at each facility (2011)



Of note, the unit cost per DTP3 child initially decreases rapidly as the total number of DTP3 children per facility increases. However, the rate of decrease falls markedly as the total number of DTP3 children per facility increases. Beyond 1000 DTP3 children per facility, the unit cost shows little variability and seems to reach a minimum unit cost threshold between $21 and $26 per DTP 3 child.

This is of interest to planners as significant cost reductions can be achieved if

[43] The cost curve was presented as a fractional polynomial prediction.

volumes at facilities can be achieved which approach the minimum threshold. However, in reality this may be difficult to do, particularly in rural facilities. An almost identical pattern is reflected as the total number of doses increases at the facility. Unit costs seem to stabilize after approximately 10 000 doses and further increases do not generate significant efficiency gains.

A number of facilities have disproportionately high unit costs. This appears to be due to a combination of factors that include:

- Particularly low DTP3 children (facility 44 and 22 are rural and reported only 95 and 124 DTP3 children respectively. Facility 44 had the least children of any facility)
- High levels of outreach work together with high staff participation (e.g. two health workers and two community health workers on each visit to eight or more outreach zones each month)
- High transport costs (bus or taxi) to remote locations or due to a higher than average frequency of vaccine collection visits and supervisory visits.

Figure 3-10 below examines the variability of total facility cost associated with the location of facilities in specific districts. The figure highlights the concentration of urban facilities in Lusaka, Ndola and to a lesser degree in Kabwe. Almost all the facilities in Lusaka and Ndola are situated well above the mean for total number of doses. Four districts (Chongwe, Masaiti, Lufwanyama and Mkushi) have only rural facilities in the sample. Facilities in these districts are generally located below the means of total costs and total number of doses.

Figure 3-10: Total facility cost by number of doses administered (Ln), by district

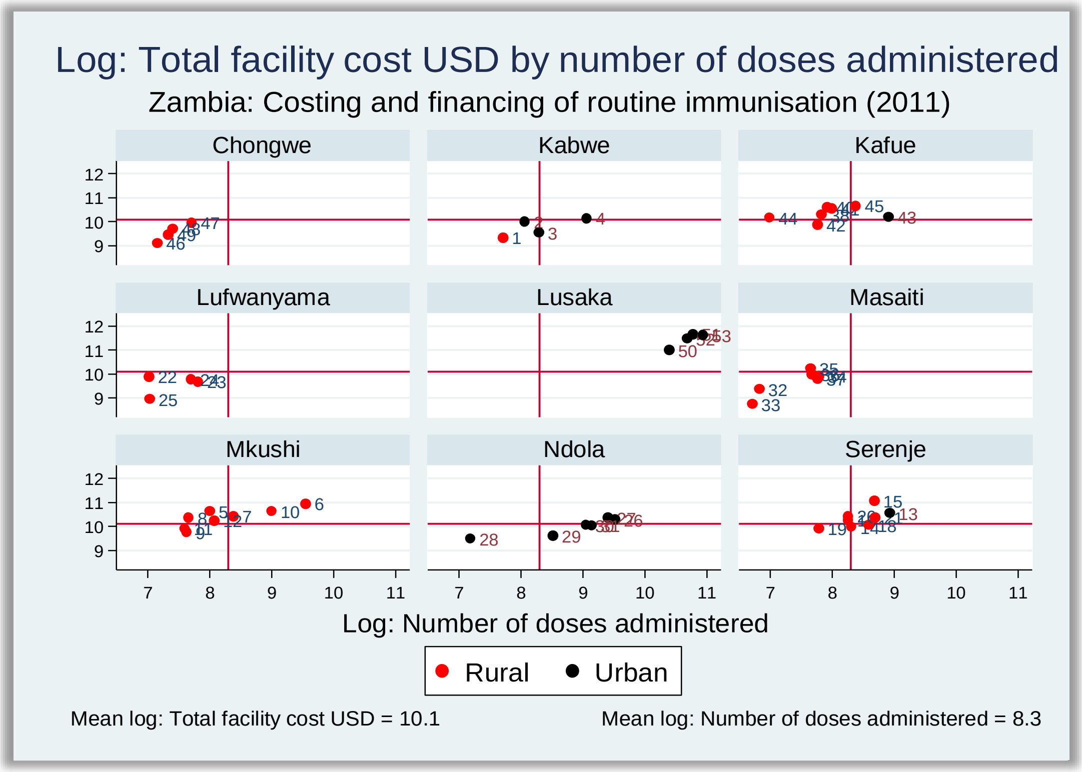
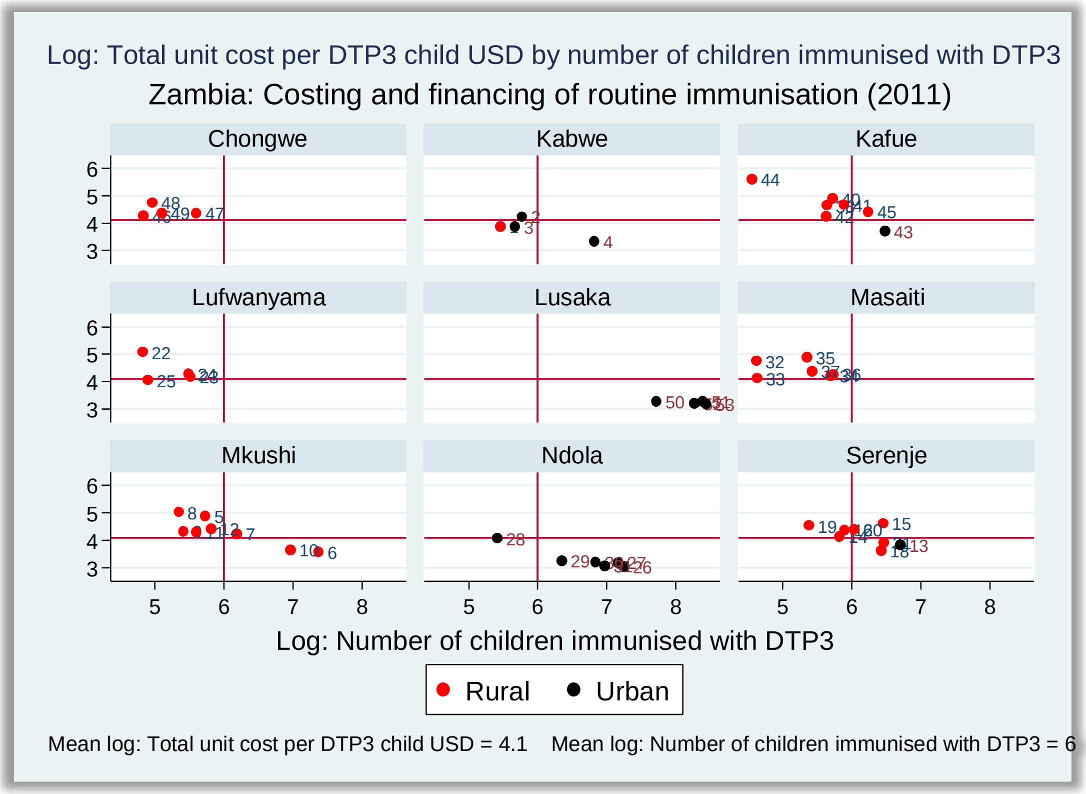


Figure 3-11 also examines district characteristics, reflecting the unit costs per DTP3 child by number of children immunized in each district. The unit costs in Lusaka and Ndola districts appear to be consistently below the mean. As noted above all of these facilities are urban facilities, which are typically more efficient than rural facilities.

Efficiency is also associated with volume: almost all facilities with unit costs above the mean are rural facilities with volumes below the average.

Annex 9 explores variations in unit costs and efficiency indicators in more detail.

Figure 3-11: Unit cost per DTP3 child by number of children immunized, by district



3.2.2 Comparison of Financial and economic costs at facility level

In this study the only differences between economic and financial costing relate to the following:

- In Zambia community health worker (CHW) costs are usually reported under human resources as they receive allowances to participate in outreach and social mobilization activities. However, in the economic costing a further cost was allocated for the time spent on these activities by CHWs.
- In the economic costing, capital costs are annualized using a 3% discount rate. The financial costing annualizes capital with a discount rate of zero, equivalent to using straight line depreciation over the life of the asset.

In Table 3-11 the economic and financial costs for the averages for urban and rural facilities are compared. For urban health facilities the average total costs per facility is $945 less in the financial costing than in the economic costing. The difference is made up of $620 on human resource costs and $325 on capital items, of which most ($220) is a reduction in building costs. For rural health facilities the difference is $566, made up of a reduction of $176 for human resource costs and $390 for capital items. The resulting overall reduction in costs is small, around 2.7% in urban and 2.5% in rural facilities.

Table 3-11: Comparison of Weighted Economic and Financing Costs by Line Item by Facility Type ($2011)

Line Items	Economic Costs			Financial Costs		
	Urban Health Centres	Rural Health Centres	Weighted Average	Urban Health Centres	Rural Health Centres	Weighted Average
- Salaried Labor	13 381	13 209	13 277	12 761	13 033	12 926
- Volunteer Labor	0	0	0	0	0	0
- Per Diems	1907	2 671	2 369	1 907	2 671	2 369
- Vaccines	16 044	3 912	8 708	16 044	3 912	8 708
- Injection supplies	487	116	263	487	116	263
- Other supplies	275	64	147	275	64	147
- Transport & fuel	361	1 454	1 022	361	1 454	1 022
- Vehicle maintenance	1.69	194	118	1.69	194	118
- Cold chain energy	142	72	99	142	72	99
- Printing	0	0	0	0	0	0
- Building overheads	0	0	0	0	0	0
- Other recurrent	0	0	0	0	0	0
Subtotal recurrent	32 598	21 692	26 004	31 978	21 516	25 652
- Cold chain equipment	379	363	369	334	320	325
- Vehicles	3	1 066	646	3	997	604
- Lab equipment	0	0	0	0	0	0
- Other equipment	735	389	526	676	338	472
- Other capital	0	0	0	0	0	0
-Buildings	726	752	742	506	524	517
Subtotal capital	1843	2 570	2283	1 518	2 179	1 918
Total Facility Immunization Cost	34 441	24 262	28 286	33 497	23 696	27 570

Interestingly, the salaried labour cost reduction for rural facilities is substantially smaller than for urban facilities, while the capital cost reduction of rural facilities is somewhat higher than for urban facilities. On average the urban health facilities reported more CHW hours than rural facilities, suggesting larger use of CHW support in urban facilities, which may relate mainly to higher out-patient volumes. The capital cost reduction is higher in rural facilities as no urban facilities reported ownership of any vehicles, while some rural facilities reported ownership of motorcycles.

Given the relatively small differences between economic and financial costs, the distribution of costs between expenditure line items and differences between costs of urban and rural facilities remain largely unchanged.[44]

Table 3-12 shows the economic and financial costing of facilities by functional activity. Lower financial costs are shown for most activities, particularly those that account for the bulk of CHW and asset costs. In urban facilities reduced routine facility based, outreach and social mobilization costs account for 73% of the difference. In rural facilities the same activities account for 67% of the reduction. The balance is made up almost entirely by reduced vaccine collection and program management costs. Activities that show very small or no difference between economic and financial costing include supervision, cold chain maintenance and surveillance costs. The distribution of financial costs across activities is almost unchanged from that of the economic costs.

[44] Salaried labour in economic costing was 39% of total costs in urban facilities and 54% rural ones. In the financial costing these proportions changed to 38% and 55% respectively. The slight increase in the rural salaried labour proportion is due to the proportionately larger decrease in capital asset costs.

Table 3-12 : Comparison of Economic and Financing Costs by Activity by Facility Type ($2011)

Activities	Economic Costs			Financial Costs		
	Urban Health Centres	Rural Health Centres	Weighted Average	Urban Health Centres	Rural Health Centres	Weighted Average
- Routine Facility-Based Service Delivery	14 985	6 216	9 683	14 782	5 988	9 464
- Record-	746	833	799	688	796	753
Keeping/HMIS	1 023	1 372	1 234	1 023	1 369	1 232
- Supervision	12 116	8 035	9 649	11 848	7 953	9 493
- Outreach Services	2 236	2 501	2 396	2 015	2 435	2 269
- Social mobilization	651	611	627	651	611	627
-Cold chain maintenance	621	2 207	1 580	570	2 139	1 519
- Vaccine collection and distribution	858	1 380	1 174	759	1 306	1 090
- Program	970	576	732	935	568	713
management	25	50	40	16	50	37
- Training	210	480	374	210	480	374
- Other						
- Surveillance						
Total Facility Immunization Cost	34 441	24 262	28 286	33 497	23 696	27 570

3.2.3 District, provincial and national level costs

Districts play an important role in implementing the EPI (see Section 2). They prepare annual action plans, coordinate submission of annual facility action plans, prepare budgets and are conduits for budget funding and some donor funding. DMOs also incur costs on behalf of facilities, of which the most important are:

- Electricity fixed availability charges for each facility
- Training of health workers on immunization, typically travel related costs
- Travel and transport costs for a range of activities, including operation of a pool of motor cycles for facilities in some districts
- Building, grounds, equipment and furniture maintenance.

Some detail is provided in the action plans, and certain amounts are split between district office, hospital and health centre costs. However, the final budget and actual expenditures are consolidated by high-level expenditure items. Therefore, it is not easy to isolate *actual* expenditure on health centres, or on the immunization program, without detailed analysis of individual transactions in the ledgers.

In order to estimate district level expenditure on the EPI, the detailed workings in the action plans were used to identify costs and it was assumed that these estimates would approximate actual expenditure during the year. Overhead and utility costs were allocated to the EPI on the basis of number of doses as a proportion of total attendance in the district. District level expenditures reported below may therefore have limitations on their accuracy.

The *provincial health offices* play a less prominent role in the EPI. The provincial health offices have a smaller role in direct coordination of operational activities of the EPI. They do not incur expenditure on behalf of health facilities. The EPI functions provided by the provincial offices include serving as vaccine collection points, providing technical assistance, supervision and performance assessment services, and assisting during Child Health Weeks. Provinces are affected by similar limitations on measurement of expenditure as at district level. Provincial health office costs are not allocated to cost centres and thus include costs of support services provided to health facilities and hospitals. Overhead and utility costs were allocated to the EPI on the basis of number of doses in the province as a proportion of total attendance in the province.[45]

Table 3-13 shows a breakdown of total costs by line item for the EPI at each level of the system. In terms of total costs, the contribution of all the 72 districts is largest followed by the 9 provinces and then the national level. Recurrent costs contribute an average of 79% at each level. Salaries and per dia contribute a somewhat larger proportion of costs at higher levels. Building-related overheads and vehicles and transport costs contribute relatively more at District level (see further discussion below).

Table 3-13: District, Provincial and National Health Office Routine Immunization Economic Total Costs by Line Item ($2011)*

Line Items	Weighted Average District		Weighted Average Provincial Level		National Level EPI Administration	
	n=9	%	n=3	%		%
- Salaried Labor	34 922	28%	53 802	43%	238 999	35%
- Volunteer Labor	0	0%	0	0%	0	0%
- Per Diems	17 770	14%	20 692	17%	160 545	24%
- Vaccines	0	0%	0	0%	0	0%
- Injection supplies	0	0%	0	0%	0	0%
- Other supplies	4 169	3%	1 063	0%	0	0%
- Transport & fuel	16 222	13%	12 017	10%	91 992	13%
- Vehicle maintenance	4 667	4%	2 636	2%	22 283	3%
-Cold chain energy costs	622	0%	403	0%	6 961	1%
- Printing	1 323	1%	0	0%	0	0%
- Building overheads	19 158	15%	7 727	6%	15 821	2%
- Other recurrent	0	0%	0	0%	0	0%
Subtotal recurrent	98 853	79%	98 341	79%	536 601	79%
- Cold chain equipment	2 931	2%	3 392	3%	14 346	2%
- Vehicles	19 394	16%	11 223	9%	87 134	13%
- Lab equipment	0	0%	0	0%	0	0%
- Other equipment	583	0%	1 370	1%	9 151	1%
- Buildings	2 978	2%	10 821	9%	35 938	5%
Subtotal capital	25 886	21%	26 806	21%	146 569	21%
Total Immunization Economic Cost	**124 739**	**100%**	**125 147**	**100%**	**683 170**	**100%**

* See Annex 13 for details of individual District costs by line item

District costs

Total district costs vary significantly from district to district (see Annex 13 (d)).[46] Some District offices are very small, such as Mkushi (total EPI cost $43 586) which provides services to a relatively small catchment population living mainly in a commercial farming area. On the other hand the Lusaka district office (total EPI cost

[45] Hospital in-patient attendance was converted to out-patient equivalents using WHO-Choice conversion factors.

[46] This wide variation, combined with the small sample of districts, was identified as one possible hazard that might arise if average district unit costs for sampled services in each district were aggregated to produce total national EPI cost estimates, rather than averages by facility type in line with the main facility strata.

of $303 416) oversees a number of very large health centres providing services to a mainly urban population in Lusaka. Difference in catchment populations and district office sizes are also reflected in the number of DTP3 children and number of doses for each district. Lusaka district is by far the largest, with a total of 530 560 doses administered in 2011, followed by Serenje, with 86 322 doses.

The district level unit cost per DTP3 child also varies widely. The lowest unit cost per DTP3, in Lusaka, was $5.23 per child. The highest unit costs of over $24 per DTP3 child in Masaiti and Lufwanyama districts, reflect in large part that they have the lowest number of children with a third dose of DTP. As indicated above these costs are incurred to manage and support health centres and do not include any service delivery costs.

Figure 3-12 highlights the tendency for unit cost to decline as the total number of DTP3 children in the district increases. This is most likely due to the fact that there is a certain level of fixed costs associated with minimum staffing and infrastructure at district level, which needs to be absorbed. As total DTP3 children increase the unit cost declines. The obvious exceptions above are Lusaka district and Mkushi districts. Lusaka has a particularly high number of DTP 3 children and generates a very low unit cost. The observation is located well above the trend line which suggests that a certain minimum unit cost threshold has been achieved which appears to be just below $6 per DTP3 child. The other exception is Mkushi district which has a low number of DTP3 children but has also a very low unit cost. The district has low staff, travel and fuel costs and only allocated a small portion of costs associated with one pick-up truck to the EPI.[47]

Figure 3-12: District economic unit costs per DTP3 child by number of DTP3 children (Zambia, 2011)

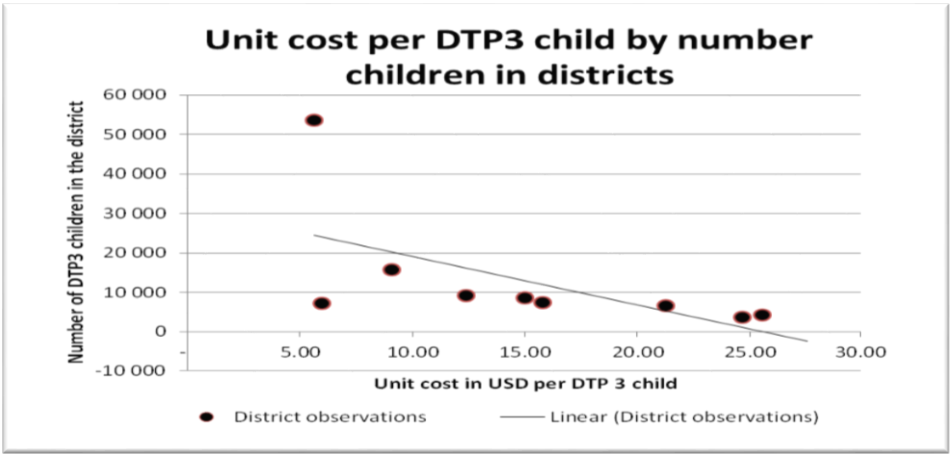


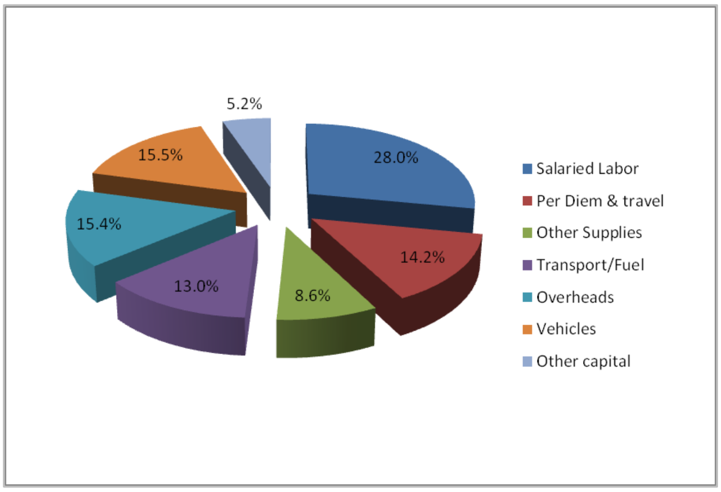
Figure 3-13 shows that among recurrent costs, the most significant expenditure item is salaried labour at 28% of the total, reflecting the time allocation by district staff to the EPI. Vehicle maintenance (included in other supplies below) and transport and fuel contribute a further 17%.[48] Travel allowances and overheads account for 14.2% and 15.4% of total district costs respectively.[49] Travel allowances include a significant allocation for social mobilization and supervision during Child Health Weeks.

[47] Of note, the declining trend persists, with a somewhat shallower gradient if the two low cost outliers are excluded. The reasons for Mkushi's low costs may warrant further investigation with other similar districts.

[48] District offices usually have two or more Land Cruiser trucks which are used extensively for fetching vaccines and supplies and supervision visits to facilities.

[49] Overhead expenses include electricity and water charges, communication charges, office rentals, and building and equipment maintenance costs, for the district office and health facilities.

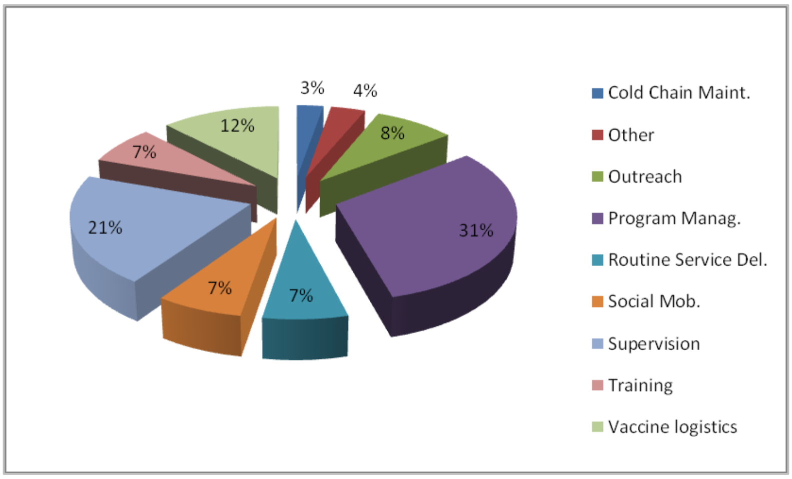
Figure 3-13: District weighted EPI economic costs by line item (Zambia 2011$)



The allocation of costs to activities in Figure 3-14 below highlights the role of the district as a supervisory and coordinating mechanism. Supervision and program management are difficult to differentiate accurately from each other, so it is useful to view the two activities together. Jointly they account for 52% of total district EPI costs and are made up primarily of staff time, allowances, transport and vehicle costs of these activities. Other significant contributors to district costs include:

- Vaccine collection, distribution and storage (12%). Districts collect vaccines from provincial offices and store vaccines until facilities collect them.
- Training (7%). Districts coordinate and fund immunization-related training. Most of the costs are participant travel allowances.
- Social mobilization (7%). District level social mobilization costs are incurred primarily as part of the Child Health Weeks that occur twice a year.
- Outreach activity (8% of total). At district level outreach refers to allocated costs of the two annual child health weeks and comprises mainly travel allowances for health workers and drivers.

Figure 3-14: Distribution of district weighted EPI economic costs by function (Zambia, 2011$)



As there is no volunteer labour at the district level, the only difference between the economic and the financial costing relates to the calculation of annualized capital costs.[50] Table 3-14 below summarizes the difference in economic and financial costs for each district. The most significant reduction occurs in Ndola which has the highest value of assets in all categories. Within these categories the biggest decrease in annualized costs occurs in the vehicles and the buildings categories. The weighted average financial costs for districts is $2 815 less than the economic cost, a 2.3% decrease. Further details of the differences in economic and financial costs at facility and higher levels are presented in Annex 13.

Table 3-14: Difference in total economic costs and total financial cost for sampled districts

Districts	Serenje	Ndola	Mkushi	Masaiti	Lusaka	Lufwany.	Kafue	Kabwe	Chongwe	Weighted Average
Total costs economic	129 282	142 750	43 586	110 894	303 416	91 168	113 746	142 768	118 443	124 739
Total costs financial	127 098	137 390	43 017	108 532	300 528	87 963	111 765	139 811	116 959	121 924
Decrease - capital costs	**2 184**	**5 360**	**568**	**2 361**	**2 888**	**3 205**	**1 981**	**2 957**	**1 484**	**2 815**

In order to facilitate the aggregation and extrapolation of district costs to national level a weighted average unit cost was calculated using both doses and number of DTP3 children. The district unit cost makes a significant contribution to the total cost per child immunized or per dose administered. The weighted average district unit costs for all of the sampled districts are:

- $10.24 per DTP3 child and
- $1.11 per child dose.[51]

Provincial and National level costs

The resulting total EPI costs at *provincial health offices* are not dissimilar to those incurred by district offices (Table 3-15). The distribution of costs reflects significant costs of activities related to supervision (37%) and program management (18%). The biggest portion of the costs is made up of salaried labour followed by transport, vehicle and related costs (Table 3-13 above). Central Province was noted to have allocated significantly more staff time to the EPI (mostly to supervision activities) when compared to the other two provinces sampled.[52] One reason for this may be that Central Province is more rural and has many deep rural and small health facilities. Lusaka and Copperbelt have large urban areas which may require fewer resources to provide required levels of support and supervision.[53]

At *national level* the activities that are the most significant contributors to total EPI costs are Vaccine collection and distribution (36%), program management (26%) and supervision (17%) (Table 3-15). As might be expected, the main line item contributors are EPI staff costs of $238 999 (35% of total national level EPI cost) and travel allowances which amount to $ 160 545 (23% of total national level costs). Transport and fuel costs reflect travel by staff and distribution of vaccines to provincial stores. Most of this is fuel costs associated with the national level vehicle fleet.[54] The most significant capital cost relates to vehicles (Table 3-13).

[50] In the economic costing a discount rate of 3% was used to calculate the annual cost of capital items. In the financial costing the discount rate was set to zero.

[51] Further details of the weighted District unit costs used in aggregation are provided in Annex 7

[52] Central Province allocated $96 000 to salaried labour. Copperbelt and Lusaka only allocated about $30 000 each.

[53] List of Health Facilities in Zambia (2010, Ministry of Health) indicates that 77% of 145 health facilities in the Central Province are rural. In Copperbelt and Lusaka, the ratio is 27% of 190 and 20% of 229 respectively.

[54] The fleet includes seven LDV vehicles and two 10 ton trucks which are used for vaccine distribution.

In addition to the time allocated by staff to surveillance activities, surveillance costs include a portion of the national expenditure on epidemic management and surveillance, and sentinel surveillance.[55] The national accounts do not describe the nature of this expenditure, but it appears that most relates to travel allowances. The amount allocated to the EPI was around $88 000.

Indirect costs are incurred in support functions that provide services to the EPI (e.g. accounting, IT, human resources). However, in line with the study methodology, indirect support services costs were not allocated to the EPI in this costing, and their value cannot be estimated.

Table 3-15: Total Routine Immunization Provincial and National Level Economic Costs by Activity ($2011)

Activities	Weighted Average Provincial Level N=3	%	National Level EPI Administration	%
- Routine Facility-Based Service Delivery	4 477	4%	0	0%
- Record-Keeping/HMIS	2 586	2%	0	0%
- Supervision	45 955	37%	116 158	17%
- Outreach Services	6 509	5%	0	0%
- Social mobilization	11 764	9%	41 776	6%
- Cold chain maintenance	2 088	2%	42 901	6%
- Vaccine collection and distribution	13 702	11%	243 040	36%
- Program management	22 945	18%	177 256	26%
- Training	7 742	6%	54 757	8%
- Other	0	0%	0	0%
- Surveillance	7 378	6%	7 282	1%
Total Immunization Economic Cost	125 147	100%	683 170	100%
- Unit cost per dose	0.19			0.14
- Unit cost per DPT3 Child	1.82			1.32

Table 3-15 also shows that there is a relatively small impact of provincial costs, and variations between provinces, on overall unit costs and national program costs. When total provincial costs are spread over total DTP3 children or doses in the province, provincial costs contribute substantially less than districts to the total unit cost. The weighted average provincial unit cost has been estimated at 19c and $1.82 per dose and per DTP3 child respectively. Similarly the unit cost contribution of national level costs to overall national costs is small. They were 14c per dose administered and $1.32 per DTP3 child and $1.20 per targeted child.

The financial cost at provincial level was calculated as described for districts. The total difference between total provincial economic costs and financial costs for the three sampled provinces is $14 964 or 4% of the economic cost.

Table 3-16: Difference in total PMO economic costs and total financial cost for

[55] The portion of expenditure included was calculated by applying the ratio of vaccine preventable disease notifications as a proportion of total disease notifications including TB to total expenditure.

sampled provinces

Provinces	***Lusaka***	***Central***	***Copperbelt***	***Weighted Average***
Total costs economic	85 075	192 529	97 836	125 147
Total costs financial	79 545	186 650	94 280	120 471
Decrease in capital costs	**5 530**	**5 878**	**3 556**	**4 675**

The national level total economic cost exceeds the financial cost by an amount of $22 794 or 2.96% of the total economic cost. The entire amount is due to differences in the annualized costs of assets.

3.2.4 Total national immunization program economic and unit costs

The total economic cost of the national EPI program was estimated at $38 162 622. [56] (see Figure 3-15 and Annex 8)

The largest cost of the EPI is salaried labour amounting to an estimated $18.862 million and making up 49% of the total EPI cost. Of this a small proportion is CHW allowances. The $6.168 million vaccine cost is the second largest cost, at 16.2% of the total EPI cost. Other significant costs are travel allowances and transport and fuel at $4.390 million and $2.359 million respectively. Building overheads, utility costs and other operational costs amount to $1.075 million or 2.8% of total costs. Human resources, vaccines and supplies, allowances and travel make up 78% of the total estimated economic cost of the EPI.

The economic cost of capital items is mainly vehicles ($2 million), buildings ($1.1 million) and cold chain equipment ($568 000). Capital costs contribute an estimated 11% of total national EPI costs. Of interest, the economic cost of cold chain equipment is less than the total cost of vehicles and buildings.

When compared to the distribution of *national total* costs across expenditure line items for total *facility level* costs calculated from the sample, salaried labour as a proportion of the total cost is similar at approximately 50%. The cost of travel allowances is also similar. The cost of vaccines at the facility level comprises a higher contribution (31%) when compared to the proportion of vaccine costs of the total EPI (16.2%). This is because district, provincial and national costs are added to the total facility costs, but vaccine costs remain the same and reduce as a proportion of the total. Most other cost categories increase as higher level costs are added during the aggregation.

[56] The total cost of the national EPI was calculated on the basis of weighted average unit costs as described in the approach and methodology above. See Annex 8 for a summary of all the unit costs used to aggregate sample data to national level.

Figure 3-15: Distribution of total aggregated national routine immunization economic cost by line item in Zambia ($2011)

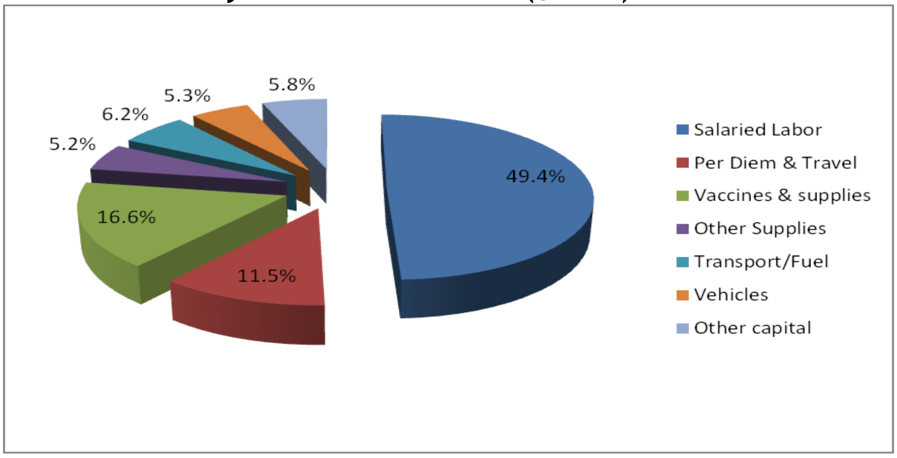
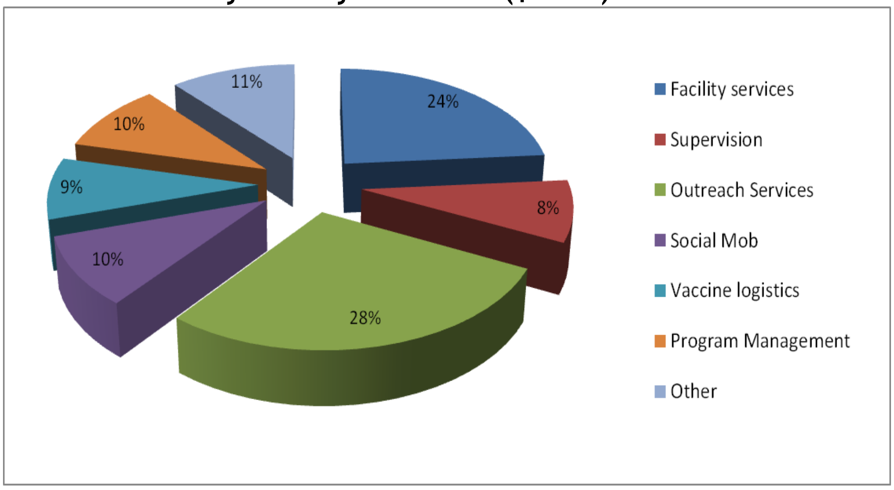


Figure 3-16 shows estimated total EPI costs by function (See also Annex 8). Outreach and routine facility-based service delivery are the two most costly activities at $10.74 million and $9.04 million respectively. Together these two activities contribute 51.8% of the total cost by function and include significant costs for salaried labour and vaccines. Other high cost functions include social mobilization ($3.7 million), program management (3.8 million), vaccine collection and distribution ($3.3 million) and supervision ($3.3 million). Together they account for 37% of total EPI costs.

When compared to the distribution of costs across functions at facility level, the service delivery costs are lower as a proportion of the total, as would be expected (see above). The lower service delivery costs are off-set by higher supervision and program management costs, which occur mainly at the district level. Supervision and program management costs amount to 18.6% of the total EPI cost, possibly higher than expected. A significant expansion of the EPI including the introduction of new vaccines should carefully consider the impact of such an expansion on indirect supervisory and program management cost. Assuming that there will be no incremental impact on these costs may result in an overburdened program management and supervisory structure.

Figure 3-16: Distribution of total aggregated national routine immunization economic cost by activity in Zambia ($2011)



The contributions of costs at each level to the full economic unit costs of immunization are summarized in Table 3-17. The dominance of facility level costs is shown, but also the important combined contribution of levels above the facility (See Annex 8 for Service Delivery unit costs and other details).

Table 3-17: Total economic unit costs per dose, per DPT3 child and by targeted child by level of health system

Level	Cost per dose*	Cost per DPT3 child*	Cost per targeted child	%
Facility	6.42	60.05	54.92	82%
District	1.11	10.38	9.49	14%
Province	0.19	1.81	1.65	2%
National	0.14	1.32	1.20	2%
Total	7.86	73.55	67.27	100%

There are substantial costs at District level in large part because many of the facility costs are accounted for at the district level and not captured during the facility data collection process. These district costs include costs of vehicles to support the facilities and collect vaccines, district immunization staff and operational overhead costs.

3.2.5 Impact of changed wastage rates

Stock records in Zambia are not well maintained at all levels, so it was not possible to calculate accurate wastage rates for vaccines. It was further noted that the cMYP and other planning documents did not use the same wastage rates. Therefore, assumptions were made in the costing of the routine immunization program about wastage rates for each vaccine. With the exception of the polio vaccine, WHO and GAVI guidance with respect to wastage rates were followed. Given the uncertainty around wastage rates it is useful to explore the impact of different wastage rate assumptions on total facility EPI costs and on national costs. Table 3-18 shows assumed wastage rates in the current costing and an alternative scenario.

Table 3-18: Vaccine wastage rates for EPI costing and alternative scenario

Vaccine	Doses per vial	Wastage rate	Reduced wastage rates
BCG	20	50%	50%
OPV	20	50%	25%
DTP-HepB-Hib	1	5%	5%
Measles	10	50%	25%

At facility level the impact of using a reduced wastage rate results in a reduction of average total facility costs of $429; in the urban strata of $815 and in the rural strata of $176. The reduction is caused entirely by the reduced cost of vaccines and the associated safe injection supplies. The larger reduction in the urban stratum is due to a higher number of doses administered in urban facilities when compared to rural facilities.

Table 3-19: Impact of reduced vaccine wastage rates on average total facility costs

Scenarios	Weighted Average	Change from Baseline ($)	% Change from Baseline
Baseline Estimate	28 286		
Scenario 1: Reduced wastage rates	27 858	-429	-2%

These savings translate into a reduction in costs of approximately 6c per dose and 64c and 53c per DTP3 child in urban and rural facilities respectively. A simple extrapolation to national level, assuming 238 urban facilities and 1037 urban facilities results in an approximate decrease in total vaccine and supplies costs associated with the 2011 schedule of $376 482.

If improved stock records and management achieve half of the saving associated with the reduced-wastage rate scenario of approximately $185 000 per annum, this would equate to a reduction of the national EPI costs of 0.5%. Importantly the introduction of new and more expensive vaccines will result in a significantly increased benefit from improved vaccine stock management and reducing wastage rates and improved stock management should therefore be a management priority.

3.2.6 Impact of reduced outreach time

A second scenario explored as part of the sensitivity analysis relates to the time allocated by health workers to outreach service delivery in RHC. The allocation of significant time by nursing staff to outreach services combined with relatively low volumes of children, may suggest that some of the time on outreach visits is not productively used time. This is most likely to comprise time spent travelling and / or waiting for relatively small numbers of children to arrive for immunization.

This scenario explores the possible economic cost of non-productive time which has been assumed to be 40% of salary cost allocated to outreach services in RHC. The impact of reducing outreach salary costs by 40% translates into a reduction of weighted average facility costs of $881 for all facilities (3%), and $1 456 for RHC specifically. A simple multiplication of this reduction by the total number of RHC points to a possible impact of $1.5 million on total national program costs. Further research would be required to assess whether this non-productive time is a reality and even if so, whether it is avoidable through interventions such as better outreach scheduling or routes, or addition of other service components to outreach to reduce down-time currently allocated to immunization.

Table 3-20: Impact of reduced staff outreach time allocation on average total facility immunization costs

Scenarios	Weighted Average	Change from Baseline ($)	% Change from Baseline
Baseline Estimate	28 286		
Scenario 2: Outreach salary costs in RHC reduced by 40 %	27 406	-881	-3%

3.3 Discussion

3.3.1 Generalisability of results

The above costing is based on the 51 facilities randomly sampled within urban and rural strata in the nine districts which had been purposively selected. The districts were specifically selected to ensure the inclusion of facilities that reflect the different contexts and operational environments which exist throughout the country. The facilities sampled within the rural and urban strata were a reflection of the national proportions of rural to urban facilities.

A comparison of the distribution of 36 sampled rural sites around the national mean of total doses for rural facilities indicated a high degree of consistency between the spread of facilities in the sample and rural facilities elsewhere in Zambia. This representative nature of rural facilities sampled is of particular importance given that 69% of the total doses in Zambia are administered in rural facilities, which account for 88% of the estimated national EPI facility cost. Of note, further analysis suggests that there were no striking outliers that were likely to distort estimates (see also Annex 10).

A similar review of the sampled urban facilities (15) indicated high representivity of the sample with the total urban facilities in the districts but the inclusion of several large urban facilities in Lusaka may have biased the sample results towards the larger facilities when compared to urban facilities elsewhere in the country. The impact that this bias has on the rest of the aggregation is difficult to quantify. Sensitivity analysis which explores the extent of the bias indicates that total national estimates may be understated by approximately a $1 million (2.7%) because of this bias. The number of *small* urban facilities sampled (4 facilities) does not allow for a rigorous analysis of unit costs in these facilities, which are underrepresented in the sample.

Given that the total national EPI cost is dominated by the cost of rural facilities, the national cost estimate is nevertheless expected to be a relatively accurate indication of the actual cost of the program, subject to the effects of the possible bias towards lower unit cost facilities in the urban strata.

Of note, total cost estimates have limited sensitivity to changing key assumptions such as wastage rates, staff time allocation and staff salaries, within likely ranges.

3.3.2 Profile of EPI costs in Zambia

The profile of EPI costs produced by the costing study for various levels of the health system in Zambia provides substantial new, detailed data for consideration and use in EPI planning and funding. The above results indicates that, as would be expected, the biggest portion of the total national EPI cost (82%) is being incurred at the facility level where service delivery takes place. Smaller, but significant costs are contributed by levels above facilities, particularly the district level (14%), which have not been well described before in the Zambian context.

For the two main types of service delivery facilities used by planners of PHC services, the total weighted average cost of Urban Health Centres ($34 441 per annum) is substantially higher than that of Rural Health Centres ($24 262). This would be expected as rural facilities generally have lower facility attendance and facility staff numbers. The costing has however highlighted significant variation in the total cost of all facilities in both the rural and urban strata. This suggests that the primary drivers of costs are not urban and rural location or RHC or UHC facility type per se, and that these may provide planners with relatively crude indicators of likely costs.

Other cost factors are explored further in Section 5 of this report, but the initial analyses above suggest that immunization volumes are a strong driver of costs.

The two expenditure line items which contribute most to the EPI are salaried labour and vaccines. The study results give more detail of human resources costs at each level than was previously available for Zambia, both at facility level and higher levels in the EPI system. The proportion of total facility cost allocated to salaried labour is high, and was higher in rural facilities (47%) than in urban facilities (39%).[57] Total vaccine costs generally comprise a much lower proportion in rural facilities (16%) than urban facilities (47%). The primary reason for this result is the different amount of labour allocated to the EPI in the rural and urban facilities for each child immunized.

The cost contributions of other line items are generally small, although they may be critical to effective immunization services. Transport and travel related costs together contribute a substantial proportion of EPI costs, particularly for rural facilities.

Of note, capital costs are relatively small once annualized. However, items such as vehicles and buildings are more substantial costs than cold chain equipment which is often a major focus of EPI planning.

When considering various EPI program activities, for both urban and rural facilities, the activities which account for the highest costs are routine facility based service delivery and outreach service delivery. Routine facility based immunization comprises 44% of the costs versus 35% for outreach service delivery in urban facilities. In rural facilities this relationship is reversed, with outreach services contributing more to total costs (33%) than facility based service delivery (26%). Of note, supervision and management contribute over 18% of total national EPI costs, suggesting that capacity for these activities may need greater attention in extending coverage or new vaccines in Zambia.

3.3.3 Unit costs

The unit costs per dose and per DTP3 child for the sampled facilities highlight the variability between facilities and between strata. The total unit cost per DTP3 vaccinated child is $87.14 per child in rural facilities compared to $33.38 per child in urban facilities.

This difference is almost entirely due to variation in salaried labour costs per dose or per DPT3 child, although transport related costs are relatively important contributors in rural facilities. Utilization rates appear to be a key determinant of unit costs although, importantly, above a certain threshold volume there is limited further decline in unit costs as volume increase. Determinants that drive differences in unit costs are considered in more detail in Annex 9.

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[57] This difference was not statistically significantly different however (z-test for proportion p-value = 0.29)

This study estimates a total economic unit cost for routine immunization in Zambia of $65.89 per child that received DPT3 in 2011. The Zambian unit cost per DTP3 child is considerably higher than previous estimates of average costs from other countries. A comparison across countries in the early 1990s suggested an average cost per child fully immunized with traditional vaccines (DPT, BCG, polio, measles) was approximately $20.[58] Subsequent country studies around 2000 indicated similar averages.[59] [60] Analysis of 56 cMYPs developed between 2004 and 2012 estimate an average cost per child of $21 and an average cost per fully immunized child of $28, but noted wide variation of estimates between regions[61]. Other than the costs estimated in the cMYP, there seem to be no other costing studies specifically examining the costs of routine immunization in Zambia. The results from this study are compared to the cMYP in more detail in the section below.

Higher, and probably more comprehensive, assessment of staff costs seems to be the main explanation for Zambia's higher costs. However, other factors such as wastage, utilization rates, coverage and vaccination completion rates may also be material influences. Even if all staff costs are removed, the unit cost is similar to higher previous unit cost estimates. Vaccines contribute only one third of non-staff costs or $12.01 per DPT3 child, suggesting an impact of price reductions for conventional vaccines over time, but also limited potential of further price reductions to affect total EPI economic costs.

3.3.4 Comparison with the cMYP

The comprehensive multi-year plan (cMYP) is a 5 year forecasting tool specifically for the EPI. The tool facilitates the forecasting of quantities and costs on the basis of a comprehensive set of assumptions. The latest cMYP for Zambia[62] covers the period 2012 to 2016 and uses 2010 as the base year, which reflects actual costs for some expenditure items as closely as possible for that year. Unfortunately this version of the cMYP does not include 2011 as a forecast year, so a direct comparison for 2011 in this latest version is not possible.[63] For the purposes of comparing national EPI costs from this study with those in the cMYP, it was decided to use the base year in the current cMYP as the best available comparator.

Table 3-21 below reflects the cost estimates by cost category (expenditure line item) from the cMYP for 2010. A comparison of the values calculated in the cMYP and the cost estimates in this study follows.

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

[59] 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.

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

[61] Brenzel L Politi C. 2012. Historical Analysis of the Comprehensive Multi-Year Plans in GAVI- Eligible countries (2004 - 2015). Mimeograph. World Health Organization.

[62] Dated 26 April 2013 and received from the national Programme Coordinator

[63] An older version of the cMYP presents estimates which are significantly different for the same years when compared to the latest version and estimates for 2011 already included new and under-utilised vaccines which were actually only introduced in late 2012 and early 2013.

Table 3-21: Summary cost estimates for 2010 from the cMYP in USD

Cost Category		Costs 2010 US$
Routine Recurrent Costs		
	Vaccines (routine vaccines only)	$6 857 695
	Traditional	$896 500
	Underused	$5 961 195
	New	$0
	Injection supplies	$532 079
	Personnel	$12 685 488
	Salaries of full-time NIP health workers (immunization specific)	$887 136
	Per-diems for outreach vaccinators/mobile teams	$9 709 200
	Per-diems for supervision and monitoring	$2 089 152
	Transportation	$17 055
	Fix site strategy (incl. vaccine distribution)	$11 700
	Outreach strategy	$3 600
	Mobile strategy	$1 755
	Maintenance and overhead	$1 486 199
	Cold chain maintenance and overheads	$1 473 624
	Maintenance of other capital equipment	$12 575
	Building overheads (electricity, water…)	$0
	Short-term training	$260 930
	IEC/social mobilization	$326 163
	Disease surveillance	$656 325
	Programme management	$587 093
	Other routine recurrent costs	$0
	Subtotal	**$23 409 027**
Routine Capital Costs		
	Vehicles	$0
	Cold chain equipment	$583 400
	Other capital equipment	$50 300
	Subtotal	**$633 700**
Shared Health Systems Costs		
	Shared personnel costs	$9 505 019
	Shared transportation costs	$265 951
	Construction of new buildings	$0
	Subtotal	**$9 770 970**
	Routine Immunization	**$33 813 697**

Vaccine costs

The cMYP total vaccine cost is estimated at $ 6.858 million. The $6.168 million in the costing study is $690 000 or 10% less than the cMYP baseline. The difference may be due to the following:

- The cMYP includes the cost of Tetanus Toxoid for pregnant women which is not included in this study. A breakdown of vaccine expenditure by antigen is not provided for the base year, but TT cost is estimated to be $164 882 for 2012 in the cMYP.
- The cMYP baseline vaccines expenditure may include some replenishment of buffer stocks. This would not be reflected in the calculation of this study.

Personnel costs

Personnel costs excluding allowances in the cMYP are a total of $10.392 million, made up of national program staff ($887 136) and shared personnel costs ($9.505 million) of staff costs in health facilities. This is significantly less than the cost of salaried labour estimated in this study of $18 861 822 million for staff at all levels, which is 82% higher than the cMYP estimate. The cMYP calculation of the shared salaried labour cost for immunization is based on several assumptions, of which the most important are the following;

- A standard staff structure in all facilities of staff involved in immunization
- An across-the-board allocation of 20% of time to immunization
- Allocation of a certain number of days per month to outreach by each staff category which is used to calculate travel allowances.

The main reasons for the significantly higher figure for salaried labour at the facility level in this study when compared to the cMYP are the following:

- This study used salary scales for 2012 in order to reflect current cost profiles better. The 2012 scales were significantly higher than the 2011 actual salary levels. For example, in the cMYP base year a nurse is included at $540 per month, while in 2012 the monthly salary scale for nurses and midwives ranged from $804 to $1055 per month. This is an increase of between 49% and 94% of the 2010 base year salary for a nurse (see further discussion below).
- Although there is quite a lot of consistency between primary health care facilities, it was apparent from the sample that both the number of staff involved in immunization, and the percentage of time allocated to immunization, can vary considerably depending on the setting, outpatient volume and the type of facility. A simple average of all staff in all the sampled facilities generates a ratio of immunization time to total time of 25% if a 46 hour week is assumed and 29% if a 40 hour week is assumed (see more details in Section 3.2.1). This suggests that further analysis of these data by staff category could generate a more accurate assumption for the cMYP if required.

Per diem expenditure

Per diem expenditure in the cMYP (normally referred to as travel allowances in Zambia) is estimated at $9.709 million for facility staff participating in outreach and $2.908 million for supervision and monitoring. These amounts add up to significantly more than the $4.390 million estimated in this study. There are several possible reasons that the cMYP may over-estimate the cost of per dia when compared to actual costs estimated from the facility surveys.

- The cMYP assumes that *all* facility staff travel on outreach excursions for at least 5 days a month.[64] Similarly, all district and provincial level staff are assumed to travel for supervision and monitoring for 5 days each month, except the DMO and PMO who are assumed to travel for 2 days a month. In reality the total number of outreach days per facility may not be as high as assumed in the cMYP. Actual number of outreach days depends largely on the number of outreach points and the total number of staff that travel, which in most cases is two.[65] On average the cMYP generates 30 outreach days per month per facility which appears to exceed the actual average.
- Actual per diem rates may differ from budgeted amounts due to exchange rate or other factors. The budgeted rate per visit for facility staff is $15 but the actual amount paid in most facilities was ZK50 000 or around $10.44. Community health workers are usually paid just over $4.

Transport and fuel costs

The transport and fuel costs in the study costing is estimated at $2.349 million compared to only $283 006 in the cMYP. A review of the cMYP model reveals that the section on vehicles was not completed with accuracy. Vehicles numbers at the different levels were not entered correctly or at all. More comprehensive completion of this section of the cMYP would have resulted in significantly higher cMYP costs. The costing study also includes bus and taxi fares in this line item while the cMYP included only a limited amount for other transport costs.

Other cost items

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[64] This is also inconsistent with the assumption that staff spend 20% of their time on immunization i.e. 4 days a month.

[65] As an example, Bulaya, a typical rural health centre, generates a total of 8 outreach days a month. Only at two sites are the CHW paid for their participation resulting in another 2 outreach days.

A number of smaller items are more difficult to compare due to the classification of the cost estimates. For example, cold chain energy costs in this study comprise a calculated cost of the energy consumption of cold chain equipment. The cost of cold chain maintenance is represented mainly by the costs of technical staff, travel and accommodation and replacement parts recorded in provincial or district maintenance overhead costs. The cMYP calculated a theoretical maintenance cost of 5% of the total capital value of the cold chain. More accurate reconciliation of the underlying assumptions and values between the two estimates is thus not possible.

In the cMYP the list of costs also included cost categories which could best be classified as *activities* and not cost items. Items such as training, social mobilization, program management and surveillance did not reflect underlying expenditure line items such as allowances, travel and transport costs.

It is interesting to note that the cMYP includes a cost estimate of annualized cold chain of $583 400 which is similar to the costing study value of $568 066. This may be coincidental as the useful life of cold chain equipment and the method of annualization differ between the cMYP and the study. The annualized cost of other equipment in the costing study of $557 284 is ten-fold the amount in the cMYP of only $50 300. No capital cost appears in the cMYP report for vehicles.

3.3.5 Comparison with health expenditure and national budget for EPI

Expenditure on health for Zambia is reported as $710.3 million for the 2011 financial year.[66] Government expenditure on health comprises 16% of total government expenditure. The estimated total cost of the routine EPI as calculated above comprised 5.4% of the total country health expenditure. Government health expenditure administered by MOH in 2011 and reflected in the ministry ledger, amounts to $388 million. The study estimate of total routine EPI costs thus amounts to 10% of MOH expenditure.

The national health budget and accounts is a high-level document structured by administrative or service delivery unit, by program and by activity. Units include the national administration unit, the monitoring and evaluation unit, provincial and district medical offices. There is a high degree of consolidation of similar cost categories and disaggregating the amounts by health program is difficult. The national budget includes the following items which are relevant to the EPI:

- For each unit the total budget for salaries and other HR costs is listed including the total cost of facility staff, but consolidated at district level. No attempt is made to unpack the salaries by health program. This is why the cMYP uses an estimated human resource cost in its base year instead of an actual amount.
- In the monitoring and evaluation unit, under health systems management, $125 626 is provided for ‘Sentinel surveillance’ and ‘Epidemic management and surveillance’ of $254 287. These allocations are however for conducting investigations and exclude human resources and laboratory services. The majority of the investigations conducted in the last three years have been for TB and not for vaccine preventable diseases. This amount is therefore not directly comparable with the surveillance costs in the costing study ($730 000) which includes a proportion of the investigation costs in the ledger, but

66 WHO Country Statistics 2012. http://apps.who.int/gho/data/node.country.country-ZMB. This includes not just the resources channeled through government budgets but also the expenditure on health by para-statals and extra-budgetary entities.

also the time allocations of staff, and vehicle and other costs.

- The amount budgeted by government on vaccines is included in the 'Clinical care and Diagnostics Services' unit under 'Drugs and medical supplies'. The final amount budgeted for the vaccines and immunization supplies in 2011 was $2 521 712. This reflects government procurement only and does not include of vaccines procured by GAVI and other partners. While it is a useful input into cost and financing calculations, the amount therefore does not reflect total expenditure on vaccines and immunization supplies in Zambia.
- Under the Reproductive and Child Health unit a single activity is identified as the EPI. The total amount against this item is $128 177 and is a provision for general EPI program management.
- Significant budgets are provided in each DMO allocation which includes allocations for the EPI.[67] However, budget items are not disaggregated and cannot therefore be allocated specifically to the EPI. These expenditure items are further examined under the financing section below.

3.4 Summary and Conclusions

This section presented the EPI costs associated with the sampled facilities, districts, provinces and the national coordination and program management function. At facility level both total costs and unit costs were examined and compared for urban and rural strata. The costs derived from the sample were aggregated to arrive at an estimate cost of the total EPI for the country. Finally these costs were compared to the cost estimates in the cMYP and the line items in the national budget.

The provinces, districts and facilities are likely to have provided a sufficiently representative sample for analysis for main conclusions to be robust, particularly in relation to facility level costs which are the largest contributors to total EPI costs. Possible over-representation of large urban health centres could have resulted in some underestimation of unit costs per dose and child. Use of sampling weights should have helped to mitigate biases in the selection of provinces and districts, although these represent much smaller proportions of total costs. The most important cost estimates and related conclusions are not very sensitive to changes in various key assumptions.

A summary of the more important costing findings include the following;

- The biggest portion of the total national EPI cost is being incurred at the facility level where service delivery takes place.
- The total weighted average cost of urban health centres is higher at $34 441 per annum than that of rural health centres at $24 262. This would be expected as they generally have lower facility attendance and facility staff numbers.
- The costing has however highlighted significant variation in the total cost of all facilities in both the rural and urban strata.
- The two expenditure line items which contribute most to the EPI are salaried labour and vaccines. The proportion of total facility cost allocated to salaried labour was higher in rural facilities (54%) than in urban facilities (39%) although not statistically significantly different (z-test for proportion p-value = 0.29).

[67] These items (referred to as activities) include salaries as previously mentioned, 'Health centres clinical care services', 'Health centre outreach services', 'Community health services and 'Utilities and other office costs'.

- Total vaccine costs generally comprise a much lower proportion in rural facilities (16%) than urban facilities (47%). The primary reason for this result is the different amount of labour allocated to the EPI in the rural and urban facilities for each child immunized.
- For both urban and rural facilities the activities which account for the highest costs are routine facility-based and outreach service delivery.
- Routine facility based immunization comprises 44% of the facility costs versus 35% for outreach service delivery in urban facilities. In rural facilities this relationship is reversed: outreach services contribute more to total costs (33%) than facility based service delivery (26%).
- The unit costs per dose and per DTP3 for the sampled facilities highlight the variability between facilities and between strata. The total unit cost per DTP3 vaccinated child is $87.14 per child in rural facilities compared to $33.38 per child in urban facilities. This difference is almost entirely due to variation in salaried labour.
- The average district unit cost was estimated at $10.38 per DTP3 child and $1.11 per dose. Provinces contribute $1.81 and the national office contributes $1.32 to the unit cost per DTP3 child
- Economic and financial cost estimates did not produce substantially different estimates of total costs, although in some instances capital costs in particular did change more substantially between the two methods.

Analysis of unit costs makes it clear that the scale of a service and the associated outpatient attendance, in particular the number of children, is strongly associated with the cost per child. Whether a facility is an urban health centre or rural health centre also affects unit costs. These relationships are examined in detail in **Annex 9**.

For planning and budgeting purposes, using average facility total costs as a means of estimating costs of existing or new facilities may not be the most accurate approach to estimating costs. More useful may be an approach that establishes benchmarks for different facility types based on the setting of the facility and the anticipated attendance volumes.

The total national economic program cost has been estimated at $38.16 million for 2011. Salaried labour contributes 49% of total cost ($18.86 million), followed by vaccine costs ($6.17 million) and travel allowances ($4.39 million). These three items account for just over 78% of the total program cost and it might be argued that management of costs and efficiency should be focused on these three expenditure items. The careful management of staff productivity and efficiency, travel and outreach activities and the improved management of stock and wastage could lead to significant savings.

A comparison with the cMYP highlights a number of substantial differences when comparing the 2011 costs calculated in this study with the 2010 baseline in the latest cMYP. The big difference in human resource costs can be explained to a large extent by the difference between 2010 salary scales and the 2012 pay scales used for this study and estimates of time allocated to immunization for facility staff in the cMYP when compared to the sampled facilities. Various costing study findings should be considered in updating the cMYP and associated plans.

The estimated total routine EPI cost comprises approximately 5.4% of total expenditure on health and approximately 10% of government expenditure on health. More detailed comparison of the total national EPI costs calculated in this study with the national health budget items is difficult, as items in the national budget are not presented in a format which facilitates comparison.

The costing highlights some of the challenges of obtaining robust expenditure data to underpin EPI planning and management. Accurate costing of the routine EPI is challenging due to the structure of the general ledger and underlying accounting systems which do not facilitate disaggregation of operational costs into different health programs, with the exception of vaccines costs. Salary and other operating costs are particular challenges as a result.

The following actions could be undertaken to more accurately cost and manage routine immunization, even if restructuring the general ledger is not likely to be feasible in the foreseeable future.

- Accurately recording opening stocks, vaccine consumption, transfers and closing stocks, together with accurate calculation of vaccine wastage by antigen, using existing tools.
- Analyzing use of vehicles to derive accurate tracing factors or introducing a system of log-books to trace the use of vehicles by program activity
- Observing allocation of staff time to immunization and other tasks over a longer time period, as a way to refine estimates produced in this report, and to generate a more robust tracing factor for allocating staff time.

4 Cost Analysis of New Vaccine Introduction

4.1 Introduction

In 2009, Zambia applied to GAVI for finance to introduce Rotavirus, Pneumococcal (PCV10), and Measles second dose (MOH, 2009) immunization. The pneumococcal and measles second dose application was conditionally approved, but re-submission for rotavirus was required.

At the time of submitting the initial 2009 proposal, the country had insufficient cold chain capacity to accommodate *all* the new vaccines (MOH, 2011b). According to the Zambian Vaccine Cold Chain Scale-up Strategy, Zambia required US$ 7.5 million for additional cold chain storage capacity at all levels (national, provincial, district and health facility) to accommodate the introduction of new vaccines (MOH, 2011b). The strategy includes full-scale expansion of vaccine storage capacity at all levels including renovation of existing buildings, installation of new cold rooms with generators, and procurement of refrigerators and cold boxes. Zambia mobilized US$1.6m and the process of upgrading the cold chain capacity commenced at national and provincial levels in 2012. In addition to the cost of upgrading the cold chain storage capacity, other non-vaccine related costs were estimated at US$1.7 million.[68]

Zambia re-submitted the proposal for introducing Rotavirus, Pneumococcal (PCV10) and Measles second dose in June 2011 (GAVI Alliance, 2011). The application was approved by GAVI as Zambia met all requirements for the introduction of new vaccines. During the second quarter of 2013, Zambia launched two new vaccines (PCV10 and Measles second dose) countrywide. However, the Rotavirus vaccine has only been introduced in 3 districts in Lusaka Province (Lusaka in 2012; and Kafue and Chongwe in 2013). USAID (CIDRZ) is the implementing agency for the Rotavirus vaccine.

This section seeks to quantify, prospectively the incremental cost of introducing PCV10 only. In the context of multiple vaccine introductions, this encountered some challenges.

4.2 Methods

4.2.1 Perspective and key assumptions

In Zambia the introduction of new vaccines provides a complex context for assessment of costs associated with the introduction of new vaccines. The MOH has initiated the introduction of a rotavirus vaccine in a number of pilot sites in Lusaka district and, at the time of data collection, had initiated the introduction activities to introduce Pneumococcal Conjugate vaccine (PCV) and a second dose of measles. PCV(10) is being introduced in a two dose vial and will be administered during DTP

[68] This included: planning meetings; training of health workers; community orientation; printing updated cards, guidelines and stickers; developing DVDs and training materials; updating of monitoring tools; distribution of vaccines and supplies; social mobilization; supervision; Post Introduction Evaluation; UNICEF administrative costs

vaccine visits. In total each child should receive three doses of PCV.

In Zambia the introduction plan is developed and managed by the Child Health Technical Working Group and senior members of the MOH and MCDMCH. Staff at lower levels of the health system confirmed in interviews, that they did not participate actively in the planning for the introduction of new vaccines. This study was requested to estimate the prospective, incremental cost of introducing PCV throughout the country.

Incremental costs

The definition of “incremental” in this study is aligned with the definition provided in the WHO Guidelines for costing the introduction of new vaccines[69] and the Common Approach. The Common Approach provided for the calculation of economic, financial and fiscal incremental costs. Interpretation of the incremental cost resulted in the following assumptions and observations:

- The costing focuses on the *additional* costs incurred with the introduction of a new vaccine
- Overhead costs (e.g. utilities, maintenance and program management) have been excluded from the calculation of incremental costs.
- Where spare capacity exists (human resources, equipment, buildings), and the introduction of the new vaccine does not require expansion of the affected resource, the cost is not included, especially where the full costing has already incorporated the cost of the spare capacity.
- Any additional costs which are associated with other new vaccines or with enhancing capacity for existing services are excluded, even if introduction of the new vaccines may have triggered the expenditure.

New vaccine introduction period

The new vaccine introduction period is not easily defined in Zambia. Planning for new vaccine introductions started some years ago and the first version of the MOH PCV introduction plan was completed in August 2009. The original plan envisaged introduction of PCV in 2010. The GAVI application for assistance was however only submitted on 27 June 2011. The most recent document used for the introduction of the PCV and measles vaccine includes a workplan and budget.[70] In terms of this workplan the planning and adaptation of guidelines was scheduled to start in late 2011 and extend through to June 2012, with the majority of implementation activities scheduled from August 2012 onward. Although some activities were not implemented according to schedule, this workplan has been used as a guide to determine the timing of the beginning of the introduction period. Some activities that took place before November 2011 have been excluded from this costing. Therefore all activities which were planned from November 2011 onwards were included in this study.

For the purposes of this costing we assume that the introduction period ends when the targeted immunization coverage in the year of introduction has been achieved.[71] For PCV the targeted coverage during year one is 60% of the target population. The GAVI Secretariat confirmed that costing this level of coverage is appropriate, given that higher coverage will only be achieved in later years, by when the vaccine will be included in routine costs.

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[69] Guidelines for estimating costs of introducing new vaccines into the national immunization system, Department of Vaccines and Biologicals, WHO, 2002

[70] Plan and budget for the introduction of PCV V2, 30 Nov 2012, MOH Excel workbook

[71] The MCDMCH was of the view that the introduction period ended when the first doses of the new vaccine are being administered, but this definition severely constrains ability to understand costs related to NUVI.

Incremental NUVI costs estimated for PCV

Table 4-1 below summarizes the quantification and valuation of those incremental costs included in the costing of PCV introduction. The table describes the method of quantification and the method of valuation for each expenditure line item.

Table 4-1: Expenditure line items, resource quantification and valuation methods[72]

Line item - recurrent costs	Quantification method	Valuation method
Salaried labour (Personnel)	Cost of personnel has been included at two levels. Firstly the time invested by staff in meetings and training has been calculated on the basis of time spent. Cost of administering the new vaccine is based on the weighted average service delivery cost per dose calculated during the facility based costing (see Section 3).	Annual remuneration defined by the total cost to the employer (MOH) of the employee including benefits. It was decided to use the 2012 scales for costing given that this comprises the bulk of the vaccine introduction period.
Cold Storage	The EPI Logistics forecasting tool was used to isolate the additional cold chain requirements at national, provincial and district level for the newly introduced vaccine. The WHO Vaccine volume calculator was used to calculate the economic cost of increased storage requirements at facility level.	The valuation of cold chain equipment was based on the PQS list. These basic prices were increased by 20% to cover freight, in-country transport and installation at facilities
Cold storage energy costs	Cold chain energy consumption was calculated on the basis of power consumption reported on the PQS list for each item. The additional energy consumption is the incremental cost incurred and the fixed cost of electricity is excluded as an overhead already included in the full costing.	A standard price for electricity consumption from ZESCO was used to value electricity usage.
Transport	Cost of additional transport was calculated on the basis of the additional number of delivery trips which would be required with the introduction of the new vaccine. Load volumes were calculated using the EPI logistics tool. Fuel costs have also been estimated for initial distribution of the vaccines and for travel associated with the training and social mobilization.	The cost of transport includes the cost of fuel and maintenance of vehicles based on average actual expenditure for the vehicles used. The price of diesel and petrol is controlled by GRZ and costs per litre are the same across Zambia. The capital cost is sunk and not incremental.
Vaccines and supplies	The total vaccine requirement was calculated with the EPI logistics tool given the target coverage of 60% of the target population, i.e. 3 doses for 60% of the target population. The logistics tool assumes a 25% buffer stock which is in line with the current policy of delivering stocks from national to provinces on a quarterly basis. Provinces should carry a buffer equal to 3 months of consumption.	Unit costs for vaccines were obtained from the in-country UNICEF office. 1 % was added to vaccine unit cost to cover freight costs. Wastage was assumed at 5%.

[72] Note: Items in Table 1 of the WHO guide (page 4) were used as a reference when developing this table.

Line item - recurrent costs	Quantification method	Valuation method
Monitoring , evaluation and disease surveillance	The vaccine introduction period includes an internal evaluation of the vaccine introduction and provides for an external post introduction evaluation. The cost of disease surveillance has however been excluded as it was felt by management that this would only be incurred after the end of the vaccine introduction period. Costs included under this line item include personnel, travel and travel allowances.	As indicated these cost comprise allowances, travel and personnel costs which have been valued at 2012 prices.
Waste management costs	Cost of additional safety boxes has been included in the calculation of supplies in the EPI logistics tool. No additional waste management capital expenditure has been incurred and no incremental disposal cost of waste at facility level (usually pits or in some cases incinerators) is provided for.	Unit costs for supplies were obtained from the in-country UNICEF office. A % for freight costs was added to each unit cost.
Other supplies	Expenditure on other supplies was estimated in the new vaccine introduction plan and budget. It includes items such as printing and development of training and orientation DVDs.	The items have been valued at the budgeted amount, or where the expenditure has occurred, at the actual expenditure amount.

Allocation of costs to PCV

Many of the budget amounts calculated in the new vaccine introduction plan and budget related not just to PCV but also to introducing second-dose measles vaccine. Accurate splitting of prospective budgets between PCV and measles is not possible with available information. The allocation was discussed with senior management and between 60% and 80% of budget was allocated to PCV for most activities (different percentages were allocated to different activities). Smaller proportions tended to be allocated to measles as health workers were already familiar with administration of the measles vaccine. Certain items were allocated fully to PCV when appropriate. The preparation of PCV specific training and orientation materials, and printing of Under-Five cards - which would have been required even if only PCV had been introduced - were allocated entirely to PCV.

Economic, financial and fiscal costs

Economic, financial and fiscal costs have been calculated for PCV introduction (see Table 4-2). As previously described the difference between economic cost and financial cost is limited to the difference in the annualized cost of capital equipment (discounted vs. non-discounted). No provision was made for the possible incremental, economic cost of volunteer labour. All training costs (mainly allowances and personnel) are reflected as once-off costs in year one and are not annualized.

Fiscal costs are likely to inform budgeting and cash flow management best, as they more closely reflect the actual additional expenditure required to introduce the new vaccine. They exclude any non-cash costs or costs which are already covered through the routine program. For example, the fiscal costing does not include labor costs in the Zambia case because, although there is an economic cost attached to personnel, no additional amounts will be spent on salaried labour as no new staff will be employed. Where capital assets are procured, the full cost of the asset is included in fiscal costs, not just the annualized portion of the cost.

4.2.2 Data collection, entry and analysis

Data collection for the prospective costing of PCV introduction was done primarily at national level in consultation with key staff members at the MCDMCH responsible for the implementation process. However, several key questions were asked of staff at facilities. The questions focused on establishing whether there was spare capacity in refrigerators at the facility, whether operating costs were likely to be affected and whether additional space would be required to deliver services associated with the new vaccine.[73]

At the national level, the Plan and Budget for PCV Introduction Workbook was used as the starting point for estimating the cost of the non-vaccine and supplies. These budgets were discussed with senior management and any additional data was captured into the workbook.[74] For some items, it was possible to replace the budgeted amount with the actual amounts transferred for the activity and in such a case, the actual amount was used. The Workbook provides budget calculations and actual expenditure for the following activities:

- Service Delivery
  - Central level meetings
  - Training/Orientation of health workers
  - Community orientation
  - Printing of updated under five cards
  - Printing of guidelines and other sundry printing costs
  - DVD Development, production and training materials
  - Preparedness and implementation checklists
  - Updating of monitoring tools (HMIS)
- Logistics
  - Distribution to Provinces - GAVI
  - Distribution to Health Facilities
- Social Mobilization
  - Social Mobilization at National Level
  - Social Mobilization District level
- M&E
  - District supervision
  - Central and provincial monitoring
  - Post Introduction Evaluation
- UNICEF administrative cost

The majority of the costs listed above are travel costs including fuel, travel allowances and other supplies. These calculations were expanded to include the cost of salaried personnel time spent on these activities, where this was possible.

The EPI logistics tool was used to capture all data related to calculation of vaccine requirements, vaccine injection and safety supplies, and additional sharps boxes for waste disposal.[75] The tool is widely used and had also been used in the initial planning

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[73] These responses are captured in the facility costing database.

[74] These interviews were carried out by the country team leader, not by data collectors.

[75] WHO Logistics Planning Tool spreadsheets (http://www.who.int/immunization_delivery/systems_policy/logistics/en/index4.html)

for the new vaccine introduction and the GAVI application. The demographic and unit cost data were updated to improve accuracy of the results.[76]

In order to isolate the cold chain requirement for introduction of PCV it was necessary to compare the cold chain requirements given the status quo, with the cold chain requirements needed after introducing PCV. In order to make the comparison, cold chain equipment was added to the total available capacity at national, provincial and district level until the current needs for storage capacity had been met. This level of cold chain capacity was then compared with the required level of cold chain capacity after introducing PCV. From the analysis it was apparent that much of the cold chain procurement in the previous year had met current demand for cold chain storage and replacement of redundant cold chain. The costs could therefore not strictly be assigned in total to the introduction of new vaccines. Nevertheless, the opportunity costs of PCV capacity requirements in the cold chain were estimated and included in the analysis.

4.2.3 Data quality and verification process

The accuracy of the data entered in the two budget workbooks described above, was tested primarily by checking the calculations presented for each introduction activity. The detailed calculations were included in the Excel workbook which underpins the summary NUVI budget.

In addition to the detailed check, the calculations were subjected to an internal review to ensure reasonableness and finally also reviewed by the country EPI coordinator to ensure that the estimates were in line with their understanding of the NUVI budget. Where changes were made to calculations these were discussed and agreed with the country coordinator.

4.2.4 Limitations of the approach

The prospective costing of a new vaccine introduction is at best a reasonable estimate of the costs that are likely to be incurred. Many assumptions are made which impact on estimated costs which may turn out to have limitations. Although every effort was made to collect information to support the assumptions made, the limitations of the following key assumptions should be noted.

- Staff participating in service provision were assumed to have no spare capacity. As a result the average cost of administering vaccines has been included in the economic cost. There is very limited data to assess whether staff do or do not have spare capacity, and how much. Immunization-related staff at facilities seem to have little spare capacity, and health workers are generally considered to be in short supply. However, some spare capacity may exist when attendance is lower than what could be managed by available staff, particularly on immunization days and on outreach visits, provided that staff time is not being diverted from other PHC activities. The economic cost of salaried labour may thus be somewhat overstated. In addition, the total weighted unit cost of labour per dose has been allocated to each new vaccine dose. This includes time allocations of support staff at some facilities for which an incremental cost *may* not be incurred when a new vaccine is

[76] It was assumed that the results generated by the tool would be accurate if an appropriate set of demographic and cost inputs was entered.

introduced.

- Volunteer labour has been excluded from the NUVI calculation. However, allowances paid to all personnel involved in NUVI, including community health workers, have been included. From available data, it is not possible to calculate the economic cost of volunteer time that might be incurred for NUVI. Some volunteer time is likely to be used for social mobilization activities preceding the introduction of new vaccines.
- The proportional split of many NUVI costs between PCV and the second dose of measles is based almost entirely on the opinions of management. This could result in an under- or over-statement of PCV introduction costs, but sensitivity of estimates to related assumptions is limited.[77]
- Facilities were assumed to have sufficient positive and ice-pack freezing capacity to introduce PCV, and no requirement for new no cold chain equipment. There is no accurate information on spare capacity at facilities throughout the country, and the true need for additional cold chain for PCV introduction. However, most of the facilities sampled indicated that cold chain capacity at the facility was adequate and this appears to be consistent with the Effective Vaccine Management report (2011).[78] The EPI logistics tool considers cold chain capacities at national, provincial and district level, but it assumes adequate capacity at facility level.
- For some NUVI activities funds had been transferred for expenditure and these actual transfers were used in costing. In some cases they were less than the budgeted amounts. It is not possible to tell whether either budgets, or lower transfer amounts, reflect the true *need* or whether some need was unmet

4.3 Incremental cost estimates

4.3.1 Total incremental NUVI costs

The table below summarizes the cost estimates for the planned introduction of PCV10 during the latter part of 2012 and the first half of 2013.

The total incremental economic cost of introducing PCV10 is estimated at $9.684 million. With the exception of salary costs which have been excluded from financial costs the economic costs and the financial costs are almost identical. This is because very little additional cold chain equipment has been procured and the discounted annual cost of assets therefore differs little from the non-discounted annual cost of the same assets. Also opportunity costs associated with storage of new vaccines are similar to the financial cost of additional cold chain equipment.

Of greater interest is the difference between the economic cost and the fiscal cost of the new vaccine introduction. The total fiscal cost of $7.339 million for the PCV introduction is $2.344 million less than the economic cost. The lower fiscal cost reflects that salaried labour is excluded from it, as no additional staff members were

[77] The allocation between PCV and measles varied from expense to expense (see above). In general, as there are more doses of PCV than measles (1.2 million vs 580 000.), PCV absorbed most of the costs and in some cases all the costs. The items which had to be allocated between the new vaccines costs also tended to be small cost, such as trainings and stationery.

[78] The Report found that all facilities had sufficient positive and ice-pack freezing capacity for current needs, and that 2 of 14 facilities needed additional capacity for all new vaccines, but no need for additional ice-pack freezing capacity. Effective Vaccine Management, July 2011, Towards improving the immunization supply chain management in Zambia, MOH

actually employed, even though economic opportunity costs are incurred. Procurement of some additional cold chain equipment was anticipated, but these assets costs only $89 202.

Table 4-2: Overview of prospective costs associated with PCV introduction *

Total Amounts by Line Item	USD Economic cost	Distrib. %	USD Financial costs	Distrib. %	USD Fiscal cost	Distrib. %
Line Item						
Salaried Labor	2 335 779	24.1%				
Per Diem & Travel Allowances	289 380	3.0%	289 380	3.9%	289 380	3.9%
Vaccines	5 888 180	60.8%	5 888 180	80.3%	5 888 180	80.2%
Vaccine Injection & Safety Supplies	139 992	1.4%	139 992	1.9%	139 992	1.9%
Other Supplies	197 570	2.0%	197 570	2.7%	197 570	2.7%
Transport/Fuel	150 779	1.6%	150 779	2.1%	150 779	2.1%
Vehicle Maintenance	10 490	0.1%	10 490	0.1%	10 490	0.1%
Cold Chain Energy Costs	16 741	0.2%	16 741	0.2%	16 741	0.2%
Printing	531 909	5.5%	531 909	7.3%	531 909	7.2%
Building overhead, Utilities, Communicatior	-	0.0%	-	0.0%		0.0%
Other services-External PIE	25 346	0.3%	25 346	0.3%	25 346	0.3%
Sub-total recurrent costs	**9 586 165**	99.0%	**7 250 386**	98.8%	**7 250 386**	98.8%
Cold Chain Equipment	91 981	0.9%	80 717	1.1%	89 202	1.2%
Vehicles	5 385	0.1%	4 932	0.1%		
Building	-	0.0%	-	0.0%	-	0.0%
Sub-total capital costs	**97 366**	1.0%	**85 649**	1.2%	**89 202**	1.2%
Total Costs	**9 683 531**	100.0%	**7 336 035**	100.0%	**7 339 589**	**100%**
Cost/month**	806 961		611 336		611 632	
Total delivery costs (excl. Vaccines and supplies)	**3 655 359**		**1 307 863**		**1 311 417**	
Total doses administered	1 280 800		1 280 800		1 280 800	
Surviving infant pop. - 60% coverage	388 803		388 803		388 803	
Total population (2012)	13 787 341		13 787 341		13 787 341	
Incrementatl NUVI cost per dose	7.56		5.73		5.73	
Incrementatl NUVI cost per child	24.91		18.87		18.88	
Incrementatl NUVI cost per capita	0.70		0.53		0.53	

* Start up and Year 1 costs for achieving 60% coverage
** Assumed introduction period of 12 months to reach 60% target. See limitations on defining implementation period prospectively and exclusion of certain costs from earlier period in section 4.2.1 above.

By far the single largest cost item is for vaccines, which is estimated at $5.888 million to achieve 60% coverage of the target group.[79] This item makes up 80% of the total fiscal costs of which the 25% buffer comprises $1.177 million. The buffer stock comprises a once-off investment assuming that the vaccines comprising the buffer are not allowed to expire. As the coverage increases in subsequent years the buffer stock will have to be increased in line with increased consumption of the vaccine. In the Zambian scenario, this will therefore require an additional once-off investment after the introduction year.

The second largest economic cost item is the human resources to administer the

[79] 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.

vaccine. The weighted average human resource costs for the sample of $1.77 per dose generates a total of $2.158 million, the recurrent cost portion. As explained above, there is no related fiscal cost as no extra personnel are employed at the facility to administer new vaccines.[80] The balance of the salaried labour costs relate to the attendance by staff at training sessions, and the cost of drivers and EPI officers during supervisory visits and vaccine deliveries.

Table 4-3 below examines the impact of changes on PCV10 coverage rates on the economic cost of salaried labour (direct service delivery), vaccine and safe injection supplies. An increase in the coverage rate to 70% would result in an additional vaccine cost of $978 299, and additional supply costs of $23 488. Economic HR costs would increase by $359 394. In contrast, reducing the coverage rate to 45% would decrease salaried labour costs of $538 754, and decrease vaccines and safe injection supply costs of $1 471 125 and $34 729 respectively. This scenario would reduce total economic cost by $2.044 million and the fiscal cost of above items by $1 506 million.

Table 4-3: Impact of reduced PCV coverage on HR, vaccine and supplies economic costs (USD 2011)

Line item	60% coverage	70% coverage	Difference	45% coverage	Difference
Doses (total requirement)	1 601 000	1 867 000	-266 000	1 201 000	400 000
Doses excluding buffer & 5% wastage	1 280 400	1 422 476	-142 076	915 048	365 352
HR service delivery	2 158 388	2 517 783	-359 394	1 619 634	538 754
Vaccine cost	5 888 180	6 866 479	-978 299	4 417 055	1 471 125
Supplies	139 992	163 480	-23 488	105 263	34 729
Total value (- increase)	**8 186 561**	**9 547 742**	**-1 361 181**	**6 141 952**	**2 044 608**

Printing costs are the next largest item (Table 4-2), mainly for the new Under-Five cards to include the new vaccine. This estimated cost of $531 909 is categorized as a once-off cost because the number of cards printed exceeds the requirement for the introduction period. However, at some point the cards will become a recurrent cost when the initial batch of cards needs to be replenished. Other print costs relate to social mobilization and communication activities linked to the introduction of the vaccine.

Although significant expenditure was incurred in the last year to upgrade the cold chain equipment at national, provincial and district level, the EPI logistics tool confirmed that this additional capacity could be ascribed *primarily to meeting existing needs and replacing redundant equipment*. The estimates in this costing include the procurement of eight additional TCW3000AC fridges at provincial level to boost positive storage capacity. These estimates are based on the quarterly delivery regime. In addition the estimates include a provision for 127 large cold boxes to facilitate increased delivery volumes.

The cost of internal supervision and oversight is reflected mainly in 'Per diem and travel allowances'. Provision was made to visit all facilities and other levels of the health system, to ensure successful implementation of the new vaccine service.

The budget also provides for an external post-implementation evaluation, reflected under 'Other services'. There is no provision for disease surveillance in the NUVI

[80] This cost was calculated by multiplying the average urban and rural labour unit cost for service delivery (weighted by the number of doses) by national doses for rural and urban facilities and dividing the total by all national doses to generate an average HR unit costs for service delivery applicable to the roll out.

budget estimates as these activities are only likely to occur after the implementation period.

4.3.2 NUVI costs by activity

Table 4-4 below summarizes the incremental economic cost by activity. The most significant activities are administration of PCV vaccine at facilities or outreach visits. Based on 2011 statistics, 59% of all doses were administered in rural facilities and 31% in urban sites. Using the percentages provided by each facility indicating the proportion of doses administered at the facility, together with the total number of doses administered at facilities, resulted in an allocation of doses to facility-based and outreach services on a 56%:44% basis. Facility based service delivery is estimated at $4.696 million whilst outreach service delivery is estimated at $3.540 million. Together these two activities cover 85% of the total estimated NUVI cost. Their costs include vaccine, salaried labour and vaccine injection and safety supplies. The amounts *include* the once-off investment in buffer stocks.

Other significant activity costs include:

- Record keeping and HMIS ($580 622) most of which is to print Under-5 cards
- Supervision and PIE ($300 614) which is mainly allowances and travel costs and the provision for external service providers and,
- Training of staff ($236 366) in preparation of the PCV introduction. The major part of the cost is allowances and travel costs, but it also includes costs of a training DVD and other materials.

The very low energy cost is the incremental cost of running eight new fridges at provincial level. However, it excludes the fixed electricity charge, which is incurred as a fixed cost by the provincial and district offices.

Table 4-4: Estimated PCV introduction economic costs by activity in USD

Activity		
Routine Facility-based Service Delivery	4 695 768	48.5%
Record-Keeping & HMIS	580 622	6.0%
Supervision (& PIE)	300 614	3.1%
Outreach Service Delivery	3 540 490	36.6%
Social Mobilization & Advocacy	118 064	1.2%
Cold Chain energy and running costs	16 741	0.2%
Vaccine Collection, Distribution, & Stora	164 053	1.7%
Program Management	30 714	0.3%
Training	236 466	2.4%
Surveillance	-	0.0%
Other	-	0.0%
Total	**9 683 531**	**100%**

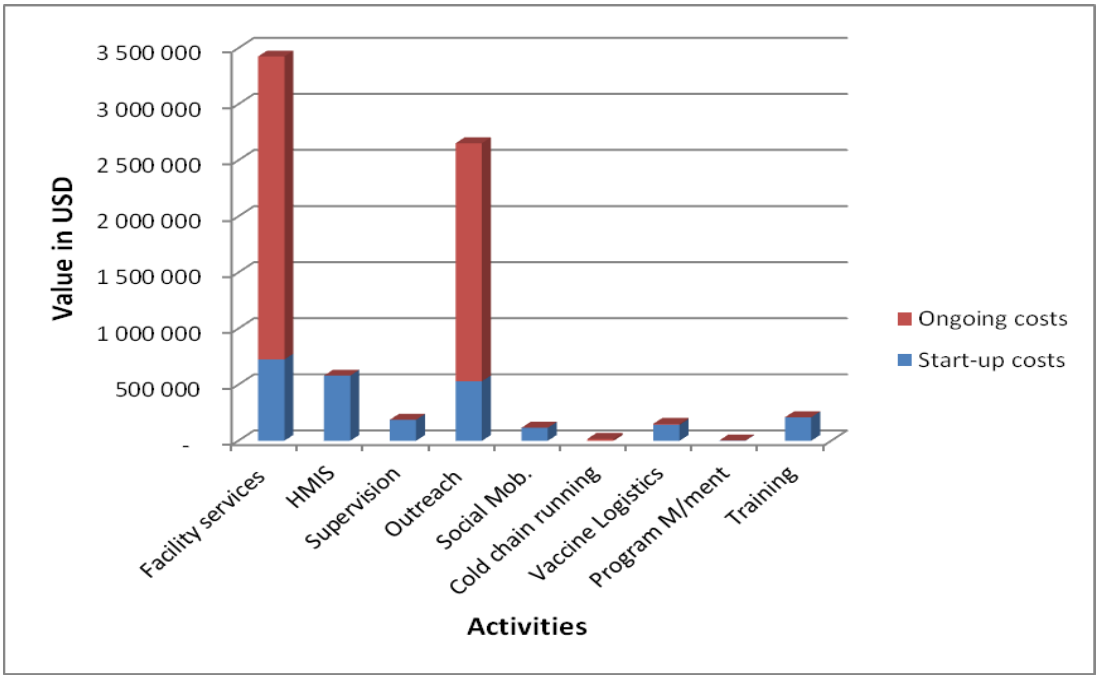
4.3.3 Start-up and Ongoing costs of NUVI

The split of NUVI economic costs into start-up costs and ongoing costs reveals that $2.58 million are estimated to be once-off costs and $7.104 million are considered to be recurring.[81] The largest of the start-up costs are estimated to be investment in the vaccine buffer stock ($1.18 million) and printing ($500 000), followed by per dia ($ 287 000), transport ($145 000). The profile of start-up costs associated with

[81] Recurring economic costs relate only to service delivery costs. They exclude items such as training for which only once-off initial costs were available.

various program activities in shown in Figure 4-1. Further details of economic, fiscal and financial start-up and ongoing costs of NUVI are provided in Annex 14.

Figure 4-1: Analysis of NUVI fiscal costs by activity and phase of expenditure (Zambia)



4.3.4 NUVI unit costs

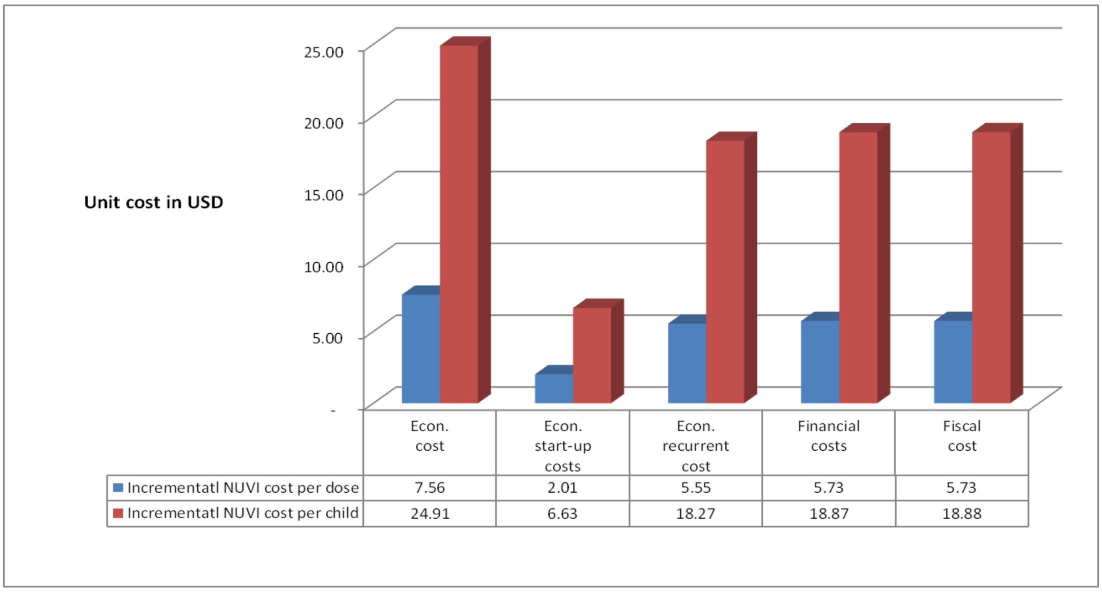
To estimate the total number of doses administered it is necessary to remove the buffer from the total number of doses procured, as calculated by the EPI logistics tool. A total of 1 280 800 doses are expected to be administered during the introduction period, once the target coverage and a wastage factor of 5% are taken into account.

The total economic cost per dose is estimated at $7.56 including start-up costs (Figure 4-2). The recurrent cost per dose is estimated at $5.55 if the start-up costs are removed. This incremental recurrent cost is almost entirely the labour cost of $1.77 and the vaccine cost of $3.54. From a fiscal perspective the total unit cost per dose is $5.73, comprising a start-up cost per dose of $1.95 and the recurrent cost per dose of $3.78. From a planning perspective the start-up cost may however be more usefully thought of as fixed costs rather than as unit costs. The amounts of the anticipated start up expenditures are likely to fluctuate less with the number of doses administered than recurrent costs.

Using the surviving infant population as a proxy for children eligible for PCV vaccination, results in higher unit costs of $24.91 per child and $18.88 per child for incremental economic and fiscal costs respectively. The higher unit costs, when compared to the cost per dose, result mainly form the inclusion of three doses of vaccine and the associated salaried labour cost (in the economic costing). The dynamics between start-up, recurrent and fiscal costs are similar to those described above for unit costs per dose.

The fiscal unit costs for service delivery charges only (i.e. fiscal costs excluding vaccines and supplies) has been estimated at $1.02 per dose and $3.37 per child targeted with PCV during the NUVI period which is considerably higher than the 30c per birth that was estimated in the NUVI application for the introduction grant (see Comparison with NUVI introduction grant).

Figure 4-2: Incremental NUVI unit costs by dose and child in USD (Zambia 2011)



	Econ. cost	Econ. start-up costs	Econ. recurrent cost	Financial costs	Fiscal cost
Incrementatl NUVI cost per dose	7.56	2.01	5.55	5.73	5.73
Incrementatl NUVI cost per child	24.91	6.63	18.27	18.87	18.88

4.3.5 Costs at various levels of the health system

The cost of PCV 10 vaccines is the biggest single cost item and comprises $5.888 million inclusive of buffer stocks. This cost is both an economic as well as a fiscal cost and is incurred at national level. It is however likely that the cost of vaccines will be largely covered by GAVI and actual expenditure is therefore incurred by UNICEF but the receiving and distribution of vaccines is managed at the national level by the ministry. The cost of vaccine injection supplies is also incurred at national level. The co-financing for PCV calculated in 2012 amounted to $124 496.

As the national office of the ministry is responsible for the distribution of vaccines and supplies, the allowances and travel costs associated with distribution are provided by the national office. In practice some of these costs will be incurred at the national level (e.g. the distribution of vaccines to provincial stores), whilst the budget for distribution from provinces to districts and health centres may largely comprise transfers to the provincial and district levels, which then take on the responsibility of collecting vaccines and distributing vaccines to health facilities.

The biggest portion of the travel allowance cost is however incurred for training, supervision and social mobilization. Of the total amount of $289 380 an estimated $148 340 is transfers to districts for district supervision ($125 481) and district social mobilization ($22 860). The fuel cost is similarly distributed across the national, province and district levels. Of the total transport and fuel costs, training accounts for $53 232 (national, province and district levels) and distribution to provinces and districts adds $ 46 210.

Of the salaried labour cost of $2.336 million, by far the largest contributor is the recurrent economic cost of service provision at the facility, which accounts for $2.158 million. As described above, this estimate represents the economic cost, not a fiscal cost, during the NUVI period.

The printing of Under-Five cards ($531 909) is incurred at the national level. Other supplies include production of a DVD and other training materials, updating the HMIS systems, and training related services and supplies. Training related services and supplies such as refreshments and hall hire are incurred at national, provincial and district levels.

In summary it is important to note that the entire fiscal cost associated with the introduction of PCV is managed and administered from the national level. Even if transfers are made to the provinces and the districts, these are not part of a routine operational budget. As such, one can argue that all the expenditure is from a national budget, even if implementation takes place at lower levels. From a fiscal cost perspective, no costs are being incurred at the facility level.

4.4 Comparison with NUVI introduction grant

In June 2011 the Zambian MOH applied to GAVI for funds to support the introduction of a second dose of measles, PCV10 and Rotavirus vaccines.[82] Unfortunately much of the need for additional cold chain and service delivery requirements is described jointly for all three vaccines, with no earmarking of items related to each vaccine (section 6.1 of the Application). In sections 6.3 and 6.4 of the application the request for GAVI support is formulated for measles and PCV respectively. These sections also show the calculation of the NUVI introduction grant. In both cases the grant is calculated on the basis of 30c per birth based on 2012 estimates. The result is a total grant request of $207 000 for each of the vaccines. Table 4-5 summarizes the estimated funding needs for introducing each vaccine (excluding vaccine and disposables) and the allocations to specific activities.

Table 4-5: Summary of GAVI introduction grant

	PCV 10		Measles 2nd dose	
Cost line item / Funder	Full funding need	GAVI introduction grant	Full funding need*	GAVI introduction grant
Training		$200 430	$313 160	$112 691
Social mobilization	$166 573		$116 525	$56 206
Cold chain	$1 126 000		$304 389	
Vehicles and transport		$6 123		$10 000
Prog. Management		$447	$31 212	
M & E			$62 424	$ 28 103
Human Resources	$24 510			
Printing	$656 250			
TOTALS	$1 973 333	$207 000	$ 827 710	$207 000
GRAND TOTAL		$2 180 333		$1 034 710
STUDY TOTAL (excl. vaccines)**		$1 311 417		

* The full funding need appears to be more accurately described as the non-GAVI funding need and the GAVI grants are in addition to the amounts listed under the full funding need.
** Fiscal total excluding vaccines and safe injection supplies

A comparison of the PCV amounts shown above with the estimates calculated as part of this study is difficult as the table above uses both activities and cost categories in the same table and the categorization of expenses differ. The fiscal, incremental service delivery cost associated with PCV10 was estimated at $1.311 million

[82] Application Form for Country Proposals for Support to NUVI, submitted by Government of Zambia, 27 June 2011

(excluding costs of vaccines and safe injection supplies). The total is $868 916 less than the total reflected in the GAVI application.

The most significant portion of the difference is the allocation of cold chain costs of $1.126 million to PCV in the application, while the study estimates a total cold chain cost of only $89 202. As described above and clearly stated in the GAVI application, significant cold chain expenditure is to replace obsolete equipment and expand cold chain capacity to meet existing needs, before introducing new vaccines. If the GAVI application total for PCV is reduced by the difference in cold chain expenditure, the revised total of $1 143 535 is not dissimilar to the study total. Dividing the study total by the number of births for 2012 (as per GAVI application) generates a rate of $1.90 per birth. This is significantly higher than the current grant of 30c per child and implies a considerable contribution from government and other partners.

A number of anomalies can be seen in the allocation of costs between PCV and measles in the GAVI application. These include the allocation of all supervision and PIE costs to measles, higher allocation of social mobilization costs to measles, and a much higher allocation of training costs to measles. This is contradicts guidance given by the national EPI coordinator for allocating NUVI costs in this study.

The figures contained in the latest cMYP for the PCV introduction and those generated by the EPI logistics tool are very similar as shown in Table 4-6 below.[83] Both tools use similar underlying assumptions. They have the same year of introduction, i.e. 2012, the same starting population, the same safety stock buffers of 25% and similar pricing. The CMYP assumes 15% for freight while the EPI logistics tool assumes 1%, and a wastage factor of 10% is used in the CMYP while the GAVI application and the EPI logistics tool use a lower percentage of 5%. Interestingly the EPI tool provides for syringes on the basis of the *total* doses required while the cMYP provides for syringes on the total doses required *excluding* the 25% buffer which explains the difference in the number of syringes.

Table 4-6: Comparison of PVC10 introduction costs between cMYP and EPI Logistics tool

		cMYP		EPI Logistics tool	
Description of items	**Units**	**Quantity**	**Value**	**Quantity**	**Value**
Vaccines procured	Doses	1 620 013	$6 520 551	1 601 000	$5 888 180
AD syringes	No.	1 360 795	$94 303	1 688 000	$ 116 472
Reconstitution syringes	No.	810 006			
Safety boxes	No.	21 060	$23 398	17 000	$17 578
Total			$6 638 252		$6 022 230

Importantly the cMYP provides for purchase of 84 small fridges in 2012 ($77 112), presumably for health facilities. In subsequent years this is followed up by 450 electrical, solar and gas fridges, i.e. a further total of 1350 fridges. As previously stated this additional capacity may be required for the introduction of all three new vaccines but without a detailed capacity assessment at facility level it is not certain what portion, if any, should be ascribed to the introduction of PCV itself.

Other funding sources

The Plan and Budget for NUVI Introduction, which formed the basis for the NUVI cost estimates also allocates certain funding sources to key activities. In this plan the

[83] Dated June 2012

original total amount of $1 675 192 was estimated to introduce *both* PCV and the 2nd dose of measles. This amount excludes vaccines and procurement of cold chain equipment. The amount was allocated to funders as shown in Table 4-7.

Table 4-7: Funding Sources for activities in Plan and Budget for NUVI

Funder	Approximate value in USD	Activities funded
GAVI	1 046 850	Training and orientation of health workers, printing of under 5 cards and other materials, updating HMIS systems and tools, distribution of vaccines to provinces, districts and health centres, social mobilization, M&E, supervision.
UNICEF	43 458	Community orientation
Zambian Government	381 319	Central level meetings, Printing of under-five cards, Distribution to provinces (insignificant amount)
GlaxoSmithKline (GSK)	183 876	Training and orientation of health workers, DVD development for training
WHO	19 689	Central and provincial monitoring
	1 675 192	Total budget estimate

At the time of drafting this report the following transfers of funds could be confirmed (Table 4-8). It is not clear why the GAVI transfer allocated to PCV and measles exceeds the amount requested in the GAVI application for both vaccines, of $414 000. Another unclear issue is why the budget assumes that GAVI will contribute over $1 million when the contribution is clearly capped at the amounts included in the GAVI application. Of the $381 319 which government had committed to the budget, $138 297 had been spent on training of health workers and supervision and monitoring. The training of health workers had originally been allocated to non-governmental partners. Government had also funded meetings and vaccine distribution activities although these were not reported at the time of writing. The printing of under-five cards by government had not been confirmed.

A significant funding shortfall ($925 426) remains when transfers are compared to the budget estimate. This would have to be met by the MOH or other partners.

Table 4-8: Summary of actual funding transfers for NUVI

Funder	**Approximate value in USD**	**Activities funded**
GAVI	167 894	Training and orientation of health workers
	79 231	Distribution of vaccines to districts and facilities
	149 584	Social mobilization
	171 302	District supervision
	568 011	Total GAVI
UNICEF	43 458	Community orientation
GRZ	74 428	Training and orientation of health workers
	63 869	Supervision and monitoring
	138 297	Total GRZ
	749 766	Grand Total
	1 675 192	**Total Budget Estimate**
	925 426	**Funding shortfall**

4.5 Conclusions

Several important conclusions emerge from the NUVI analysis. These are likely to be robust, despite the challenges posed by costing PCV introduction in a period when several vaccines have been introduced, and by the need to largely do a prospective study with limited retrospective expenditure data.

PCV introduction costs in the year of introduction are a substantial addition to the overall costs of the Zambian EPI program. The indication of a recurrent cost to achieve 60% coverage in the region of $ 7.9 million (approximately $ 5.2 million in fiscal costs after salaries are excluded) suggests that sustaining the on-going cost of maintaining PCV coverage at even higher levels may be a material challenge to Zambia and its partners. This challenge is increased by the planned introduction of a second dose of measles at the same time, and the subsequent introduction of the Rotavirus vaccine. The largest costs by far remain the vaccines and safe injection supplies, so the ability to reduce these as PCV becomes part of routine EPI programs is a key issue affecting long-term sustainability of the program and to increase cost effectiveness.

A particular challenge for budgeting and costing of NUVI arises from uncertainties around realistic coverage targets and actual implementation timeframes. The Zambian costing illustrates that vaccines comprise by far the most substantial cost component which is heavily dependent on coverage targets and assumed wastage rates which may not be informed by previous experience and/or evidence. Over-estimating initial coverage rates may lead to an over investment in vaccines stocks for routine and buffer purposes, may generate unnecessary wastage and place unnecessary strain on existing cold chain and distribution.

Furthermore, there are quite substantial differences between economic and fiscal costs which are relevant to consider in making various planning and funding decisions. The primary reason for this difference is the inclusion of salaried labour as economic cost and potentially the impact of acquiring cold chain equipment specifically for NUVI. The assumption that health staff has no spare capacity, which results in the costing of human resources in economic costing, appears to be at odds with the general decision by the MOH not to employ additional staff. This decision seems to indicate that staff have spare capacity and are able to absorb additional workload of multiple new vaccine introductions without having an impact on other health services. In reality it is likely that health staff has spare capacity in certain settings and not in others and that an accurate costing of the incremental human resource cost of NUVI is not possible without a more comprehensive assessment of health staff capacity at facilities. Also, the decision that no new staff should be employed does not necessarily mean that there is not a *need* for additional staff, and that their time may be diverted from other key service functions. If such a need does exist then the fiscal costs is misleading and the economic costing may be more indicative of the true opportunity cost associated with introducing new vaccines.

Uncertainties exist about the true cold chain capacity at facility level, and how much need there is for extra capacity related to PCV introduction specifically. Much of the recent acquisition of equipment was to replace previous capacity rather than for new capacity to accommodate PCV (or other new vaccines). The data illustrate that cold chain costs can be a substantial part of funding applications, and can also be a major focus of NUVI planning.

Costs of new cold chain capacity may best be considered as a somewhat separate issue from NUVI itself. Firstly, funding of cold chain capacity to deliver NUVI may well be required but will be heavily dependent on overall existing capacity and cold chain upgrading requirements, rather than NUVI introduction per se. Secondly, cold chain costs are relatively small in relation to overall EPI funding and may best be contextualized in relation to overall program costs and priority needs rather than NUVI introduction costs. The EVM highlights that efficiency gains may be possible by more coordinated and systematic plans at each level for distribution routes, frequencies and quantities, to allow better cold chain capacity planning.

What is clear is that the NUVI process *triggered* significant expenditure in cold chain in Zambia, Uganda[84] and in Ethiopia[85] and that new vaccine introduction processes need to anticipate large scale cold chain refurbishment and expansion beyond the need of the new vaccine requirements. Also the costing has highlighted the need to support the planning process with an accurate assessment of cold chain capacity at facilities, which is currently not available.[86] This would result in a more accurate estimation of resource requirements and would also support the implementation process.

Importantly, the costing reveals that government contributions to NUVI are substantial and comprise a valuable finance component over and above the specific funding by development partners. Even where human resources are not reflected in fiscal costs, government contributes a baseline capacity of staff, cold chain equipment and infrastructure, without which service provision cannot take place. The current GAVI grant of 80c per child born clearly only covers a portion of the equivalent non-vaccine service delivery costs in Zambia.

The Zambian example suggests that, in many countries, other uncertainties including delays and limited information, will also affect the rigour and completeness of resource estimates for NUVI. In particular, the complexity of introducing several vaccines at the same time, and having appropriate resource planning for each independently, is evident. There may be limited benefit to trying to isolate introduction plans and costs of separate new vaccines too minutely, and countries may instead benefit from long-term, multi-vaccine introduction plans which provide for all the major start-up and routine activities and associated costs.

[84] See Guthrie T et al. 2014. Costing and Financing Analyses of Routine Immunization in Uganda. Technical Report to Bill and Melinda Gates Foundation.

[85] 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

[86] Although a reasonably accurate inventory of cold chain at facilities exists the extent to which this capacity is currently used is not clear.

5 Productivity Analysis

5.1 Background: assessing 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.[87] This study provides a unique opportunity to examine variation in unit costs, outputs and total cost for the sample of facilities in Zambia.

This section presents examples of scatter plot analyses of factors that influenced productivity (levels of output) in delivering immunization services in Zambia. More detailed statistical analysis of facility productivity follows. Annex 9 presents some further analysis of variations in unit cost (efficiency) indicators. 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.[88] However, in spite of the necessity to avoid waste of scarce resources in health care in resource constrained settings, which include most countries in Southern and Eastern Africa, health economic research in Africa is focused on specific intervention programs or the entire health care system.[89] 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, with findings that are of interest but limited relevance to this study, given its focus on immunization which is typically implemented at the primary health care level.

The literature reports no specific information on studies of productivity factors specifically for immunization in Zambia. However, an examination of the productivity and efficiency of primary health care facilities in Burkina Faso provides valuable insights into the factors which impact on relative efficiency and productivity.[89] 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 correlations 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. In the Burkina Faso study various determinants were examined in relation to productivity and efficiency including household income,

[87] Brenzel L. Common Approach for the Costing and Financing of Routine Immunization and New Vaccines, 2013

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

[89] Marshall P Flessa S. Efficiency of primary care in rural Burkina Faso. A two-stage DEA analysis, Health Economics Review 2011

religion and geographical location. Geographical accessibility is highlighted as a key determinant closely correlated with efficiency.

In Eritrea a study using a similar methodology to that in Burkina Faso examined the efficiency of public hospitals and had similar findings, i.e. improved utilization is key to improved productivity and efficiency.[90] Unlike primary health care centres, the possibility of re-allocating human resources becomes feasible.

A similar study of human resource efficiency in hospitals and health centres in Zambia aimed primarily to establish the relative 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.[90] Regression analysis was however not carried out as a second step to examine possible determinants of productivity and efficiency.

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 associated with the number of doses administered, but there were no statistically 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.[91]

Some information is also available on factors related to immunization coverage which could influence productivity. A recent analysis of the 2006 Uganda Demographic and Health Survey 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.[92]

A Bangladesh study found that maternal education and child age affected immunization coverage.[93] 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.[94] Other studies on determinants of immunization outputs and coverage have also identified service and community factors that are worthy of consideration in

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

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

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

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

[94] 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

analysis.[95] [96] [97] [98] [99]

5.1 Methods

5.2.1 Approach to productivity analysis

The analysis of data on outputs and costs had two distinct stages. The first stage comprises an analysis of the productivity of the sampled facilities focused primarily on the relationship between utilization and total output and the determinants of utilization and output. The second stage focuses on the determinants of total facility cost, which is addressed in Section 6 of the report. The research question of 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 unit cost analysis and by the hypothesis 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 (also representing available infrastructure for immunization services) impact on total facility productivity and results in reaching populations which may otherwise not have presented at the facility.

The utilization of the facility is most likely to have greatest impact on the outputs 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. Urban facilities that provide the majority of their services at the facility and reflect high attendance are expected to have higher outputs per staff member than rural facilities which proved most immunizations through outreach activities. Although they may impact on costs, based on observations during data collection, the energy source, collection frequency and the similar operational factors impact are 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. Two-way scatter plots provided a useful, visual representation of the level of correlation between the variables and the distribution of the observations around the mean.

On each scatterplot, rural facilities are represented by red points while urban facilities are black. Each observation also has an identifier number to facilitate the identification of facilities on the graph. The reference lines are placed on the mean

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

[96] 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.

[97] 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.

[98] 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.

[99] 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.

of the variable and marked with the appropriate value. All of the graphs are presented with a linear prediction. A list of the facilities and their identification number is contained in Annex 6.

Regression analysis followed the scatterplot analyses, to examine the correlation between the selected dependent and independent variables. After assessing model fit of untransformed data, the normality assumption, and constant variance were not met. After investigating a number of transformations using the ladder command in STATA, the best transformations were the log transformation on both the dependent and independent variables.

Simple linear regression models look at the relationship between a dependent variable and one independent variable at a time. Multiple linear regression models look at those independent factors that are collectively associated with the outcome, and are a much more realistic, useful way of exploring the inter-relatedness of factors. Several regression models were developed to explore the predictability of the effects of different combinations of independent variables on the outcome, and to assess the impact of specific variables. The final model fitted was of the form:

$$\log(y_i) = \beta_0 + \beta_1 \log(x_{1i}) + \beta_2 \log(x_{2i}) + \cdots \beta_p \log(x_{pi}) + \varepsilon_i$$

where y_i, is the dependent variable and x_i are, independent variables for facility i *and there are p of these independent factors under study*. 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. STATA software (version 12) was used to conduct the regression analysis.

5.1.1.1 Selection of dependent and independent variables

In order to assess total productivity of the sampled facilities the indicators of productivity shown in Table 5-1 were selected and are listed in the table below. These include both total facility productivity measures and staff productivity measures.

Table 5-1: Measures of productivity

Productivity indicators	Description	Mean (Std. Dev.)	Min / Max
DTP3 Children	Total number of children with 3rd dose of DTP (2011)	708 (1006)	95 / 4634
Total facility doses per annum	Total doses for all child vaccines administered during 2011 for each facility	7309 (11760)	826 / 56 168
Child doses per FTE - immunization staff	The total number of child doses per annum / full time equivalent staff providing immunization	5 758 (5752)	729 / 21 829

A number of other possible indicators of productivity were not analyzed because it was not possible to calculate the indicator, or where an analysis of correlation indicated a high degree of correlation between two independent variables. For example, there is high correlation between catchment population and facility attendance and these variables were not used together in the same regression model. Also in Zambia it is not possible to calculate accurately the wastage rates for each facility, thus measures related to wastage were excluded. The relationship between distances travelled by clients and utilization may also have been useful to explore, but the study did not collect this data. Distance to vaccine collection points was however used as an independent variable in the regression analysis as a proxy indicator of remoteness or limited accessibility (see below).

For the quadrant and statistical analysis the log-transformed values of the following independent variables were used and explored as possible environmental determinants of output and utilization at the sampled facilities.

Table 5-2: Summary of independent variables for productivity analysis

Independent variable	Description	Mean (Std Dev)	Min / Max
Facility catchment population	Size of the facility catchment population, obtained at facility	22 212 (37 639)	2544 183932
Facility attendance	Total outpatient attendance at the facility in one year (2011)	19 486 (24 672)	3300 145456
# Community health workers	Number of community health workers involved in immunization	13 (21)	0 105
Number of Zones supported	Number of zones at which outreach activity takes place for the facility	8 (5)	1 26
Distance to vaccine collection point (km's)	Distance between the facility and vaccine collection point at DMO in km's	50 (45)	.001 160
Material deprivation index	Proxy for socio-economic well-being of population in a district	-1.51 (2.11)	-4.65 1.1
Type of health facility (number & % of sample)	Facility is either - urban or - rural	15 (29%) 36 (71%)	0 1
Access road rating	Description of road to facility, in two categories: -good + fair or - poor + extremely poor	24 (47) 27 (53)	0 1
Distance from capital	Total distance of facility from Lusaka	301 (177)	7 609

5.2 Results

5.2.1 Quadrant analysis

Scatter plot analyses were used to identify possible associations with productivity and guide development of regression models. As might be expected, scatter plots indicated a positive association between facility productivity measures (total doses per annum; total DPT3 per annum) and the facility catchment population and total facility attendance.

The scatterplots presented below illustrate relationships between staff productivity, a key factor in facility productivity, and other variables. They show several in which a pattern or correlation between the two productivity variables can be observed, and one in which a correlation was expected but was not observed. The relationships are examined further in the statistical analyses below.

The possible relationship between utilization and geographical location is examined below. The relationship may be accentuated if for small, remote facilities, outreach becomes more important for achieving good immunization coverage, and those outreach visits also tend to administer fewer doses than average services.

Figure 5-1 examines whether there is a correlation between the total distance to Lusaka (the capital) and the number of doses administered by each equivalent full time health employee, an indicator of facility or staff productivity. The question which is being tested here is whether the distance from Lusaka is a good indicator of whether a facility is rural and small in nature or typically larger and more urbanised. If there is a correlation, the small rural facilities would be clustered in the lower right-hand cluster and the large and more efficient facilities would have been locate in the top, left-hand quadrant.

The correlation appears to be poor. Observations are scattered across all four quadrants and, although the predictor line does indicate a reduction in the number of doses per FTE health staff member as the distance from Lusaka increases, deviations from the predictor line are high. There is some clustering of urban facilities in the Lusaka cluster (facilities 50-53) located very close to or in Lusaka, and the Ndola cluster (facilities 26-31) near and in Ndola town in the Copperbelt province, which are all just over 330kms from Lusaka. The distance between facilities and vaccines collection points was therefore selected as a better indicator of remote location in later statistical analyses.

Figure 5-1: Doses per FTE by distance of facility from Lusaka

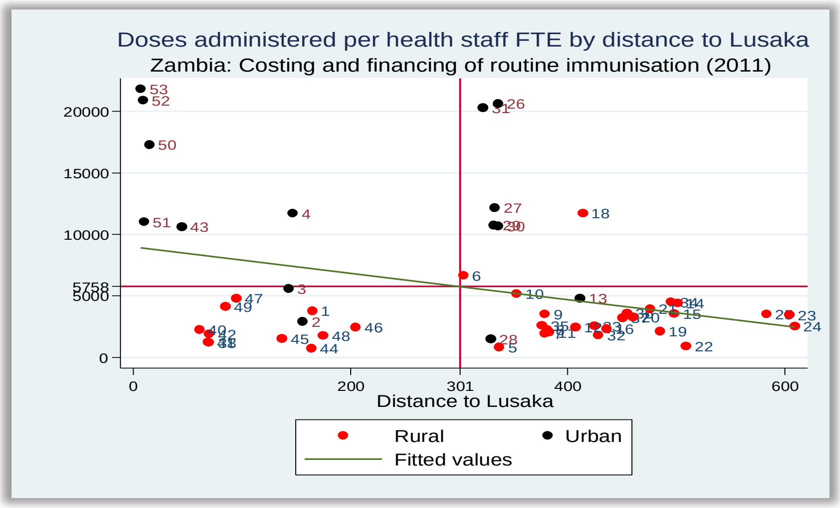


Figure 5-2 and Figure 5-3 do however confirm that urban facilities tend to be closer to Lusaka and rural facilities further away. The distribution of number of doses per FTE was much higher and more variable in urban centers than rural facilities.

Figure 5-2: Distance of urban and rural facilities from Lusaka

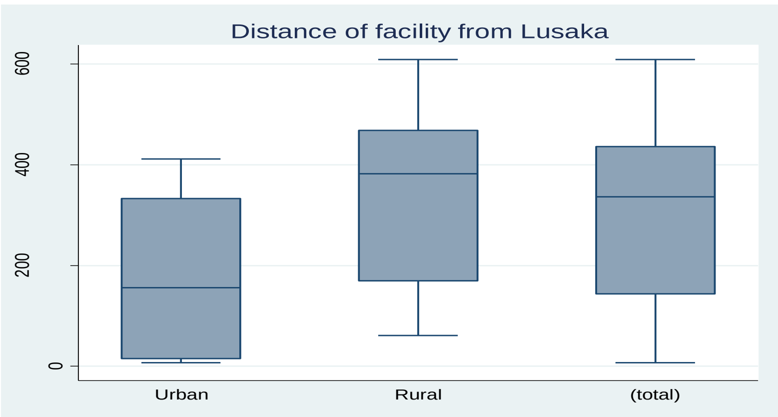


Figure 5-3: Number of doses per FTE in urban and rural sites

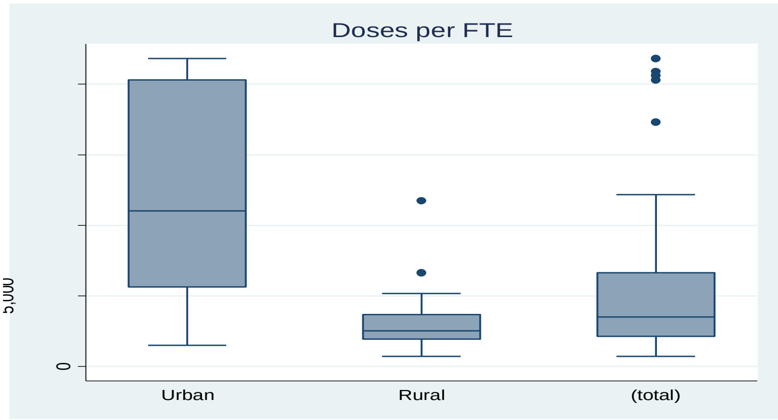
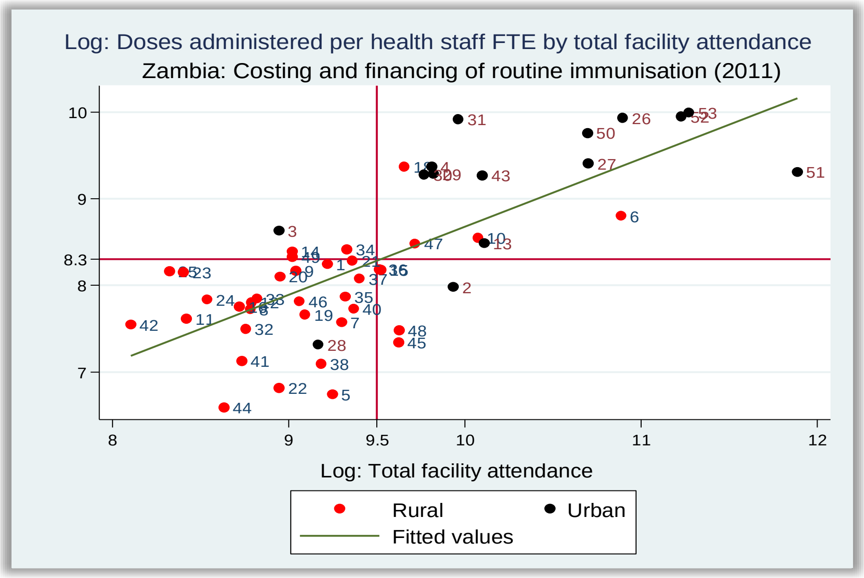


Figure 5-4 explores the relationship between scale and total number of doses administered by FTE immunization health staff. In the scatter plot, the lower left-hand quadrant is indicative of smaller facilities with lower than average facility attendance, together with low productivity in terms of the number of doses delivered per annum per FTE staff member working in immunization. The top right-hand quadrant contains observations with facility attendance and higher numbers of doses per FTE staff. Facilities that are placed above the line have more productive staff than those below the line.

The graph indicates a clear increase in productivity correlated with increases in facility attendance. There are sites (31 and 26) where high levels of productivity are achieved even though the total attendance and number of doses are lower than 50 or 53. Both facility 31 and 26 are urban facilities and reported very low FTE (less than 1) when compared to the average across all facilities of immunization FTE staff. This suggests that in these two sites immunization might have been prioritized, and limited staff capacity used efficiently to provide it. If so, similar prioritization and use of staff might be able to enhance productivity in other settings. Alternatively the prioritization of immunization with limited resources may also lead to curtailment of other health services.

Figure 5-4: Doses administered per FTE health staff by total facility attendance



Facility 51's location below the line in Figure 5-4 is interesting given its high number of doses and attendance volumes, indicating slightly lower performance than some of the other large urban sites, although still well above the mean performance. Comparing it to the other facilities (50, 52, 53) the number of FTE staff members is higher by a substantial margin.[100] Facility 28 (reported particularly low productivity and is an urban health centre with a relatively low number of children under 1 year old (688). In addition, its DTP3 coverage rate was reported as only 36%. It is possible that there is an overlap in catchment population with a newer facility established in close proximity to this facility and that clients now attend the new centre, which administered 12 373 child doses in 2011.

Amongst the rural health facilities it is interesting to compare sites with very productive staff such as facility 47 and 34 with poorer performers such as facilities 44, 22, 45 and 48. In each case the position of the facility in relation to the prediction line is determined by the number of FTE reported and the total number of doses administered. Facility 9 reported only one staff member for immunization services (FTE of 0.33) to provide just over 2000 doses. Most other facilities reported two or more staff even where far fewer than 2000 doses were delivered in 2011, with around 1 FTE allocated to immunization. There is no clear indication of why some facilities can produce much more outputs per staff member than in other sites.

5.2.2 Statistical analysis

This section reports on the statistical analysis of productivity in the sampled facilities, with output measured in total doses or total number of DTP3 children. Productivity in terms of annual doses per staff member, is explored in Annex 9.

5.2.2.1 Determinants of facility productivity

The regression models presented below examined the determinants of total facility productivity in terms of total children with a third dose of DTP and total number of doses administered for the year. Independent variables selected for the analysis included FTE immunization staff, the number of community health workers involved with immunization, outreach zones supported and the distance to vaccine collection point in km's. Environmental variables were selected to test accessibility and other contextual determinants and included the facility type and setting, the condition of access roads and the district material deprivation index.[101]

The *facility catchment population* and *total facility attendance* was highly correlated with both outcomes (Pearson correlation coefficients ranged from 0.87 to 0.92) and were thus excluded from the regression analysis. The correlation between the two variables was 0.74, p-value < 0.001.

Table 5-3 summarizes the results of the regression analysis of facility productivity. The most consistent predictors of total productivity in facilities are the number of outreach zones supported and the facility type and setting. In all models these two variables were statistically significant at the 1% level. An increase of 10% in the number of zones supported is associated with an increase in DTP3 children of just over 6% and an increase of total facility doses of between 5.6% and 6.2%. The facility type is negatively associated with the total DTP3 children and total doses which

[100] Chawama reported 4 FTE compared to 1.8, 1.7 and 2.6 for the other facilities respectively, resulting in the lower than average doses per FTE.
[101] See Annex 11 for analysis with Confidence Intervals.

points to a lower total number of DTP3 children and doses in rural health centres when compared to urban facilities. The district material deprivation index was associated with model 1 and 2 (DTP3 children) at the 5% level of significance. An increase in the poverty index is associated with a decrease in the total number of facility DTP3 children. In model 2 (doses) the poverty index becomes significant at the 1% level after removing all other variables except for the number of zones supported and the facility type. In this case a 10% increase in the poverty index value is associated with a 2.1% decrease in total doses.

Table 5-3: Statistical analysis of facility productivity

	Ln Total number of DTP3 children			Ln Total number of facility doses		
Variable	**Model - 1 β (std err) p-value**	**Model – 2 β (std err) p-value**	**Model - 3 β (std err) p-value**	**Model - 1 β (std err) p-value**	**Model – 2 β (std err) p-value**	**Model - 3 β (std err) p-value**
Ln FTE Immunisation staff	0.22 (0.15) 0.16	0.22 (0.15) 0.14	0.22 (0.15) 0.15	0.26 (0.16) 0.12		0.25 (0.16) 0.12
Ln # Community health workers	-0.004 (0.03) 0.91	-0.002 (0.03) 0.93		0.01 (0.03) 0.85		0.004 (0.03) 0.89
Ln # Zones supported (outreach)	0.62 (0.15) <0.01	0.62 (0.15) <0.01	0.61 (0.14) <0.01	0.57 (0.16) <0.01	0.62 (0.14) <0.01	0.56 (0.16) <0.01
Ln Distance to vaccine collection point (km's)	-0.01 (0.06) 0.89		-0.01 (0.05) 0.91	0.01 (0.07) 0.83		
Facility type & Area Urban Rural	- -1.04 (0.32) <0.01	- -1.08 (0.19) <0.01	- -1.05 (0.30) <0.01	- -1.12 (0.34) <0.01	- -0.91 (0.20) <0.01	- -1.06 (0.20) <0.01
Ln District poverty index	-0.12 (0.06) 0.04	-0.12 (0.05) 0.02	-0.12 (0.06) 0.03	-0.14 (0.06) 0.03	-0.21 (0.05) <0.01	-0.14 (0.05) 0.01
Roads Good/Fair Poor/very poor	- 0.23 (0.18) 0.23	- 0.24 (0.15) 0.13	- 0.23 (0.18) 0.20	- 0.36 (0.20) 0.08		- 0.33 (0.16) 0.05
Constant	5.48 (0.34) <0.01	5.47 (0.31) <0.01	5.49 (0.33) <0.01	7.74 (0.36) <0.01	7.70 (0.29) <0.01	7.77 (0.33) <0.01
R – squared (adjusted R^2)	0.75	0.75	0.75	0.74	0.69	0.74
F statistics	F(7, 43) = 18, <0.01	F(6, 44) = 22, <0.01	F(6, 44) = 22, <0.01	F(7, 43) = 18, ,0.01	F(3, 47) = 35, <0.01	F(6, 44) = 21, <0.01

* Statistically significant at the 5% level, ** significant at the 1% level
The symbol # refers to number of units

Several factors showed no significant association with productivity. The number of FTE immunization staff was not statistically associated with facility productivity, i.e. increasing or decreasing the total number of staff hours dedicated to immunization is not associated with a predictable change in productivity indicators. Also the number of CHW involved in immunization was not a predictor of productivity. The distance to vaccine collection point and the quality of the facility access roads did not reach statistical significance with productivity. Excluding or including these variables one at a time had no impact on the models abilities to explain the variability of productivity measures between facilities. In model two (DTP3), removal of the distance to vaccine collection point, had no impact on model and similarly, in model 3 (DTP3), the inclusion of the distance to vaccine collection point and the exclusion of the community health workers resulted in no change to the model results. A similar pattern emerged in the doses models. However, removing *all* of the above from the regression model (model 2 doses) resulted in a decline of the R-squared value from 74% to 69%.

Further regression results assessing the predictors of outputs per FTE staff member are provided in Annex 9.

5.1 Discussion

The quadrant analysis, as well as correlation coefficients, point consistently to a high degree of correlation between facility productivity indicators and facility catchment population or total facility attendance.

In regression analysis, when these variables are held constant, total facility productivity is strongly and positively associated with the number of zones supported, and urban facility type and setting. Greater district poverty is associated with lower productivity. All other factors being constant the distance between the facility and the vaccine collection point, road condition, FTE staff and number of community health workers were not associated with total productivity. These relationships support the hypothesis that the rural / urban facility type and setting, together with higher client volumes, is the strongest predictor of productivity.

There is a strong positive association of DPT3 doses and total doses with catchment population, facility attendance and number of zones supported. Similarly, staff productivity increases as attendance rises. This suggests that once facilities are in place they are generally able to respond to demand for immunization e.g. by prioritizing it and reducing time per patient. When combined with the observation that rural facility type and location, as well as poverty, are negatively associated with output, this suggests that the main constraints on facility productivity may be due to limited effective demand and barriers to accessing services in these contexts, rather than services' supply-side capacity per se.

The strong association between total catchment population and facility productivity is not unexpected. The advantage of this co-linearity from a planning perspective is that it should be relatively easy for planners to predict the total number of doses which a new facility is likely to administer once the catchment population, a known quantity, and the number of zones supported by the facility has been quantified. The size of the facility, together with the setting may also be used to estimate the efficiency ratio and thus the required number of FTE immunization staff. Cost analysis shows (Section 6) that this information in turn is predictive of the total cost of a facility.

5.3 Conclusions

Total facility outputs of DPT3 and doses are very highly correlated with facility catchment population and total facility attendance. In addition, staff productivity rises with service volumes.

When other variables are considered, the urban facility type and setting, and the number of zones supported, have strong positive associations with productivity when population and attendance are held constant. On the other hand, higher poverty levels are associated with lower productivity. This suggests that demand factors and ability to access services may be stronger determinants of service outputs than facility capacity, especially as available staff seem to be able to prioritize and increase their immunization outputs in response to higher facility attendance overall.

No other factors were identified as significant predictors of productivity. However, it is possible that some other factors may also have important associations with outputs, but that their associations would only be shown to be statistically significant with a larger sample size.

From a planning perspective the setting and facility type of any new facility or program expansion should be carefully considered, together with the method of service delivery and the number of zones to be supported. These factors together with the catchment population impact on the facility attendance, number of children to be immunized and the resulting output of facilities.

6 Analysis of the Determinants of Routine Immunization Costs

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

The purpose of this section is to examine and test the possible determinants of total facility routine EPI costs in Zambia and establish which combination of independent variables is most predictive of facility EPI costs. The ability to estimate total facility costs is of particular interest to planners and management in Zambia and this remains our primary objective for the regression analysis. The facility costing, unit cost and productivity analysis provide some indication of those factors which might influence costs and explain the variability between facilities. The selection of specific independent variables is described in section 6.2.1 below, but the following observations provide a context for the selection of specific variables for regression analysis.

The most significant components of total cost are staff costs, vaccine costs, allowances and travel costs. The size of the facility as measured in terms of doses or DTP3 children has a direct impact on the total cost of the facility but is unlikely on its own explain the high variability between facilities. Even where the size of the facilities is similar, total cost variability exists and inversely, certain facilities have similar costs but are different in size. It is probable that for smaller facilities, a certain level of cost is being incurred for the EPI which can be considered a fixed cost. This may be related to a minimum number of staff, a minimum number of immunization sessions per week, or a minimum number of outreach zones supported. The associated, basic costs are likely to be inflexible and some spare capacity may exist at these facilities.

As a result, increasing the facility patient load may initially not result in a proportional increase in total facility costs until these minimum thresholds of capacity and activity have been passed, although operational efficiency may improve significantly (see analysis in Annex 9). For example the total cost of salaried labour may only increase once it becomes necessary to either deploy more staff during immunization sessions or to arrange an extra immunization session. Until such time the increase in total costs is likely to be driven mainly by increased vaccine costs. Similarly changes in routine activity levels such as supporting additional outreach zones may trigger an in increased total costs. Once these thresholds have been breached, an increase in size is more likely to have a more direct impact on total facility costs. These indicators of increased activity levels or breaching minimum thresholds will be examined together with quantity variables as part of the regression.

There is also an expectation that there are significant differences between urban and rural health facilities. Typically it is expected that urban facilities will be larger in size simply because they typically service higher catchment populations, population densities are much higher and they are more accessible when compared to rural health facilities. The facility costing highlights that urban facilities display different cost patterns to rural facilities, even where these are of similar size. Comparing the characteristics of urban and rural facilities it is likely that the method of service delivery and the associated logistics have an impact on total cost. Rural facilities typically reflect a number of differences when compared to urban facilities. These include:

- A higher proportion of clients reached through outreach services
- Significant differences in productivity
- Higher travel and logistics costs associated with outreach, i.e. zones being supported are further away or simply harder to reach than in urban areas
- Greater distances to vaccine collection points
- Smaller catchment populations and lower population densities.
- Socio economic well-being of the catchment population combined with poor access to facilities

The relationship between urban and rural facilities is therefore also likely to influence the total cost of facilities.

There are a number of other possible cost drivers which may have been important determinants in other countries, but are not expected to contribute significantly to explaining the variability in facility costs in Zambia. These include factors such as the energy source and/or type of fuel used. Also possible price variability in salaries and other inputs is unlikely to explain variability between facilities. This is largely due to the fact that prices for most immunization service inputs are standardized throughout the country. Nevertheless, some of these variables, including a price variable, have been examined as part of the regressions.

A review of previous studies in the Common Approach[2] indicates that there have been relatively few statistical analyses of the immunization program cost function. Nevertheless results described in that document from statistical and non-statistical studies, largely support our expectations of which variables are likely to determine costs. These include volume indicators, number of immunization sessions and vaccine delivery strategy.

In this context, the specific variables described in section 6.2 below have been selected for inclusion in the regression analysis.

6.2 Methods

6.2.1 Dependent and Independent variables: selection and description

Given the primary objective of establishing the determinants of total immunization cost at facility level, the *dependent* variables selected for the regression analysis included the total facility immunization cost, and also total service delivery costs excluding the cost of vaccines and salaried labour (Table 6-1). The latter outcome was examined given that salaried labour and vaccine costs comprised a very major portion of total costs, the inclusion of which might have masked possible relationships between determinants and other cost elements.

Table 6-1: Analysis of facility costs – Dependent variables

Variable	Description	Mean (STD Dev) (USD)	Min / Max
Total cost	Total economic cost of the immunization program at the facility	30 813 (23 174)	6 261; 115 938
Total costs less vaccine and HR costs	Total costs of immunization for the facility *excluding* costs of labour, vaccines and safe injection supplies	6 855 (5 768)	861;35 661

Independent variables were selected to represent the components of the standard cost function, namely quantity, price and other environmental and contextual factors which may influence the shape of the cost curve, and which may also shift the curve up or down. In addition to these categories the analysis considered the main cost drivers of total facility costs indicated by earlier analyses i.e. personnel costs, vaccines and travel related costs such as travel allowances. The independent variables selected for each cost function category are described below.

Quantity, price, quality and capital investment factors incorporated in the basic model. The independent variables were tested for colinearity, including the VIF test, and were found not to be collinear (See Annex 10). Diagnostics also included an assessment of regression assumptions, as well as the effect of high influence values (either large residuals and/or large leverage values).

a) Quantity

As described in the previous section, the most likely determinants associated with total facility cost are likely to be those which impact directly on the main cost drivers. It was therefore anticipated that a quantity indicator such as total number of children immunized with DTP3, catchment population and total number of doses would generate a strong association with total cost given the assumption that these will drive total people costs, total vaccine costs and travel allowances. Given strong cross-correlation it was decided to use total doses as well as an estimate of doses from the productivity analysis regression function as the indicator for the quantity variable. Scatter-plot graphs were used initially to test these assumptions, and confirm the relationship between quantity indicators and total cost.

b) Price

Input prices these did not show differences across facilities. Fixed government salary scales for staff, centralized purchasing of all equipment (i.e. cold boxes, freezers, ice packs, thermometers, refrigerators) and fixed energy and fuel costs show no variability from one facility to the next. It is however possible that the mix of staff at the various facilities differed and therefore impacted on the unit cost of human resources. In order to test the extent to which this might have impacted on total facility costs, the average hourly costs per FTE staff member involved in immunization was included as an independent variable in the model.

c) Quality and productivity

Selecting a possible indictor of service quality in Zambia proved to be difficult. The most frequently proposed indicator, facility wastage factor, was not suitable in Zambia as the wastage for each facility was assumed to be the same in the absence of accurate stock records. Similarly energy source, the same for most facilities, was not considered to be an indicator of service quality and impact on costs which was subsequently confirmed in modeling. Observations in many aspects of health care indicate that practitioners who do high volumes of the same procedure tend to provide better quality service, are more efficient and have better outcomes. In addition, the ability to achieve high levels of DPT3 coverage suggests a combination of staff successfully reinforcing health seeking behavior by carers of infants, as well as accessibility of services, and important dimension of quality. The number of DTP3 children per FTE was thus included as a proxy for quality.

d) Capital investment factor

In order to test the impact of different levels of capital investment in the regression models a square metre measure for each facility was included as an independent variable. As most facilities had no vehicles and also had the same cold chain equipment, the size of buildings for immunization was considered a good proxy for capital investment. Square metres included a value for outreach points as well, to reflect the use of extra infrastructure.

e) Environmental and contextual factors:

A number of environmental factors were tested based on expectations of what would influence the quantities and total cost of a facility, as well as explain the variability between facilities. For example, in the Zambian context, it is expected that if a facility is far away from the vaccine collection point, it is probable that it is located in a more rural setting where population densities and total numbers of children are low. This in turn would point to a smaller facility with lower total cost, but also possibly higher logistics related costs. In order to explore these possible associations, a number of independent variables were initially selected which were expected to be related to the primary cost drivers or be good indicators of total cost in regression analysis. These independent variables included the number of zones supported, the facility type and setting, distance to vaccine collection point and number of immunization sessions a week. Finally as a feasible proxy for demand, the district material deprivation index was included as an independent variable based on a presupposition that in districts with high poverty, demand would be lower due to reduced means to access services, longer distances and lower education levels.[102]

Figure 6-1: Summary of regression model and variables

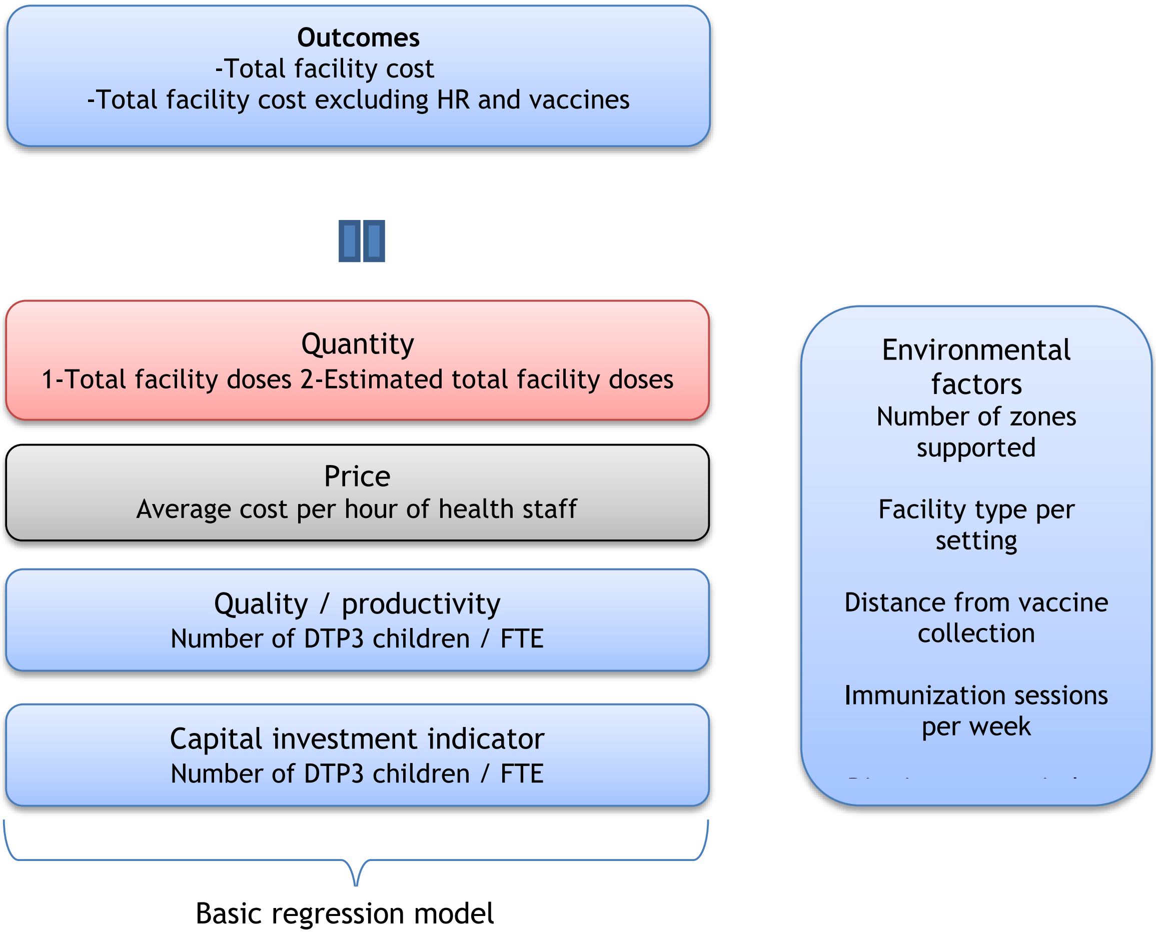


Table 6-2: Description of independent variables used in total cost analysis

[102] Bishai D. 2002. The role of public health programmes in reducing socioeconomic inequities in childhood immunization coverage. Health Pol Plan: 17(4): 412-419; Odusanya O. Alufohai E. Meurice F. and Ahonkhai V. 2008. Determinants of vaccination coverage in rural Nigeria. BMC Public Health. Parashar S. Moving beyond the mother-child dyad: women's education, child immunization, and the importance of context in rural India. Soc Sci Med. 2005 Sep;61(5):989-1000. Epub 2005 Feb 17.

	Description	Mean (STD Dev)	Min / Max
No child doses	Total number of child doses administered (excluding TT)	7 309 (11 760)	826 ; 56 168
No of child doses - estimated	Child doses estimated using the regression model developed during the productivity analysis	7 538 (11 414)	826 ; 56 168
Number of DTP3 children per FTE	Number of DTP3 children per full time equivalent immunization staff member	589 (551)	64 ; 2 299
FTE / hour	Average cost per hour of health staff involved in immunization	5.22 (0.66)	3.06 ; 7.07
Number of zones supported	Total number of zones supported by the health facility. Zones also indicate level of outreach effort	8.51 (4.56)	1 ; 26
Rural / Urban health facility	A binary variable classifying the facility as a urban or rural health facility; also aligns with its setting	36 (71%) 15 (29%)	
Distance to vaccine collection point in km's	Distance between facility and vaccine collection point at the district pharmacy	50 (45)	0.001 ; 160
Number of community health workers	The number of community health workers involved in immunization services	13 (21)	0 ; 105
Number of immunization session per week	Number of days on which immunization services are provided in any week	1.93 (1.47)	0.5 ; 6
Energy source Electricity/Other	Energy source at the facility level. A binary variable distinguishing between grid electricity and other	34 (67%) 17 (33%)	
District material deprivation index	Index used as an indicator of socio economic well-being	-1.52 (2.11)	-4.65 ; 1.10

6.2.2 Functional form for evaluating the cost function & estimation techniques

In all initial models, all costs were in USD, and all models had an identity link (untransformed USD outcome). However, after assessing model fit, the normality assumption was not met. After investigating a number of transformations using the ladder command in STATA, the best transformation was the natural log transformation on the independent and dependent variables.

As described in Section 5, multiple regression models look at those independent factors that are collectively associated with the outcome, a much more realistic and useful way of looking at the interrelatedness of factors compared to simple linear regression models. Several regressions models were developed to examine the predictability of different combinations of independent variables on the outcome and to assess the impact of specific variables. The final model fitted was of the form:

$$\log(Total\ facility\ cost) = \beta_0 + \beta_1 \log(doses) + \beta_2 \log(DTP3/FTE) + \beta_3 \log\left(\frac{cost}{hour}\right) + \beta_4 \log(m^2) + \beta_p \log(contextual_7) + \varepsilon_i$$

where y_i, is the dependent variable total facility cost or service delivery cost and the independent variables for each facility include total doses, the DTP3/ FTE ration, the HR cost per hour and the square metres. Contextual variables were added to the basic model one at a time and seven of these independent factors were studied in the final model. The β_i are unknown regression coefficients, β_0 represents the intercept or mean value when all factors are 0, and ε_i is the error term reflected in the residuals. Residual diagnostics to assess normality as well as Breusch-Pagan test for heteroskedasticity to assess equal variances were used to assess model fit. STATA software (version 12) was used for the regression analysis (see Annex 10).

6.3 Results

6.3.1 Quadrant analysis

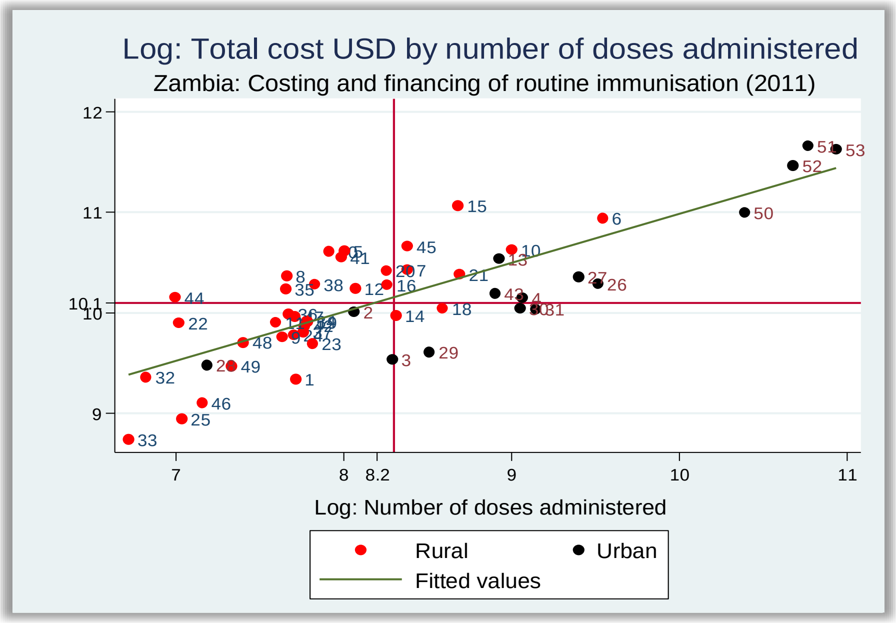
As indicated above, scatter plot graphs were used to test the assumption that there is a strong correlation between volume indicators and total facility costs. The graph in Figure 2-1 shows the relationship between total facility costs and the total number of doses administered by each facility. The high cross-correlation between total doses is apparent. Facilities in the bottom-left quadrant represent small facilities with low doses and immunized children but also reflect low total costs. Facilities in the top-right quadrant are large facilities with reflect high total facility costs. The facilities above the predictor line have higher total costs when compared to facilities below the line, given the same number of doses or DTP3 children. The relationship between total facility costs and the number of DPT3 had very similar features. Both therefore demonstrate a positive relationship between facility size and total cost.

In both scatter graphs the dynamic between urban and rural facilities was also reflected. On average urban facilities (black observations) appear to have lower total costs when compared to rural facilities given the same number of doses or DTP3 children. This corroborates the observations made during the efficiency analysis which indicated that urban facilities were typically more efficient than rural facilities. As pointed out above, it is not always clear why the rural facilities are less efficient given the same value for the quantity indicator, but differences are likely to be caused by the higher proportion of outreach immunizations in rural facilities, longer travel times to outreach points, poor road conditions and lower demand for services. In regression analysis none of these factors were however predictive of efficiency or productivity on their own. In several regression models the setting was however statistically significant in explaining the difference between rural and urban facilities and the setting is clearly a good proxy for the combined impact of all the above mentioned factors.

Comparing facility 15 (above the line) with facility 29 (below the line), highlights the kinds of factors that lead to differences in total facility costs for similar levels of output.

- Chitambo (F15) supports 14 outreach zones while Ndeke (F29) supports only 7 outreach zones
- Facility based immunizations are 30% for Chitambo and 60% for Ndeke
- Chitambo reported 1.6 FTE while Ndeke only reported 0.43 FTE
- Distance to vaccine collection points were 87km's and 4 km's respectively.

Figure 6-2: Total facility costs by total number of annual doses



Further plots of total and unit costs of facilities and their association with levels of output are provided in **Annex 9.**

6.3.2 Regression results

The summary results of the regression analysis which explored firstly the determinants of total facility cost and then the total cost *ex*cluding salaried labour and vaccines are presented in Table 6-3 below. Regression tables which include additional models are included in Annex 11. The results of each cost category are discussed below.

a) Total cost models

In the total cost models, the total number of child doses observed and number of doses estimated were statistically associated with total facility costs at the 1% level in all three models which included a doses variable. In Model 1 a 10% increase in the number of doses resulted in an increase in total cost of approximately 7.5%. This close correlation is not unexpected given the relationship between doses and vaccine costs and HR efficiency. For doses estimated using the productivity regression in Model 2 and for observed doses in Model 4, the coefficient value is lower at 0.58 and 0.55 respectively. Using estimated doses in the basic model (Model 2) reduced the R-squared value from model one from 0.89 to 0.63.

In total cost Models 1 and 2 the number of DTP3 children per FTE staff member was negatively associated with total costs at the 1% level of significance. This suggests, with all other factors being equal, that an increase in quality and productivity can be associated with lower facility costs. In other words for the same number of doses and in the same setting lower quality and efficiency are associated with higher costs.

Adding the facility type to the basic model did not result in a statistically significant association for this variable (Model 3). Model 4 however demonstrates that removing the quality variable from the basic model and including the facility type results in a statistical association for facility type. The positive association suggests an increase in costs for a given number of doses for rural facilities compared to urban facilities.

The quality variable generates a basic model in Model 1 which is more predictive of total facility cost (R-squared 0.89) than Model 4 (R-squared 0.76). However, the facility type of any new facility is known, while the quality value is *not* likely to be, so Model 4 may be a more useful as a guide in planning new facilities.

In models 1, 2 and 3 the facility square metres are positively associated with total facility cost at the 1% level of significance. In models one and two the coefficient value is relatively low at 0.19 and 0.27 respectively. In model 3, the total number of doses is removed altogether which results square metres being the only variable associated with total cost. In this model the coefficient increases to 0.46. Model 3 has an R-squared value of 0.38 which is lower than any of the other models and reflects its relatively poor ability as a predictive tool of total cost. Interestingly in this model the quality variable is not associated with total costs and this variable is only significant when included with total doses. Quality and expected efficiency on its own is therefore not a predictor of total cost.

In all four models the price per FTE hour is not significantly associated with total cost. All the environmental variables other than the facility type, i.e. distance to vaccine collection point, number of CHW, immunization sessions per week, energy source and the district deprivation index, were tested with the basic model but were not found to be associated with total facility cost.

b) Total cost *excluding* salaried labour and vaccine cost model

As previously described, in these models the same independent variables were analyzed but the dependent variable excluded salaried labour and vaccine costs (models 5-8 in Table 6-3 below). The purpose of this exercise was to examine the determinants of service delivery costs excluding labour.

In all three models that include total number of doses (Models 5, 7 and 8) the total number of doses is statistically associated with the outcome at the 1% level of significance. The association predicts an increase in non-HR service delivery costs but the coefficient value is lower than in the total cost models and ranged from 0.38 (Models 5 and 8) to 0.49 (Model 7). In other words a 10% increase in dose results in an approximate increase in costs of between 3.8% and 4.9%. When estimated doses were included as opposed to observed doses, only the square metres variable was positively associated with non-HR service delivery costs.[103]

The other variable consistently associated with non-HR service delivery costs was the number of square metres. In all four models the association was positive and at the 1% level of significance. An increase of 10% in the number of square metres resulted in and approximate increase of between 4.2% (model 8) and 6.4% (model 6). The relatively strong association can be explained by the fact that the square metres are not only an indication of the physical size of the facility but also constitutes, to some extent, a proxy for number of outreach visits and zones supported as a value was included in this variable for each zone supported. Costs such as travel, allowances and capital costs would increase therefore as the value of this variable increases.

[103] The related model is not shown among models in Table 6.3.

Table 6-3: Regression results for total facility cost and costs excluding HR and vaccines

	Ln Total facility cost (n=51)				Ln Total cost excluding vaccines and salaried labour (n=51)			
	Model 1*	Model 2*	Model 3*	Model 4*	Model 5*	Model 6*	Model 7*	Model 8*
Quantity Ln Dose	0.75 (0.05) <0.01			0.55 (0.07) < 0.01	0.38 (0.12) <0.01		0.49 (0.12) < 0.01	0.38 (0.10) < 0.01
Ln Doses estimated		0.58 (0.10) <0.01						
Quality Ln DTP3 / FTE	-0.49 (0.06) < 0.01	-0.27 (0.10) ,0.01	0.05 (0.19) 0.68		-0.36 (0.14) 0.01	0.08 (0.13) 0.54	-0.23 (0.14) 0.11	
Price Ln cost / FTE Hour	0.17 (0.25) 0.50	-0.61 (0.43) 0.16	-0.92 (0.56) 0.11	-0.58 (0.34) 0.10	-0.63 (0.60) 0.30	-1.40 (0.63) 0.03	-0.71 (0.58) 0.22	-1.07 (0.54) 0.05
Capital Ln SQM	0.19 (0.05) <0.01	0.27 (0.08) < 0.01	0.46 (0.11) < 0.01	0.13 (0.08) 0.11	0.58 (0.11) < 0.01	0.64 (0.13) < 0.01	0.43 (0.12) <0.01	0.42 (0.12) < 0.01
Facility type urban rural			- -0.28 (0.20) 0.17	- 0.43 (0.15) 0.01		- 0.24 (0.23) 0.31	- 0.65 (0.25) 0.01	- 0.78 (0.24) < 0.01
Distance to vaccine collection point				-0.01 (0.03) 0.76			-0.05 (0.05) 0.27	-0.51 (0.05) 0.28
Constant	6.00 (0.49) <0.01	7.10 (0.88), <0.01	10.06 (1.06) <0.01	5.80 (0.81) < 0.01	6.77 (1.18) <0.01	8.18 (1.19) < 0.01	5.44 (1.26) < 0.01	5.54 (1.28) < 0.01
R-Squared	0.89	0.63	0.38	0.76	0.56	0.48	0.62	0.60
F statistic	F(4, 46) = 89, <0.01	F(4, 46) = 19, <0.01	F(4, 46) = 7, < 0.01	F(5, 45) = 28, < 0.01	F(4,46)= 15, < 0.01	F(4,46)= 11, < 0.01	F(6,44) = 12, <0.01	F(5,45)= 13, < 0.01

* ß, Standard Error, p-value
See Annex 11 for presentation of Confidence Intervals

Removing doses from the basic model and including the facility type (Model 6) results in the cost per FTE hour and square metres being associated with costs. In this model the cost per FTE hour is associated with cost (5% level of significance). The association is however a negative one suggesting a decrease in costs of approximately 14% for a 10% increase in FTE hourly cost. Interestingly, there is also a relatively large negative correlation with costs in most models. The simple average cost per hour for FTE staff in rural and urban facilities is almost identical and the cost per hour is therefore not a proxy related to facility type.

In Models 7 and 8 the facility type was included as an independent variable together with number of doses. In both models the facility type was positively associated with non-HR service delivery costs at the 1% level. The association suggests an increase in these costs when comparing rural facilities with urban facilities other factors being equal. This corroborates the findings from the costing section that allowances and travel costs in particular, are higher in rural facilities than in urban facilities. The facility type has replaced the quality variable as a better predictor of non-HR service delivery costs in Models 7 and 8. The only model in which the quality variable was significantly associated with non-HR service delivery costs was Model 5, where the facility type was not included. The model with the highest R-squared value of 0.62 is however Model 7 which includes both the quality and the facility type variables.

From a practical planning perspective, given that the quality variable value will often not be known, Model 8 is probably the most useful. Total non-HR service delivery costs can be estimated if there is data on quantities of doses, facility type and square metres.

6.4 Discussion

It is not unexpected that the determinants of total costs and non-HR service delivery costs include variables which are drivers of vaccine, salaried labour and allowance costs. The total number of doses is a direct driver of the vaccine cost and one of the drivers of the number of immunization staff employed at facilities and the amount of time allocated to routine immunization. The number of children per FTE staff is in turn indicative of the staff costs for a given level of doses and in almost all models the size of the facility, inclusive of outreach zones, is associated with cost. The facility type is a predictor of total cost when the quality variable is omitted but is more consistently associated with non-labour and vaccine delivery costs.

In all models that exclude staff and vaccine costs, the quantity variable is still associated with costs, but the influence of doses is reduced when compared to the total costs models, i.e. the coefficient value is consistently lower. This would be expected as total costs are heavily affected by costs such as vaccines, which are directly linked to number of doses.

When compared to the results of other studies (Section 6.1), this analysis corroborates the findings that the total number of doses is strongly predictive of total costs. Also the quality variable and the facility type, both proxies for service delivery strategy (facility based vs. outreach), are associated with total costs and this association is also consistent with findings in other countries.

However the number of immunization sessions, highlighted as a predictive variable in other studies, was not statistically significant in multiple regression models for Zambia, where the number of doses was a dominant association. It is probable that the number of immunization sessions, expected to be associated with costs, is adequately represented in the other variables such as the difference between urban and rural facilities and number of doses.

Most rural facilities provided immunization services on a once a week basis while the larger urban facilities typically provided multiple sessions during the week.

Of interest, the facility type was only predictive of costs when included together with a quantity variable, which implies that the facility type on its own is not predictive of facility cost. This is consistent with our observation that there is high variability of facility size and cost within the urban and rural strata.

Other than the facility type, the environmental variables were not associated either with total cost or non-HR service delivery costs when included with the basic model. This is the case even where we expected an association of costs with, for example the distance from the vaccine collection point and the district material deprivation index. As mentioned above, it is likely that these characteristics are adequately represented by the quality and facility type variables.

Our expectation that the price variable would not be significantly associated with total costs was confirmed. The significant negative association of the price variable with two no-HR service delivery cost models (and consistent high negative but non-significant correlation in most other models) was unexpected, especially in light of the fact there were no HR costs in the outcome and that the quality and / or the facility type variables were included in these models. The reason for this association is not clear but it suggests that use of better qualified or experienced staff who are more expensive may actually reduce overall costs through certain efficiencies. Alternatively, the variable could be a proxy for another factor as human resource costs are excluded from the outcome in Models 5-8. Also the simple average hourly costs for immunization staff in the urban and rural strata are almost identical.

A key objective was to not only determine key cost drivers but also to provide a potential tool which planners could use to predict the cost of new facilities. This arguably, requires a regression model which establishes a balance between predictive accuracy and complexity and usability. Importantly, the value of variables in the model needs to be known for new facilities. In this regard it is encouraging to note that with the expected number of doses, the price per hour for staff, the size of each facility and the facility type (Model 4) the total facility cost can be predicted with reasonable accuracy (R-squared 0.76). The linear relationship between the catchment population and total doses makes it possible to estimate total expected doses in a new catchment area and other variable values are known. The same four variables are also reasonable predictive of non-HR service delivery costs, should there be a need to examine these more closely (model 8, R-squared 0.6)

The high variability of costs around the average should however be remembered. Thus the model is likely to be most useful for estimating costs at program level across a number of facilities. For individual sites, specific characteristics of those sites will need to be considered, and plans should assume that there will be need for some flexibility and adjustment as information on actual implementation becomes available. Consideration of specific circumstances is likely to be even more important for rural health centres, where greater variability is observed.

Using the model referred to above, the cost of an additional dose, administered as part of the routine immunization program is US$ 1.68 (95% CI US$ 1.57 ; 1.81).

6.5 Conclusions

The examination of determinants of both total immunization facility costs and service delivery costs excluding vaccines and HR, confirmed our expectation and the finding of previous studies that the determinants of the two most important cost drivers, human resource costs and vaccine costs, are closely associated with total costs.

In multiple regression models the quantity and quality determinants predictive of *total facility cost* were the total number of doses administered by the facility and the number of immunization DTP3 children per FTE staff member. The size of the facility was associated with total costs in most total cost models. In the basic model the price variable was not associated with total cost. Of the contextual variables, only the facility type and setting was associated with total costs and only if the quality variable was removed. Number of zones supported, distance from vaccine collection point, immunization sessions per week, energy source and the district poverty index were not associated with total cost when included in the basic model.

In regression models which examine the determinants of non-HR service delivery costs, similar patterns emerge with some exceptions. In all models the quantity variable is associated with costs, but the strength of association is reduced when compared to the total costs models. The quality variable is only associated with costs if the facility type is excluded. Including the facility type, results in the quality variable not being associated with costs, but in a strong association between facility type and costs. In all models the size of the facility is statistically significant.

Planners are likely to be able to estimate with a reasonable degree of accuracy what the total number of doses is likely to be for new or existing facilities, given the catchment population and the anticipated coverage rate for that population taking into account the setting and coverage at similar facilities in that district. Together with the facility type, size of the facility and the expected cost per FTE hour, it is possible to predict, with this relatively simple regression model the cost of new facilities and the costs associated with non-HR service delivery.

7 Analysis of Financial and Commodity Flows for Routine Immunization

7.1 Background: health care financing, immunization planning and budgeting

As highlighted in the National Economic Management Cycle, budget ceilings for the health sector and other government ministries are decided through a process involving the Ministry of Finance, Cabinet Office, parliament, and all sectors in the country. The Ministry of Finance begins by estimating the total resources available in the country after which constitutional and contractual expenditures are made. This includes domestic and international debt servicing, affiliation to international organizations, and counterpart financing for projects and programs based on agreements with bilateral and multilateral agencies. After this process, the Ministry of Finance makes an expenditure proposal to cabinet based on the country's macroeconomic and fiscal framework. The various sectors, including health, are then provided with annual budget ceilings. From these, budget ceilings are set for districts, provinces, departments and units under their mandate. In the health sector, resource allocation criteria are used to allocate the operational grant to all the districts in the county.

At the central co-coordinating level, MOH provides policy direction and technical guidelines, resource mobilization and allocation, and monitoring and evaluation. The functions of the MOH at the headquarters are provided at a more decentralized level by the provinces. District structures, through district health offices, oversee policy guidance of health program formulation and implementation at the district level. Specifically, this includes oversight of planning the medium term work plan and budget, implementation of health care provision, and related public health services in the district. The plans and programs of all stakeholders in the communities and health facilities are reflected in the district annual work plan.

Community level activities are incorporated into the health facility action plans, which feed into the district annual action plan. Once the districts finalize their action plans, they submit them for approval to the Provincial Medical Office where a contract is signed.

7.2 Methods for the quantitative analysis of financial and commodity flows

7.2.1 Data collection and key assumptions

Broadly speaking the purpose of the financing analysis is to develop an understanding of how the EPI is funded, and to attempt an analysis of how the available funding is expended in terms of the expenditure line items and functional activities defined as part of this study. The purpose suggests a 'top-down' approach which has as its starting point the source of funds for the EPI. Once the source of funding has been identified an attempt has been made to trace and document the flow of funds as these are transferred to the intermediary and recipient institutions and subsequently expended on the EPI.

This 'mapping exercise' does not constitute a full resource tracking analysis and is therefore largely dependent on the available funding and expenditure reports produced routinely by the affected institutions. This has resulted in a number of limitations which are described in more detail below.

For the purposes of data collection the following methods were applied:

- Two financing questionnaires were developed, one for the National Ministry of Health and another for donor organizations supporting the EPI. The national Ministry questionnaire asked the Ministry to identify the source of its funds as well as how these are either transferred or expended. The donor questionnaire sought to quantify the funds available and transferred by each donor in support of the EPI.
- Provincial and district level questionnaires asked respondents to indicate whether any funds or other support had been received other than from the MOH for the EPI.
- The MOH detailed general ledger expenditure report for 2011 was interrogated and certain district data further analyzed in order to isolate total expenditure on the EPI. However, vaccine expenditure by the MOH is the only EPI item recorded separately in the ledger, and not consolidated with other program costs.

As indicated above, the major portion of EPI funding for expenditure other than human resources and vaccines is included in the annual transfers from the MOH to districts in support of their respective action plans. As the general ledger does not record expenditure separately for the EPI, it is not possible to extract the EPI total expenditure by district from the general ledger without further analysis. In order to estimate the EPI expenditure by districts based on actual expenditure, the following analysis was undertaken:

- For the nine districts in the sample, the total EPI cost excluding HR, vaccines and capital expenditure was estimated by applying the appropriate weighting to the corresponding costs for the selected facilities in those districts.
- Actual district expenditure (excluding hospital expenditure, HR and capital expenditure) was extracted from the general ledger in sampled districts and the estimated EPI cost as a proportion of the total actual expenditure was calculated.
- This proportion was then applied to the actual district expenditure (for relevant line items as described above) for all districts in the country to arrive at an estimate of EPI expenditure at district level.

Given that HR expenditure is consolidated at all levels in the ledger, the financing analysis reflects the aggregated cost of salaried labour calculated in the costing in the absence of a feasible alternative for identifying and isolating EPI human resource expenditure.

7.2.2 Coding and analysis

An Excel database was developed for capture of financing flow data and the subsequent analysis of these flows both by expenditure and activity. To facilitate analysis, a system of coding was developed as part of the Common Approach guiding the studies.[2] This allowed each transaction to be classified in terms of the source of the funds, the intermediary recipients, the service delivery agent, the expenditure category and the activity. These codes were largely based on the System of Health Accounts (SHA) 2011. More specifically the system of codes comprised the following main categories:

- Financing Sources (FS codes) which classify the funding source at country level. Sub-categories were developed to describe specific donors, commodity transfers and in-kind receipts
- Financing Agents (FA codes) which are typically government institutions which act as conduits for funding from the source to the health care service providers
- Health Providers (HP) which are components of the health system responsible for service provision and include the various levels of health care facility
- Health Care Functions (HC) comprise the activity and functional classifications previously described in this report
- Factors of production (FP) that reflect expenditure line item classifications

For the Health Care Functions (HC) further disaggregation was required since the SHA only has one code for all immunization activities (HC.6.2), and this mapping required more detail. Given the limitations described below, associated with the lack of disaggregation of transaction in the national system of accounts, it was also necessary to develop codes which provided for transactions which could not be allocated accurately either to activities or expenditure line items. A detailed list of the classification codes is attached as Annex 6.

7.2.3 Limitations of the approach

The single largest limitation of the analysis of financial flows results from the general ledger structure and the account definitions in the MOH accounting system. The ledger expenditure accounts are not classified according to SHA codes, which makes it difficult to allocate actual expenditure according to those codes. Although vaccines are separately identified, all other expenditure is allocated to only 3 or 4 expenditure line items, such as human resource costs, outreach costs and operational costs. Within these line items there is no allocation to health programs and the national accounts favour a split by operational units. Operational units are defined at the level of PMOs, DMOs, hospitals and specific operational and support units at national level. Accurate identification of expenditure to the EPI is therefore not possible. Similarly the ledger does not facilitate the allocation of expenditure to activities, so significant amounts estimated as part of this analysis remain consolidated and cannot be disaggregated further.

The approach described above allocates total district operational expenditure (excluding HR and vaccines) to the EPI based on observations from a small number of districts. Actual operational EPI expenditure for the country may thus differ from the calculated estimate.

During data collection it became apparent that certain private sector donors and NGOs provide invaluable financial or in-kind support to the EPI (see below). These contributions are made directly to the PMO or DMO and are not channeled via the national MOH and the budget system. A number of donors may thus not have been listed as sources of finance and the total financing to the EPI may be understated. However, given that human resources and vaccines comprise by far the largest share of EPI costs, it is unlikely that these omitted contributions are material within the context of the total financing.

This analysis makes use of the GAVI disbursement and payment schedule to calculate the finance contribution with respect to vaccines. In the absence of good stock records in Zambia it is not possible to tell how much of this contribution was consumed and how much resides in stock. The actual value of vaccines consumed may therefore be different to the financing provided for the procurement of vaccines.

7.3 Mapping of financial flows

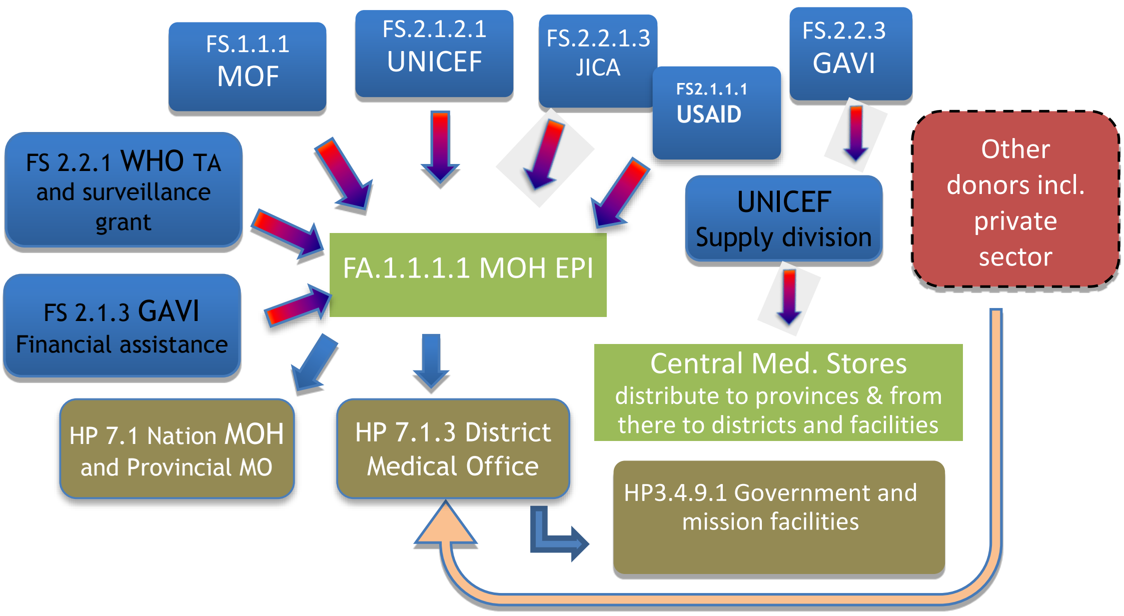
In Zambia the funding of the EPI is relatively simple. The figure below provides an overview of the funding map as it applied in 2011. The most significant contributors to the program are the Ministry of Finance and GAVI through the contribution of mainly vaccines but also financial assistance. A number of other partners however provide valuable support. The most important financiers of the EPI include:

- The Ministry of Finance (MOF) provides funds to the MOH through the budgetary system. These transfers provide for human resource costs at national level, vaccine purchases, support services and transfers to provinces and district medical offices. Provincial and district medial offices transfer operational funds to hospitals and health facilities and incur certain costs on behalf of health facilities such as utility costs. Health facilities are funded by the district medical office.
- The largest contribution from GAVI is funding of vaccines. In 2011 these funds were

used to procure Pentavalent vaccine. The funds are forwarded to the UNICEF supply division which procures the vaccines and then arranges for the delivery of the vaccines to the national central medical stores. In addition, GAVI supports the EPI with health system strengthening grants and grants to support the introduction of new and under-utilized vaccines.

- Other important partners include the UNICEF in-county office which supports the EPI in a number of ways and also funds a portion of the annual Child Health Week costs, campaign costs and new vaccine introduction costs. In 2010 JICA provided support through procurement of vaccines and technical assistance, but no financial or in-kind contribution from JICA in 2011. The WHO country office employs a logistician to provide on-going technical support to the EPI. WHO also funds some technical support and contributes to disease surveillance and campaign costs.
- During data collection, it became apparent that there are a number of smaller donors who from time to time provide financial or in-kind support directly to DMOs or PMOs. These smaller donors include NGOs and private sector companies which may support the implementation of child health weeks or contribute to capacity building costs. These contributions are poorly documented as they do not result in a financial flow through the district accounting system e.g. where transport is provided or allowances are paid directly to community health workers. Similarly, physical infrastructure provided by mission hospitals and facilities is not accounted for in the funding flow as there are no rental or similar payments.
- During 2011, CIDA and CIDRZ supported the procurement of additional cold chain equipment for the EPI.

Table 7-1: Map of major funding flows and support



7.4 Results of the quantitative analysis

7.4.1 Sources of finance and funding agents

The table below summarizes the source of financing and allocates the EPI funding to the finance agents or intermediaries for routine immunization activities. As described above, the intermediaries allocate the received funding to the providers of health and other services. By far the biggest contribution to the EPI is derived from the MOF and amounts to a total of $32.1 million and comprises 82.3% of the total estimated EPI funding requirement.

This contribution comprises primarily the contribution to salaries and wages ($19.7 million), PMO, DMO and health facility EPI operational costs ($9.5 mil) and procurement of vaccines ($2.4mil). The government contribution to procurement of vaccines includes the government's co-financing obligation. The annual progress reports submitted to GAVI reflect the co-financing contribution as $397 760 (124 300 doses) and $586 447 (191 540 doses) for 2011 and 2010 respectively.[104] Most of the funding, other than the procurement of vaccines, is channeled through the MOH which therefore acts as an agent for a total of $30 million.

The second largest financing source is GAVI. The bulk of the GAVI contribution comprises a funding transfer to the UNICEF supply division. These funds are used to procure vaccines and the procured vaccines are then delivered directly to the Central Medical Stores for distribution to provinces, districts and facilities. A total amount of $5.7 million was disbursed for 2011, but it is not clear from stock records whether the product associated with these disbursements was consumed during the 2011 program year. It is probable that there is some carry-over of vaccines from the previous year and a carry-over into the next year. The 2010 disbursement for vaccines was very similar in value ($5.5 million) and it is therefore likely that the two carry over amounts are similar and at least partially off-set each other. In addition GAVI supported the EPI with cash grants amounting to $145 991 to improve HMIS capacity and to support program management at central level.

Finally, UNICEF made a cash contribution to the EPI ($330 943) for a range of purposes including improved HMIS capacity, social mobilization and child health weeks, maintenance of the cold chain and support to program management.

The 2011 country progress report submitted to GAVI reports financing for surveillance of $348 000 by the WHO. These funds were used to employ permanently seconded staff which includes an EPI Team Leader, a National Program Officer (surveillance), four surveillance officers and a logistician. USAID contributed $325 000 to child health support in 26 districts which includes, but is not exclusively for, the EPI. In consultation with the National Program Coordinator 60% of this value was allocated to the EPI.

Table 7-2: Financing for 2011 by source and agents in US$

	MOH EPI	USAID	Central Med Store	Total	Share of total
Source					
GAVI			5 736 924	5 736 924	14.8%
UNICEF	330 943			330 943	0.8%
JICA			152 336	152 336	0.4%
MOF	29 684 067		2 392 781	32 076 848	82.3%
GAVI	145 991			145 991	0.4%
WHO	348 000			348 000	0.9%
USAID		195 000		195 000	0.5%
Grand Total	**30 509 001**	**195 000**	**8 282 041**	**38 986 041**	**100%**

Note: JICA made an in-kind contribution of BCG vaccine received at the end of 2010 but consumed in 2011.

Other funders that supported the EPI include World Vision International, Merck

[104] These values may not agree with the final value attached to the co-financing calculated by GAVI due to price variations.

Pharmaceuticals and Communication Support for Health but contributions were not quantified. The support provided by these three organizations is also not EPI specific but included activities which support it through for example, training and capacity building of clinical staff. As noted above, funding may have been provided from a number of other external sources which would not have been included in routine reporting. Where the private sector or other donors make contributions, for example to child health week activity, the funding agent is likely to be the PMO or the DMO, as it is unlikely that such funding is made available directly to health facilities. Without a more extensive review of the district accounts and additional data collection at district and provincial level, it is not possible to estimate the total value of contributions that fall into this category.

In addition to the financing flows above for routine activities of the EPI, the following contributions were received for procurement of equipment in 2011:

- CIDA - $552 847 for cold chain equipment and $192 308 for other equipment
- CIDRZ - $270 000 for cold chain equipment.

It is likely that many of these purchases were both for the replacement of obsolete equipment and in preparation for the introduction of new vaccines.

As the study methodology relied on the routine EPI costing study to generate some financing estimates it was not possible to capture all financing for the EPI for 2010. Table 7.3 below however summarizes the most important sources of EPI financing in that year. The figures *exclude* significant government contributions for human resources and transfers to districts for operational funding. The FAVI contribution for vaccines was slightly lower in 2010, while government expenditure on vaccines and supplies is similar in both years. GAVI support for non-vaccine expenditure was $108 384 more in 2011 and was allocated primarily to strengthen program management, supervision and surveillance. However, it also included procurement of cold chain equipment mainly for outreach services. The WHO allocation was higher in 2010, but a detailed breakdown of support was not provided. USAID probably made contributions to the EPI in 2010 of a similar magnitude to those in 2011, but no amount was reflected for USAID in the progress report.

Table 7-3: Financing for 2010 by source and agents in USD

	MOH EPI	Central Med Store	Total	Share of total
Source				
GAVI		5 500 721	5 500 721	59%
UNICEF	387 093		387 093	4%
MOF	176 079	2 352 197	2 528 276	27%
GAVI	254 375		254 375	3%
WHO	656 325		656 325	7%
Grand Total	**1 473 872**	**7 852 918**	**9 326 790**	**100%**

7.4.2 Transfers from funding agents to service providers

Table 7.4 below summarizes the flow of funding from financing agent to service provider. All vaccines provided by both GAVI and the MOH via the Central Medical Store are ultimately consumed in service provision at health facilities supporting the EPI. By far the majority of these are government facilities. As previously described, some district hospitals and health centres are mission facilities but, even though the infrastructure may not be government owned, service provision is substantially similar to that provided in government facilities. The proportion of vaccines delivered in mission facilities is insignificant.

The national management structure of the MOH (EPI) has been classified as a service provider with respect to funds ($1 279 482) allocated to it for program management, central vaccine storage and distribution, cold chain maintenance and surveillance activities. Similarly EPI funds allocated to the PMOs ($1 020 819) are not typically distributed to districts but are consumed at the provincial level for program management, assessments, vaccine storage and cold chain maintenance. On the other hand the bulk of the funds allocated to districts are expended to support service delivery at the facilities and district transfers have therefore been allocated to government health facility service provision.

Table 7-4: Transfers from finance agents to service providers ($2011)

Row Labels	MOH EPI	USAID	Central Med Store	Total	Share of Total
National MOH	1 279 482			1 279 482	3.3%
Government facilities	28 208 700		8 282 041	36 490 740	93.6%
Provincial MOH	1 020 819			1 020 819	7.9%
Private research institutions		195 000		195 000	0.5%
Grand Total	**30 509 001**	**195 000**	**8 282 041**	**38 986 041**	**100%**

7.4.3 Allocation of funding to expenditure categories and line items

Table 7.5 below summarizes the allocation of funding provided by sources of finance to expenditure line items. Unfortunately it was not possible to obtain an accurate analysis of the allocation of finances to expenditure line items within the scope of our analysis. As a result expenditure was frequently allocated to the item' Not disaggregated' or 'Other'. However, this analysis confirms that the major portion (97.5%) of the contribution from GAVI comprises vaccines and related supplies. The JICA contribution comprises only vaccines donated. 61% of the contribution from the MOF comprises a contribution to wages and salaries at all levels of the health system, but most of this relates to service provision at health centres. The bulk of the $9.6 million (30% of the MOF total), which has not been disaggregated is an estimation of the operational costs incurred by districts in support of the EPI and includes utilities, maintenance, travel allowances, vehicle costs and other operating costs. The financing of vaccines and supplies ($2.4 million) comprises 12% of the expenditure financed by the MOF.

Although funds received from UNICEF were not specifically allocated to expenditure line items, we can infer what these might be from the activities undertaken. In 2011 the $221 501 (of the $330 943) was incurred to support Record keeping and HMIS. These expenditures are likely to have included technical assistance and supplies related to the HMIS system. The support form WHO can be allocated to the salaries and wages associated with seconded staff and although not confirmed, it is likely that much of the USAID funding also comprises salaries and wages.

Table 7-5: Allocation of finance from sources to expenditure categories for 2011

Row Labels	GAVI	JICA	MOF	UNICEF	WHO	USAID	Grand Total

Cold chain equip.			391 523				391 523
Maintenance				-			-
Not disaggregated	41 729		9 603 248	44 285		195 000	9 884 262
Other	104 262			221 501			325 763
Travel allowances				65 157			65 157
Vaccines and other goods	5 736 924	152 336	2 392 781				8 282 041
Wages and salaries			19 689 296		348 000		20 037 296
Grand Total	**5 882 915**	**152 336**	**32 076 848**	**330 943**	**348 000**	**195 000**	**38 986 041**

Further tables and graphs of Financial Mapping results are provided in **Annex 15**.

7.5 Results of the qualitative assessment

7.5.1 Comparison with cMYP estimates of financing and aggregated costs

The latest cMYP for Zambia covers the period 2012 to 2016 and uses 2010 as the base year, which theoretically should reflect actual costs as closely as possible. Unfortunately this version of the cMYP does not include 2011 as a forecast year and a direct comparison for 2011 in this latest version is therefore not possible. An older version of the cMYP presents estimates for various years which are significantly different to the latest version. The older estimates already include new and underutilized vaccines for 2011, while the latest version only starts to provide for them from 2012. For the purposes of comparing financing estimates in this report with those in the cMYP the base year in the current cMYP has been identified as the most meaningful and accurate comparator.

Table 7-6: Comparison with financing in the cMYP

Calculation method	Total need / cost- routine	Funding secured	Funding Gap	MOF / MOH	GAVI	UNICEF	WHO	Other
cMYP 2010 base year	33 179 997	32 142 678	1 037 319	25 164 163	5 374 848	380 000	714 348	509 319
Costing study estimate 2011	33 944 849	38 600 864	- 4 656 015	31 685 325	5 889 260	330 943	348 000	347 336

Note: Total EPI resource requirements and cost estimates exclude capital costs

In the CMYP the government contribution to financing the EPI is usually derived from the estimated costs and not from expenditure records. In other words in the CMYP many contributions are the same as the cost estimate. This approach creates an inevitable alignment between the estimated costs and the value of government financing. The costing study approach differs in that the aggregated national costs are derived from the facility based costing and the available funding from an apportionment of *actual expenditure* incurred and from data obtained from financing sources. One consequence of this difference in approach is that the shared expenditure estimated by the costing study is much higher than that provided for in the cMYP (as described above) which results in the significant difference between the MOF funding contribution when comparing the cMYP with the costing study result which has a much higher value.

According the cMYP the total financing available for the 2010 base year was $32.142 million which resulted in an estimated funding gap for the EPI of $1.037 million or 3.2% of the resource need for routine activities. The gap arises mainly due to the fact that there is inadequate funding for national level staff ($203 136) and for travel allowances ($586 656).

All other routine expenditure items are covered mainly with government financing except for vaccines which are largely paid for by GAVI. Other donor funding has been allocated to social mobilization, disease surveillance, capacity building and program management.

In Table 7-6 above, the study estimate of funding secured for the EPI appears to exceed the total estimated national EPI cost by $4.656 million. The following may be reasons for the difference:

- Expenditure incurred on vaccines by the MOH, GAVI and JICA in 2011 exceeds the estimated cost by $1.986 million. A portion of the government expenditure includes the cost of TT. This was excluded from the cost estimates but only explains approximately 56% of the difference.
- Estimates of District transfers for the EPI have limited accuracy and may thus be overstated. This could result in overstatement of government's contribution.
- Other once-off expenditures reflected in the contributions from financing sources are not part of routine EPI expenditure estimates. For example, the cost of upgrading and expanding the capacity of the HMIS systems funded by partners is in essence a capital expenditure and is not reflected in the routine cost estimates.

The government contribution in the cMYP is $6.521 million less than the government contribution reflected in the costing study calculation. To some extent this might be due to the effects of inflation, but the main reasons are:

- The costing study estimates a much higher facility based routine salary and wages cost than the cMYP. In both calculations salaries and wages are funded by the government, which results in a difference of $10.2 million in the government contribution.
- In the costing study the government contribution to vaccine purchases is higher than in the cMYP ($1.062 million).
- These increased levels of actual funding are counterbalanced by high estimates for funding of other expenditure line items in the cMYP. The biggest discrepancy is in estimates of travel allowance expenditure, which in the cMYP is significantly higher than in the costing study. The combined difference of expenditure on such line items (above the estimates from this study) amounts to $4.398 million.

7.5.2 Other observations

The government ledger structure does not facilitate the tracking of resources from source to point of expenditure. One might argue that it should not necessarily have to do so, unless donor partners have earmarked funds for specific uses which require separate reporting. However, once partner funding is consolidated with the general budget, the funding loses its specific identity and it becomes difficult for government or partners to identify what the funding was spent with any accuracy. To aggravate the situation, as previously explained, the ledger structure is built around functional units and separating shared expenditure between different health programs becomes difficult. A further issue is that in certain instances donations may be made which may not necessarily be reflected as income in the accounts although this is likely to be mainly in the case of in-kind contributions at lower levels of the health system.

Another issue of note is that there is no single system which *accurately* captures all donations received from partners and other donors and also reconciles figures in government reports to those in donor reports. Although this type of reconciliation may not always be possible it should be feasible to establish a system which accurately records all donations and the primary purpose of these donations at all levels of the health system above facility level.

The highest value expenditure item, salaried labour, is the one that is most difficult to allocate accurately from the ledger. Almost all salaried labour comprises a shared expenditure and ability to trace human resource costs through to health programs is currently limited by the absence of a comprehensive activity analysis. Allocation of human resource costs to programs, would require a unit wide activity analysis at mainly the facility and district levels, i.e. not just of one program, in order to establish more accurate tracing factors which could then be applied to allocate human resource expenses in the ledger to different health programs. A similar unit-wide analysis could be carried out to generate accurate tracing factors for allocating shared overhead costs.[105]

7.6 Discussion

The routine and recurrent activities of the EPI appear to be adequately funded before taking into account the cost impact and resource requirement of new vaccines. However this assumes some level of flexibility to reprogram overall funding to meet under-budgeted needs as there appears to be over- and under-funding in various areas.

The Zambian government makes a significant contribution to the program which has been estimated between $25.1 million (cMYP 2010) and $32 million (this study) which covers between 76% and 83% respectively of the EPI routine program resource requirement. The balance is currently met almost entirely by the procurement of vaccines by GAVI with other partners making smaller but valuable contributions.

The sustainability of the EPI program depends to a large extent on whether additional funding can be secured for increased resource requirements associated with the introduction of new vaccines, the second dose of measles, improved coverage of existing vaccines, a rapidly expanding population and the improved or more timely and on-going replacement and improvement of cold chain capacity. The cMYP estimates an increase of vaccine costs of just over $8 million dollars when comparing the 2012 estimate with the base year. In 2013 the cost of vaccines and supplies increases to over $25 million which comprises a further $10 million increase. The estimated cost of vaccines and injection supplies escalates by approximately $4 million each year thereafter as the coverage of newly introduced and under-utilized vaccines improves. In 2016 the vaccine and supplies cost is estimated at $34.5 million, approximately $29 million more than in the base year.

Once-off capital expenditure is estimated in the cMYP at $3.2 million and $3.6 million for 2012 and 2013 respectively with no estimated cost in subsequent years. The Zambia Vaccine Cold Chain Scale-Up Strategy 2011 estimates the cost of additional cold chain capacity at approximately USD $2.1 million at national level and USD $5.2 million at provincial level. This funding requirement will apparently be funded by the government and other partners but amounts are not specified.

The key sustainability issue is how the cost of additional vaccines will be funded in the long run and more importantly if GAVI cannot fund the increase, whether the MOH could potentially absorb the increase in the existing health budget. The cMYP examines the issue of sustainability and reflects total health expenditure for Zambia of $613 million for the base year (2010). Of this expenditure the government contribution is $325 million which suggests that other health programs are more heavily subsidized by partners than the EPI.

[105] Of note, the *OneHealth* planning and costing tool, recently launched by WHO, has not been designed to facilitate allocation of human resource cost to health programmes. The tool aims to cost the direct costs of health programmes by programme but then requires users to estimate the total human resource requirement to provide a suite of health services at different levels of the health system. This approach is thus unlikely to encourage a change in leger structures and has been designed to accommodate ledgers in most countries which do not allocate human resource costs to programmes.

In 2011, government's contribution to the EPI ($32 million) comprised 8.25% of total government expenditure on health of $388 million. The routine EPI expenditure referred to above for 2016 represents a 4.7% increase on the government 2010 health budget and an 8.7% increase in governments funding contribution to health. On a cumulative basis this represents an increase in the health expenditure of approximately 2.5% and 3.1% in the first two years with an annual increase thereafter of 1% per annum. However, the total increase in vaccines and supplies referred to above comprises a 90% increase of the 2011 government contribution to the EPI program over five years, an annual increase of approximately 15% per annum. These are significant increases given that that there is likely to be limited fiscal space within which to maneuver. The expectation of relatively slow economic growth rates (the cMYP anticipates GDP growth of 2.8% for much of the forecast period) would mean that any increase in the health budget as a result of growing state revenues is likely to be offset by increased resource requirements due to population growth and all health programs reporting increased resource needs.

The sustainability of the EPI therefore seems likely to depend on on-going and increased funding from partners, combined with an increased contribution from government. The significant contribution which the state already makes to the EPI points to a commitment to the EPI and a strong sense of ownership. This should help to mobilize further contributions to it.

7.7 Conclusions

The mapping the financing of the EPI above, confirms the substantial contribution of government to the EPI mainly through shared resources comprising salaried labour, operational costs and infrastructure. The contribution of vaccines from GAVI comprises the next biggest share of total financing, with a total amount of $5.7 million disbursed for the 2011 program year, although it is probable that there is some carry-over of vaccines from the previous year and a carry-over into the next year.

As coverage levels for PCV vaccines increase and the Rotavirus vaccine is rolled out, vaccine costs and related resource requirements are likely to increase significantly. These may impact on the sustainability of the EPI as vaccine costs are expected to increase to $34.5 million by 2016. Although the increase may seem small when viewed as a percentage of the total health budget, securing the additional funding within government in a context of competing demands may be a challenge. However, it is likely that a significant proportion of the increase in resource requirements will be funded by external partners and donors for the foreseeable future.

A review of the general ledger reports generated by the national accounting system, which reflect budget and actual expenditure for the year, highlights that it is difficult to isolate and track EPI program resources and expenditure. The cost of salaried labour and other operating expenditure items at all levels of the system are reported by functional unit and are not disaggregated by program area. Government expenditure on vaccines is however reflected as a separate line item but excludes the contribution of vaccines by GAVI and other partners which comprise non-cash items. Although desirable, it is unlikely that the ledger system can be changed to reflect more accurately the expenditure on different programs. Should a more accurate split be required, it would have to be achieved through a comprehensive activity costing analysis for operational units. The accuracy of the ledger would also be improved if significant contributions in kind were reflected as income and expenditure in ledger accounts.

There appears to be no single record which accurately captures all on- and off-budget donations received from partners and other donors, and at the same time reconciles government reported figures to donor reports. Although this type of reconciliation may not always be possible, it should be feasible to establish a system which accurately records all donations and the primary purpose of these donations at all levels of the health system above facility level. Even if the system does not track resources through the system it would at least provide a more accurate indication of external financing, and its proportion of total financing, which will in turn support the planning and budgeting process.

8 Conclusions and recommendations

8.1 Main conclusions

The study estimation of routine immunization program costs has provided considerably more detailed information on costs to inform planning and financing of routine and new vaccine programmes. A number of key conclusions arise in areas investigated by the study.

Routine EPI program costs

The total national program economic cost was estimated to be $38.16 million for 2011. The estimated total routine EPI cost comprises approximately 5.4% of total expenditure on health and approximately 10% of government expenditure on health. Further analysis of the total national programme cost by functional area and line item reveals that:

- The bulk of routine programme costs (82%) were incurred at facility level. Costs at district level (14%) were also substantial, with small contributions at province and national levels.
- The most significant single cost item was labour which contributed an estimated 49% of total EPI costs. Vaccines contributed a further 16%, and travel and allowances 12%. Together these items comprised 77% of the total national EPI cost and efficient management of these resources is likely to be key to any efforts to improve cost efficiency or extend coverage.
- The most significant functional costs related to facility-based and outreach service provision which together contributed 51.8% to total costs and include mainly the cost of salaried personnel, vaccines, and allowances.
- Total supervision and program management costs amounted to a relatively high 18.6% of the total EPI cost. Significant expansions of the EPI and introduction of new vaccines, should thus carefully consider indirect supervisory and program management capacity requirements to ensure management is not overburdened.
- Other activities with substantial costs included social mobilization and advocacy and vaccine collection and distribution, which contributed 10% and 9% to total costs respectively.
- Recurrent costs contributed by far the largest portion of economic costs. Annualized capital costs contributed 11% of total costs. Within capital costs, vehicle costs were the largest, contributing 5.3% of total program costs mainly at district level. Cold chain equipment is a relatively small contributor to economic costs. However, up-front fiscal costs of capital items are important considerations.
- The economic and financial costs of the programme generally differed by only 2-4%. Thus, unrecognised economic costs seem unlikely to be a major consideration in current program planning.

A comparison with the cMYP highlights a number of substantial differences. The big difference in human resource costs can be explained to a large extent by the difference between 2010 salary scales which were used in the cMYP and the 2012 salary scales used for this study, and updated estimates of staff time allocated to immunization.

Profile of total and unit costs at facility level

The costing highlighted significant variation in the total costs and unit costs of facilities between, and also within, the rural and urban health centre strata. Important findings include:

- The total weighted average cost of urban health centres was higher at $34 441 per annum than that of rural health centres at $24 262. This would be expected as they generally have lower facility attendance and facility staff numbers.

- For both urban and rural facilities the activities which account for the highest costs are routine facility-based and outreach service delivery. However outreach is a larger contributor to costs in rural sites.
- Total vaccine costs generally comprise a much lower proportion in rural (16%) than urban facilities (47%). This is mainly due to the larger allocation of staff time to EPI activities per child in rural facilities.
- The unit costs per dose and per DTP3 for the sampled facilities highlight the variability between facility types. The total unit cost per DTP3 vaccinated child is $87.14 per child in rural facilities compared to $33.38 per child in urban facilities. The average district unit cost was estimated at $10.24 per DTP3 child and $1.11 per dose, an important consideration in planning and budgeting.
- There was wide variation of unit costs within facility types, particularly those with lower volumes, related particularly to staff and travel related costs.

Unit costs and efficiency

Unit costs and efficient use of staff capacity for immunization services are closely linked with service volumes and also whether a facility is urban or rural. Increasing staffing levels tends to increase cost per dose and reduce output per staff member. Other factors, including extent of outreach services, are however not consistently associated with efficiency. Importantly, below a threshold of around 10 000 doses per annum unit costs rise rapidly and there is high variation between facilities. Lower flexibility to adjust staffing to workloads in smaller facilities is an important consideration.

- Initial study of outliers and productivity drivers suggests that options such as task shifting or sharing, and reorganization of outreach and other services to enhance utilization volumes and economies of scale, may enhance efficiency of immunization and other PHC services in certain contexts.
- The reasons why some facilities cope with similar volumes with substantially different staffing levels is not completely clear.
- Vaccine wastage rates may also be a particular, significant influence on resource needs and efficiency but could not be studied due to limited records.

These factors need to be explored further, preferably in the context of comprehensive PHC services and systems, not just immunization alone. This may facilitate more detailed identification of feasible adaptations to health services to improve efficiency and coverage of all services including immunization.

From a planning and budgeting perspective the location and setting of any new facility or program expansion should be carefully considered. There are major impacts of the catchment population, facility attendance or number of children to be immunized, on the resulting efficiency and immunization unit costs. When developing plans and budgets for facilities below the lower volume threshold, planners should consider basing budgets on total facility costs and specific circumstances, as unit costs vary significantly for low volume facilities. As the majority of new facilities in Zambia are likely to be located in remote, rural settings, the latter approach to budgeting for the total cost per facility is more likely to be indicative of their likely cost.

Given the above findings, it is clear that using average total costs as a means of estimating costs of urban and rural facilities may not be the most accurate approach to predicting costs. More useful may be an approach that establishes benchmarks for different facility types based on the setting of the facility and expected attendance volumes.

EPI Program funding and funding flows

The Zambian government makes a significant contribution to the EPI program which was estimated as $32 million or 82% of the EPI routine program resource requirement in 2011. This exceeds the cMYP estimate of $25 million and 76% for 2012, as well as estimates of government percentage contributions from many other countries cMYPs.

The most important financial flows for the EPI in 2011 included the following.

- The Ministry of Finance (MOF) provided the $32.1 million to the MOH through government budgets. These transfers provide for human resource costs, vaccine purchases through UNICEF, support services and transfers to provinces and district medical offices. District medial offices transfer operational funds to all health facilities under the district and part for some items on behalf of facilities, such as utility costs.
- GAVI made the largest external contribution estimated at $5.7 million, of which most was used to procure Pentavalent vaccine. The funds are forwarded to the UNICEF supply division which then procures vaccines and arranges for the delivery of the vaccines to the national central medical stores. In addition to vaccine purchases, GAVI provides grants for health system strengthening and to support introduction of new and underutilized vaccines.
- The UNICEF county office funded a portion of Child Health Week costs, campaign costs and new vaccine introduction costs ($330 943). WHO employs a logistician to support the EPI, funds some external technical support, and contributes to surveillance and campaign costs.
- CIDA and CIDRZ supported the procurement of additional cold chain equipment for the EPI for $552 847 and $270 000 respectively.
- Some smaller donors give direct support to DMOs or PMOs from time to time. They include private companies that support Child Health Weeks or capacity building.

The Zambian government's significant contribution to the EPI points to a commitment to the EPI and a strong sense of ownership. However, a key sustainability issue is how the cost of additional vaccines will be funded in the short and longer term. If GAVI cannot fund the increase, it is uncertain how much of the increase in required expenditure can be absorbed by GRZ. The cMYP estimates an increase of EPI vaccine costs from around $8.2 million in 2011 to $34.5 million in 2016. This would be the equivalent of a 90% increase of the 2011 government contribution to the EPI program over five years, and an 8.7% increase in government funding of health care. Substantial reliance on partners to make contributions seems necessary for the foreseeable future: partners contributed an average of 38% of the total health expenditure between 2007 and 2010[106], there are competing demands from rapid population growth and other health needs, and there will probably be limited extra resources from economic growth.

The incremental costs of PCV introduction

PCV introduction costs in the year of introduction are a substantial addition to the overall costs of the Zambian EPI program. The estimated incremental recurrent economic cost to achieve 60% coverage is in the region of $ 7.1 million (fiscal cost of approximately $ 7.2 million after salaries are excluded). This suggests that sustaining the on-going cost of PCV coverage may be a material challenge to Zambia and its partners.

- The total incremental economic unit cost per dose in the year of introduction is estimated at $9.684 including start-up costs, similar to the average total economic costs per dose of $7,56 for the routine EPI. The incremental unit cost falls to $5.55

[106] Ministry of Health, 2007 – 2010 National Health Accounts.

per dose when start-up costs are removed. The fiscal total unit cost is $5.73 per dose, including start-up costs of $1.95 per dose. Estimated service delivery costs of $3.37 per targeted child are significantly higher than the GAVI contribution of 30c per birth (and also the new rate of 80c).

- The largest cost component by far was PCV10 vaccine and safe injection supplies. The estimated cost of the vaccine to achieve 60% coverage in the year of introduction was $5.888 million of which $1.177 million was buffer stock. So reducing vaccine cost is a key issue to enhance sustainability and cost effectiveness of PCV as part of the routine EPI.

A particular challenge for budgeting and costing of NUVI arises from uncertainties around realistic coverage targets and actual implementation timeframes. Over-estimating initial coverage rates may lead to an over investment in vaccines stocks, unnecessary wastage and unnecessary strain on existing cold chain, distribution and other capacity.

There are quite substantial differences between economic and fiscal costs due to the inclusion of salaried labour in economic costs but not in the fiscal cost. The decision by the MOH not to employ additional staff for new vaccine introduction the decision not to employ new staff does not necessarily mean that there is not a *need* for additional staff. Human resources are often allocated to immunization as a priority, and do not manifest as a clear funding or capacity gap. However, there are strong indications of constraints on availability of human resources in the health system at service and programme levels, and the study indicates that immunization programme management makes up a substantial proportion of PHC system management costs. There are clear opportunity costs of diverting resources from strengthening and increasing sustainability of the broader health system on which immunization depends. The economic cost of staff may thus not be an overestimate of incremental costs of NUVI. An accurate costing of the human resource cost of NUVI will require a more comprehensive assessment of staff capacity at facilities.

Uncertainties exist about the true cold chain capacity at facility level, and how much need there is for extra capacity related to PCV specifically. Much of the recent acquisition of equipment was to replace previous capacity rather than for new capacity for PCV (or other new vaccines). The data illustrate that cold chain costs can be a substantial part of the fiscal cost and funding applications, and can also be a major focus of NUVI planning. The NUVI process has *triggered* significant expenditure in cold chain in Zambia and other countries. NUVI processes therefor need to anticipate potential reasons for large scale cold chain refurbishment and expansion, and consider them in terms of overall EPI requirements rather than only NUVI requirements. The costing also highlighted the need to support NUVI planning processes with an accurate assessment of facility cold chain capacity.

The Zambian example suggests that other uncertainties will also affect the rigour and completeness of resource estimates for NUVI. In particular, the complexity of introducing several vaccines at the same time, and having appropriate resource planning for each independently, is evident. There may be limited benefit to trying to isolate introduction plans and costs of separate new vaccines too minutely, and countries may instead benefit from long–term, multi-vaccine introduction plans which provide for all the major activities and associated costs.

Analysis of productivity

In assessing productivity of facilities, catchment population and total facility attendance have the strongest correlation with outputs measured by total doses and DPT3 doses. However, urban or rural setting of facilities and the numbers of zones that they serve also have significant associations with productivity. Staff productivity (doses/FTE) also rises with higher service volumes, while increasing poverty levels are associated with lower facility outputs.

Together these associations suggest that once facilities are in place, contextual factors affecting demand and barriers to access may be stronger influences than supply constraints in determining levels of immunization outputs. Other factors including use of CHWs, distance to depots and road conditions were not significant, although they and other factors may be important, particularly at the level of individual facilities.

Determinants of total facility cost

The examination of determinants of total immunization facility costs, human resource costs and non-HR service delivery costs confirmed the expectation, in line with findings of previous studies, that the determinants of the two most important cost drivers, human resource costs and vaccine costs, are closely associated with total costs.

In multiple regression models the quantity and quality determinants most predictive of total facility costs were the total number of doses administered (which is highly correlated with DTP3 doses and catchment population), and the number of immunization DTP3 children per FTE staff member. The size of the facility in m^2 was associated with total costs in most total cost models. In the total cost model the price variable of staff cost per FTE was not significantly associated with total cost. Of the contextual variables, only the facility type and setting was strongly associated with total costs, once the quality variable was removed.

In regression models which examine the determinants of service delivery costs (excluding vaccines and staff), similar patterns emerge with some exceptions, although models tend to be able to predict a smaller proportion of costs. In all models the quantity variable is associated with costs, but the influence of this variable is reduced when compared to the total costs models, i.e. the coefficient value is consistently lower. There is a strong association between facility type and costs. The quality variable was only associated with costs if the facility type is excluded. In all models the size of the facility in m^2 is statistically significant.

Of interest, the facility type was only significantly predictive of costs when models included a quantity variable, which implies that the facility type on its own is not predictive of facility cost.

A relatively simple regression model which includes only the number of doses, DPT3 per staff member, cost per FTE and facility size predicts total facility costs with a high R-squared of 0.89, but service delivery costs with an R-squared of only 0.56. A model which includes the expected number of doses, facility type, size of the facility and the expected cost per FTE hour can be used to generate estimates of the total cost of existing or new facilities (R-squared 0.76) and the costs associated with non-HR service delivery (R-squared 0.60).

Limitations of the study and analysis

The main conclusions of this study are likely to be robust despite limitations of data availability or quality, as well as various methodological limitations and assumptions. Routine government accounting systems as well as EPI funding reports make it difficult for planners and managers to easily disaggregate EPI (and probably other priority program) related expenditure.

There is a need for caution in interpreting cost data as a measure of operational efficiency and particularly of allocative efficiency. From a public health point of view it may be efficient to reach more children with immunization services, even at relatively high marginal cost, if it allows a threshold to be attained in terms of herd immunity or achieves equity objectives. Also, results need to be assessed and used within the context of broader PHC planning and management as these are intimately linked with immunization service delivery.

8.2 Recommendations

On the basis of the findings outlined in this report, the results derived from the costing exercise and the subsequent analysis of the determinants of productivity and costs, a number of main recommendations have been formulated for consideration by the implementing agents of the EPI in Zambia, in addition to some of the suggestions made throughout the report.

Program and Service Management

1. *The outcomes of this study should be communicated to EPI and general managers and planners* at District, provincial and national levels to inform their practice in relation to routine immunization and new vaccines. The key results should be disseminated to district and facility management in an action-orientated way, involving support for application of information and use of insights in routine operational planning and implementation. This and broader, systematic dissemination is seen as a critical next step by EPI stakeholders.

2. *Program managers should explore the potential to incorporate key results into a management training and planning program* to guide future planning and practice at key levels. This could be useful to enable managers to use M&E and cost data more effectively at each level, and would, in turn, be expected to also improve efficiency and M&E. Trainings that just provide fairly generic information on the main cost related concepts and parameters from this study, could prompt managers to analyze and plan resource-related issues more effectively without requiring them to have very good quality data already at hand.

3. The *diligent implementation of existing or revised stock management systems at all levels be treated as a priority* to operationalize appropriate stock management policies, obtain accurate wastage rates and manage inefficiencies. At all levels systems were not well maintained and the calculation of vaccine consumption on the basis of reported stock levels unreliable.

Planning and Financing

4. Planners *should develop revised estimates and mapping of resource needs, finance sources and funding gaps* to ensure sustainability of the program especially with respect to the introduction of multiple new vaccines. It is suggested that a consolidated planning framework be established, which may make use of existing planning tools, to consolidate the results from various planning initiatives to ensure the establishment of one integrated long term plan for the EPI which combines and reconciles the output from the various planning tools.

5. *The accuracy of cMYP cost projections can be improved by* drawing on data from this study to inform the underlying assumptions in the cMYP, especially with respect to the cost of salaried labour and allowances for outreach and supervision. It may however be necessary to adapt results from the costing study to facilitate the population of assumptions in the cMYP. Therefore establishment of a task team should be considered to interrogate the detailed costs and results of this study and to formulate appropriate inputs to fit the structure and methodology of the cMYP.

6. Any significant expansion of the EPI, including the introduction of new vaccines, should carefully consider the impact of such an expansion on *indirect supervisory and program*

management cost. Assuming that there will be no incremental impact on these costs may result in an overburdened program management and supervisory structure. The total supervision and program management costs (18% of total) may be higher than what is currently assumed.

7. The GRZ should develop a *coordinated, single mechanism which accurately captures all contributions* received from partners and at the same time reconciles government reported figures to donor reports. This is particularly relevant for the GAVI grant. Although this type of reconciliation may not always be possible it should be feasible to establish a system which accurately records all donations and their primary purpose, at all levels of the health system above facility level. Development partners in turn should explore ways to increase the detail of reporting of EPI support to facilitate more informed resource tracking and costing of programs, including for cMYP purposes.

8. *GAVI and other partners should consider implications of the study for future planning and funding policies and decisions*. Particularly important findings relate to higher than anticipated government contributions to the EPI; high unit costs and differences between facility types and location; the high service delivery costs of NUVI in relation to GAVI grants; and the scale of NUVI costs and implications for longer term sustainability in resource constrained health systems. The limitations of current immunization planning and budgeting tools, and their application should also be considered. Potential benefits of developing more efficient resource tracking systems should also be assessed.

9. *New ways should be explored to plan and budget for immunization services and facilities*. Using average total costs for facility types to estimate costs of existing and new facilities, or of extending coverage, may not be sufficiently accurate. It might be more useful to establish benchmarks for different facility types based on the setting of the facility and the anticipated attendance volumes. Use of regression equations may help to refine estimates in this process. The facilities can then be categorized accordingly and the appropriate total cost used. Staffing is the largest contributor to total costs, and varies substantially between facilities. Thus, it may also be useful to develop a simplified model or decision making mechanism to assist planners to determine the number of FTE required by facilities. This may be possible for example by exploring the use of one of the linear models as a substitute for predicting the FTE.

Strengthening information

10. The *number of doses administered during outreach activities should be accurately recorded* and separately reported from the doses administered at the facility. This will enhance understanding of service delivery patterns and trends, and inform development of operational strategies to improve efficiency and service delivery.

11. *Actual costs of implementing PCV (and other new vaccines) should be monitored*. Particular emphasis should be given to monitoring:
    - The cost of vaccines and injection supplies which are the largest costs and have the greatest implications for sustainability.
    - Staff capacity issues in various settings, including "hidden" diversion of staff capacity from other PHC priorities, or of management capacity requirements which appear to be quite substantial from the routine program costing.

12. *More detailed study of sites with particularly high or low productivity* and related efficiencies should be considered. The study could further explore reasons for outlier performance, understand immunization productivity better in the context of comprehensive PHC services, and potentially identify more detail of adaptations which

may be feasible to improve productivity and coverage. This study suggests that options such as task shifting or sharing, and organization of outreach and other services to enhance utilization volumes and economies of scale may assist in enhancing productivity of not only immunization.

13. *Further analysis of immunization productivity and efficiency* should be carried out in the context of accessible, equitable comprehensive PHC services, particularly in relation to efficient staffing and understanding and managing vaccine wastage. Formulation of recommendations based on immunization productivity assessments alone, in the absence of understanding of key dimensions of accessibility and coordination with other priority services, is difficult.

14. Ways to *enhance capacity utilization in low volume settings should be explored* to enhance efficiency. Instead of changing organization of immunization services per se to improve efficiency, this may appropriately involve provision of a comprehensive package of cost effective PHC interventions to ensure that, overall, capacity is well utilized. For example, if Child Health Week or other outreach includes a wider range of services, this could use capacity more fully and reduce unit costs of immunization and other interventions.

15. *District and higher level financial systems should be reviewed* to establish whether these can be adapted to isolate *actual* expenditure on immunization or other priority programs to assist in management and planning. Also simple systems should be introduced to facilitate resource tracking especially where donations in kind or otherwise are not recorded in the ledger. However, it is uncertain that immunization planning by itself would justify major changes to financial systems.

Annex 1 – References

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Annex 2 - Sampling Frame

The following provinces were purposively selected after extensive consultations with government and non-government stakeholders:

- *Lusaka province:* Lusaka province includes the capital city Lusaka together with many peri-urban as well as rural areas. Lusaka province has the highest population density in the country at over 100 persons per square kilometer (ppkm^2).
- *Copperbelt:* The province has the second highest population density of 63 people per square kilometer. This province includes densely populated areas around the urban nodes. Outside of the urban areas the province is rural to deep rural.
- *Central Province:* Central province is situated between the Copperbelt and Lusaka provinces and is characterized by smaller towns, rural and deep rural areas. The population density (13.4 ppkm^2) is midway between the extremes reflected in the remaining provinces which range from 6.6 ppkm^2 to 24.6 ppkm^2.

Within these provinces the following districts were purposively selected based on their characteristics and the need to select districts which would generate a representative sample of facilities given the criteria described above. The selected districts were expected to provide adequate data to allow examination of the potential effects of distance, remoteness, socio-economic and demographic profiles on immunization unit costs.

Summary of districts selected

Province and districts	Reasons for inclusion
Lusaka – Lusaka, Kafue, Chongwe	Lusaka province has four districts. The three most populated districts were selected. The sites in Luangwa district (district 4) are situated next to the Mozambique border, and productivity statistics are distorted by cross-border movement, so it was excluded from the sample.
Copperbelt – Ndola, Masaiti, Lufwanyama	The town of Ndola was selected given its relatively large population and a number of UHCs. Of two rural districts selected, one is deep rural (Lufwanyama) the other more accessible. These two rural districts have the second and third lowest population per facility in the province.
Central - Kabwe, Serenje, Mukushi	Kabwe is the urban area selected in this province. Serenje district is rural, remote and typical of many remote areas of Zambia. Mkushi is a commercial farming area where population densities are relatively low.

Final Sampling Frame and Sample (Expanded sample)

Total Facilities - National

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	1	16		
Hospital affiliated site - Rural			3	30
Urban Health Centre	14	212		
Rural Health Centre			35	1 007
Subtotal	**15**	**238**	**38**	**1 037**

Total Facilities – 3 Provinces selected (Totals exclude military/police clinics)

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	1	1		
Hospital affiliated site - Rural			3	3
Urban Health Centre	14	56		
Rural Health Centre			35	91
Subtotal	**15**	**57**	**38**	**94**

District 1: Kabwe

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	1		
Hospital affiliated site - Rural			0	0
Urban Health Centre	3	14		
Rural Health Centre			1	1
Subtotal	3	15	1	1

District 2: Mkushi

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			0	0
Urban Health Centre	0	0		
Rural Health Centre				
Subtotal	0	0	8	16

District 3: Serenje

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			2	2
Urban Health Centre	0	0		
Rural Health Centre			7	14
Subtotal	0	0	9	16

District 4: Lufwanyama

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			0	0
Urban Health Centre	0	0		
Rural Health Centre			4	11
Subtotal	0	0	4	11

District 5: Ndola

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural				
Urban Health Centre	6	18		
Rural Health Centre			0	1
Subtotal	6	18	0	1

District 6: Masaiti

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			0	0
Urban Health Centre	0	0		
Rural Health Centre			6	17
Subtotal	0	0	6	17

District 7: Chongwe

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			1	1
Urban Health Centre	0	0		
Rural Health Centre			3	21
Subtotal	0	0	4	22

District 8: Lusaka

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			0	0
Urban Health Centre	4	18		
Rural Health Centre				
Subtotal	4	18	0	0

District 9: Kafue

Type of Facility	Urban Sample	Total Urban Facilities	Rural Sample	Total Rural Facilities
Hospital affiliated site - Urban	0	0		
Hospital affiliated site - Rural			1	0
Urban Health Centre	1	6		
Rural Health Centre			6	10
Subtotal	1	6	6	10

Annex 3 - Codes for mapping financial flows

The following codes, based on SHA codes, were used to map immunization finances

FSR.Source of Source Code	Source of Source Description	FS. CODE	FS. Descritpion
FSR.1	Loans	**FS.1**	**Transfers from government domestic revenue**
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 classifiec (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*

Annex 4 – List of sample facility numbers

Facility ID	Facility Name	District Name	Type	Sample weight
1	Kasavasa	Kabwe	Rural	18.3
2	Ngungu	Kabwe	Urban	27.2
3	Pollen	Kabwe	Urban	27.2
4	Makululu	Kabwe	Urban	27.2
5	Chalata	Mkushi	Rural	18.33
6	Chibefwe	Mkushi	Rural	18.33
7	Chikupili	Mkushi	Rural	18.33
8	Fiwila	Mkushi	Rural	18.33
9	Kampelembe	Mkushi	Rural	18.33
10	Masansa	Mkushi	Rural	18.33
11	Nshinso	Mkushi	Rural	18.33
12	Old Mkushi	Mkushi	Rural	18.33
13	Serenje Hahc - Boma	Serenje	Urban	27.2
14	Chibale	Serenje	Rural	18.33
15	Chitambo	Serenje	Rural	18.33
16	Kabamba	Serenje	Rural	18.33
18	Malcolm Moffat	Serenje	Rural	18.33
19	Mapepala	Serenje	Rural	18.33
20	Muchinka	Serenje	Rural	18.33
21	Nchimishi	Serenje	Rural	18.33
22	Bulaya	Lufwanyama	Rural	30.56
23	Fungulwa	Lufwanyama	Rural	30.56
24	Mushingashi	Lufwanyama	Rural	30.56
25	Chikabuke	Lufwanyama	Rural	30.56
26	Chipulukusu	Ndola	Urban	45.33
27	Lubuto	Ndola	Urban	45.33
28	Masala	Ndola	Urban	45.33
29	Ndeke	Ndola	Urban	45.33
30	Nkwazi	Ndola	Urban	45.33
31	Railway Surgery	Ndola	Urban	45.33
32	Chondwe	Masaiti	Rural	30.56
33	Kambowa	Masaiti	Rural	30.56
34	Kashitu	Masaiti	Rural	30.56
35	Masaiti Council	Masaiti	Rural	30.56
36	Mutaba	Masaiti	Rural	30.56
37	Njelemani	Masaiti	Rural	30.56
38	Chanyanya Clinic	Kafue	Rural	12.22

Facility ID	Facility Name	District Name	Type	Sample weight
40	Chikupi	Kafue	Rural	12.22
41	Chipapa	Kafue	Rural	12.22
42	Chisankane	Kafue	Rural	12.22
43	Estate	Kafue	Urban	18.13
44	Kambale	Kafue	Rural	12.22
45	Mwembeshi	Kafue	Rural	12.22
46	Lukwipa	Chongwe	Rural	12.22
47	Kankumba	Chongwe	Rural	12.22
48	Mpashya	Chongwe	Rural	12.22
49	Mwalumina	Chongwe	Rural	12.22
50	Chelston Clinic	Lusaka	Urban	18.13
51	Chawama Clinic	Lusaka	Urban	18.13
52	Chipata	Lusaka	Urban	18.13
53	Kanyama	Lusaka	Urban	18.13

Annex 5 – Final Matrix of expenditure line items by activities

Line Item	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Outreach Service Delivery	Train-ing	Social Mobiliza-tion & Advocacy	Surveill-ance	Cold Chain Mainten-ance	Vaccine Collection, Distribu-tion Storage	Program Manage-ment	Other
Salaried Labor	X	X	X	X	X	X	X	X	X	X	X
Volunteer Labor	X			X		X	X				?
Per Diem & Travel Allowances			X	X	X	X	X		X		
Vaccines	X			X							
Vaccine Injection & Safety Supplies	X			X							
Other Supplies	X	X		X	X	X	X			X	
Transport/ Fuel			X	X	X	X	X		X	X	
Vehicle Maintenance	X		X	X			X		X		
Cold Chain Energy Costs	X			X			X		X		
Printing	X	X			X	X					
Building overhead, Utilities, Communication	X						X				
Other Recurrent											
Activity	**Routine Facility-based Service Delivery**	**Record-Keeping & HMIS**	**Super-vision**	**Out-reach Service Delivery**	**Train-ing**	**Social Mobiliza-tion & Advocacy**	**Surveill-ance**	**Cold Chain Mainten-ance**	**Vaccine Collection, Distribution**	**Program Manage-ment**	**Other**
Cold Chain Equipment	X			X			X		X		
Vehicles	X		X	X			X		X		
Lab Equipment							X				
Other Equipment	X	X								X	
Other Capital											
Buildings											
TOTAL											

X = possible overlaps between the expenditure line items and activities where the expenditure might be incurred.

Annex 6 – Data quality assurance

The following quality assurance (QA) approach was used to help to prevent poor practices and to minimise errors in data collection and capture. [107] Standard operating procedures for QA were outlined at the beginning of a survey and QA was an on-going process through the life of the project.

Identifying the potential causes of poor quality data
Poor data quality can be defined as missing, or incorrectly captured or coded data. In order to identify possible risks and causes of poor data quality the following questions were considered before starting data collection and also during and after the initial pilot phase.

- 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 in a consistent manner 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 user-friendly?
- Is the tool user-friendly with adequate coding information?
- How do we know that data in the Excel spread sheets have been accurately captured into database?

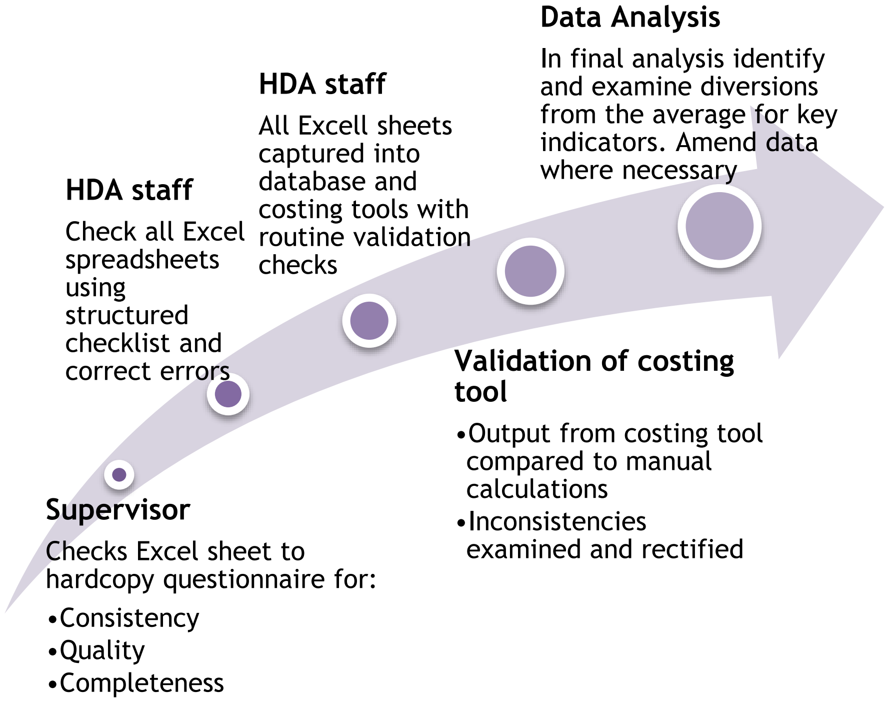
Quality assurance procedures
The following steps were taken in response to risks identified and as a way to mitigate the risk of poor data quality:

- Experienced senior researchers and skilled data collectors were recruited to administer the questionnaire
- The questionnaire was reviewed and revised in an iterative process involving senior researchers, data collectors and technical leads. Data collectors were trained using the questionnaire as the main training tool.
- A pre-test of the tool was conducted which assisted in further refining the tool and clarifying questions and data requirements.
- All completed questionnaires (Excel version) were reviewed by the senior researcher and compared to the hard-copy questionnaire, and queries and inconsistencies were identified
- All reviewed Excel version questionnaires were reviewed a second time by other team members using a structured checklist. A trail of all queries and how they were resolved was thus created for each facility.
- Data collectors at HDA captured the approved Excel questionnaires into the database and costing tool.
- Costs generated by the tool were compared to manual calculation of costs by senior technical team members. When inconsistencies were identified, a thorough process reviewed formulae in the costing tool and corrected them where required.

[107] Adapted from: United Nations Statistics Division. Household Sample Surveys in Developing and Transition Countries

- The same process also highlighted and addressed inconsistencies in captured data.
- The database and costing tool included a number of validation checks which prevented processing of data until the errors are corrected.

Finally the results for all facilities were compared with each other. Where unit costs and other values appeared to divert significantly from the average, the data were re-examined to ensure that it had been accurately captured from source. The Figure below illustrates the quality assurance process described above.



Annex 7 – Selected unit costs, wastage rates and Useful Life Year estimates

A: Vaccine unit costs used for this study - 2011

Vaccine	VaccineCode	Formulations	Doses per Vial	Price per vial ($US)	Price per dose ($US)	Calculated cost per dose	Freight\	USD cost per dose
BCG	BCG	Lyophilized	20	$2.12	$0.11	$0.11	10%	$0.12
Polio	tOPV	Liquid	20	$2.58	$0.13	$0.13	10%	$0.14
DTP-HepB-Hib liquid 1)	DTP-HepB-Hib	Liquid	1	$3.05	$3.05	$3.05	1%	$3.08
Measles	Measles	Lyophilized	10	$2.37	$0.24	$0.24	10%	$0.26
Pneumo. Conjugate vaccine 10-valent 1)	PCV-10	Liquid	2	$7.00	$3.50	$3.50	1%	$3.54

Source: UNICEF Zambia office; prices indicated were weighted average prices, updated Feb 2011.

B: Vaccine wastage rates EPI costing and alternative scenario*

Vaccine	Doses per vial	Wastage rate EPI costing	Reduced wastage rates
BCG	20	50%	50%
OPV	20	50%	25%
DTP-HepB-Hib	1	5%	5%
Measles	10	50%	25%

*Note: In section 3.2.6 the impact of reduced wastage rates for certain vaccines is examined

C: Staff remuneration rates: selected staff **at Health Centres (2012: $1 = ZMK 4787)**

Salary Scale	Description	Job Title	Monthly Gross Salary (ZMK)	Monthly Gross Salary ($US)
CE01	Classified Employees	Handyman / General Worker / Storeman	1 491 798.33	311.61
CE02			1 480 147.85	309.17
CE03			1 433 509.68	299.43
GENW		Domestic worker	1 420 456.70	296.70
WATCHMAN		Security Guard	1 429 905.05	298.68
GSS12 Urban	General Salary Scale	Dispenser	2 757 790.68	576.05
GSS12 Rural			3 158 755.76	659.80
GSS14 Urban		Data Entry Clerk	2 142 486.37	447.52
GSS14 Rural			2 458 744.56	513.58
HB10	Health Board Scale	Domestic worker	1 550 129.83	323.79
HB11			1 500 531.97	313.43
MS04 Urban	Medical Salary Scale	Nursing Sister/ Health Centre in Charge	9 982 114.72	2 085.06
MS04 Rural			11 101 389.84	2 318.85
MS06 Urban		Registered Nurse / Midwife / Clinical Officer / EHT	5 823 054.93	1 216.32
MS06 Rural			6 679 928.32	1 395.30
MS07 Urban			5 039 284.43	1 052.60
MS07 Rural			5 782 931.78	1 207.94
MS08 Urban		Enrolled Nurse / Midwife / Clinical Officer / EHT	4 404 796.36	920.07
MS08 Rural			5 047 591.31	1 054.34
MS09 Urban			3 850 231.75	804.23
MS09 Rural			3 850 231.75	804.23
TTW09	Trade Tested Workman	Driver	1 489 957.74	311.22

D: Districts – Unit costs applied to aggregation model

	Serenje	Ndola	Mkushi	Masaiti	Lusaka	Lufwanyamc	Kafue	Kabwe	Chongwe
Total numbre of doses administered	86 322	145 759	40 429	40 429	530 560	31 450	75 230	63 350	64 618
Total number of DTP 3 children	8 612	15 714	7 317	4 340	53 709	3 694	9 179	6 716	7 508
Unit costs per dose total- district costs	1.50	0.98	1.08	2.74	0.57	2.90	1.51	2.25	1.83
Unit cost per DTP3 child	16.49	9.08	5.96	25.55	5.65	24.68	12.38	21.26	15.78

E: Useful life year (ULY) estimates for capital items

Items listed below are the most frequently occurring assets and equipment at facility level with the exception of motor vehicles, most of which are located at district offices.

EQUIPMENT ITEM	ULYs*
Cold chain equipment	
Walk in Cold Room	25
Refr. Electric/Kerosene - RCW42EK/CF	8
Refr. Electric - RCW50AC	8
Refr. Electric - RCW50AC/CF	8
Refr. Electric - RCW50DC	8
Refr. Electric - RCW50DC/CF	8
Refr. Electric/Gas - RCW50EG	8
Refr. Electric/Kerosene - RCW50EK	8
Refr. Electric/Kerosene - RCW50EK/CF	8
Refr. Solar - VR50F	8
Cold Box - RCW 25	15
Vaccine carrier	25
Ice Packs	15
Other equipment and vehicles	
Generator (small to medium size)	5
Air conditioner	10
Incinerator	10
Motorcycles	3
Motor vehicles (Mainly LDV 4x4 type)	5
Desktop computers	4
Printer	3
Tables	10
Chairs	5
Cabinet	10
Bench	5
Buildings	
Clinic buildings and similar outreach facilities	25

* Useful Life Years

Annex 8 – Economic cost of the national EPI

program

Annex 8 (a): Aggregated Immunization Economic and Unit Costs in Zambia by Line Item ($2011) *

Input cost item	Facility level	District level	Provincial level	National level	Total Routine Immunization Costs in Zambia	%
	N = 1275	N = 72	N = 9			
Salaried Labor	16 747 522	1 472 211	403 089	238 999	18 861 822	49.4%
Volunteer Labor	-	-	-	-	-	0.0%
Per Diem & Travel Allowances	3 297 223	777 191	155 028	160 545	4 389 987	11.5%
Vaccines	6 167 984	-	-	-	6 167 984	16.2%
Vaccine Injection & Safety Supplies	185 702	-	-	-	185 702	0.5%
Other Supplies	94 375	194 847	7 965	-	297 187	0.8%
Transport/Fuel	1 491 808	675 029	90 034	91 992	2 348 864	6.2%
Vehicle Maintenance	198 469	180 149	19 749	22 283	420 650	1.1%
Cold Chain Energy Costs	85 905	23 657	3 022	6 961	119 545	0.3%
Printing	-	77 645	-	-	77 645	0.2%
Building overhead, Utilities, Communication	-	1 001 753	57 890	15 821	1 075 464	2.8%
Other recurrent	-	-	-	-	-	0.0%
Cold Chain Equipment	428 698	99 612	25 410	14 346	568 066	1.5%
Vehicles	1 069 653	766 271	84 085	87 134	2 007 144	5.3%
Lab equipment	-	-	-	-	-	0.0%
Other Equipment	518 656	19 217	10 261	9 151	557 284	1.5%
Other capital	-	-	-	-	-	0.0%
Buildings	870 347	97 919	81 074	35 938	1 085 278	2.8%
Total immunisation economic cost	**31 156 342**	**5 385 501**	**937 609**	**683 170**	**38 162 622**	**100.0%**
Delivery economic cost	24 802 655	5 385 501	937 609	683 170	31 808 936	
- Total child doses administered	4 854 604	4 854 604	4 854 604	4 854 604	4 854 604	
- Infant population	567 320	567 320	567 320	567 320	567 320	
- Total DTP3 Vaccinated Children	518 843	518 843	518 843	518 843	518 843	
- Total population	13 411 810	13 411 810	13 411 810	13 411 810	13 411 810	
- Cost per Dose	6.42	1.11	0.19	0.14	7.86	
- Cost per child	54.92	9.49	1.65	1.20	67.27	
- Cost per DTP3 Vaccinated child	60.05	10.38	1.81	1.32	73.55	
- Cost per capita	2.32	0.40	0.07	0.05	2.85	
- Delivery cost per Dose	5.11	1.11	0.19	0.14	6.55	
- Delivery cost per child	43.72	9.49	1.65	1.20	56.07	
- Delivery cost per DTP3 Vaccinated child	47.80	10.38	1.81	1.32	61.31	
- Delivery cost per capita	1.85	0.40	0.07	0.05	2.37	

* These Unit costs were used to produce aggregate national program costs. They were weighted according to the proportion of doses delivered by various sites, not inverse probability method.

Annex 8(b) Economic cost of the national EPI program by activity (2011 $) and related unit costs by child dose and targeted child

Expenditure line item	TOTAL NATIONAL EPI COST 2011	% of total	Cost per dose	Cost per targeted child
Routine Facility-based Service Delivery	9 042 757	23.7%	1.86	15.94
Record-Keeping & HMIS	1 282 561	3.4%	0.26	2.26
Supervision	3 296 417	8.6%	0.68	5.81
Outreach Service Delivery	10 739 276	28.1%	2.21	18.93
Social Mobilization & Advocacy	3 705 166	9.7%	0.76	6.53
Cold Chain Maintenance	982 463	2.6%	0.20	1.73
Vaccine Collection, Distribution, & Storage	3 313 367	8.7%	0.68	5.84
Program Management	3 789 100	9.9%	0.78	6.68
Training	1 210 161	3.2%	0.25	2.13
Surveillance	729 628	1.9%	0.15	1.29
Other	71 724	0.2%	0.01	0.13
TOTAL Programme cost	**38 162 622**	**100%**	**7.86**	**67.27**

Annex 8 (c): Total facility cost, non-HR facility cost, delivery cost and non-HR delivery cost and unit costs

Total costs Facility Type	Total Cost	Total, Non-HR Cost	Delivery Cost	Total, Non-HR Delivery Cost
Urban Health Centre	34 441	21061	17910	4529
Rural Health Centre	24 262	11053	20234	7025
Total for all facilities	28 286	15 009	19 315	6 038
Costs/Dose	Total Cost/Dose	Total, Non-HR Cost/Dose	Delivery Cost/Dose	Total, Non-HR Delivery Cost/Dose
Urban Health Centre	3.78	1.83	2.43	0.53
Rural Health Centre	9.43	4.13	8.07	2.77
Total for all facilities	7.18	3.22	5.84	1.89
Costs/Child	Total Cost./Child	Total, Non-HR Cost/Child	Delivery Cost/Child	Total, Non-HR Delivery Cost/Child
Urban Health Centre	22.85	12.68	13.79	3.62
Rural Health Centre	83.17	38.33	70.56	25.73
Total for all facilities	59.32	28.19	48.12	16.99
Cost/FIC	Total Cost/FIC	Total, Non-HR Cost/FIC	Delivery Cost/FIC	Total, Non-HR Delivery Cost/FIC
Urban Health Centre	33.38	17.32	21.07	4.85
Rural Health Centre	87.14	43.81	74.72	29.52
Total for all facilities	65.89	29.92	53.51	17.54

Annex 9 - Further analyses: unit costs, efficiency and total facility costs

This Annex firstly expands on the scatter plot and multiple regression analysis of differences in facility level unit cost to identify factors that affect unit costs and efficiency of services. The final sections show further scatter plots of total facility economic costs which exclude outlier facilities, followed by graphs to show the distribution of facility total costs of rural, urban and all facilities.

A. Statistical Analysis of Unit Costs and efficiency

The following analysis sought to identify what determines unit costs and efficiency at the facility level. Of particular interest were why some facilities appear to be more efficient and generate much lower unit costs per dose and per DTP3 child, and why urban and rural facilities seem to have efficiency differences.

The methodology involved scatter plot analyses and then multiple regression modeling with the same overall approach to analyzing associations as set out for the productivity analysis in Section 5 and total cost analysis in Section 6 of the report. 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, due to logistics-related costs.

In the analysis of performance or efficiency, 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.

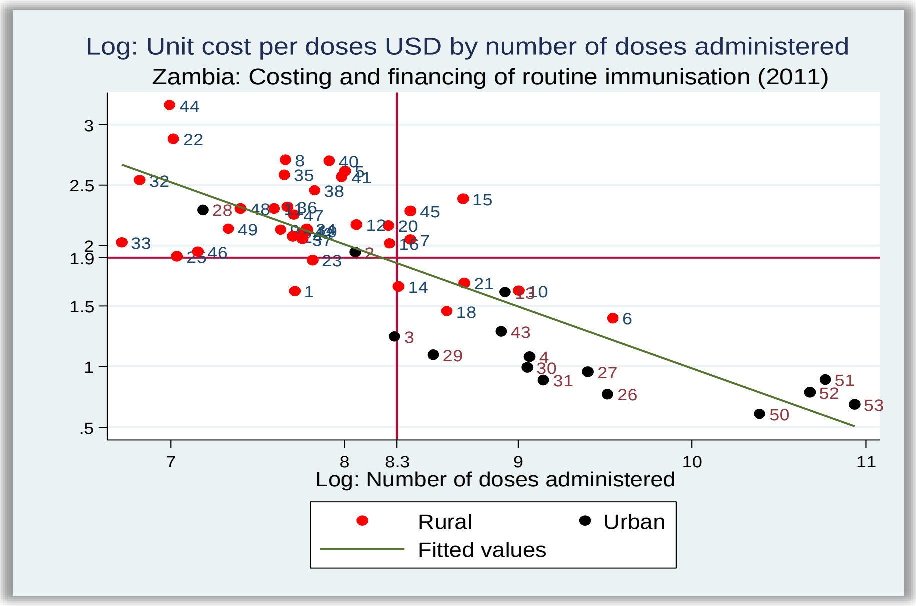
Results: scatter plot analyses of performance

Figure 9.1 examines the relationship between the total number of doses administered by each facility with the unit costs per dose. Facilities located in the top, left-hand quadrant are small facilities with low total doses combined with relatively high unit costs and low efficiency. Those located in the bottom, right-hand quadrant are larger than average facilities, with lower than average unit costs and higher efficiency. In all quadrants, facilities above the line are less efficient than facilities below the line for any given number of doses. The graph suggests a clear reduction in the unit costs, and therefore higher efficiency, as the total number of doses increases.

Urban health facilities seem to be largely clustered in the bottom right hand quadrant, below the linear prediction line, which indicates higher total numbers of doses and higher efficiency for a given number of doses. Rural facilities are largely clustered in the quadrant with lower number of doses, above the prediction line and higher unit cost. With some exceptions, even where urban and rural facilities appear in the same quadrant, rural facilities appear to be less efficient than urban facilities. The large efficient centres are located largely in the Lusaka and Ndola districts which contain large urban areas. Within the rural cluster there are a number of marked deviations from the line. An almost identical pattern was presented in the DTP3 unit costs scatterplot in Section 3.2.1 of the main report. The reasons for the deviations are similar and relate to:

- Particularly low DTP3 children. Facility 22 reported only 124 DPT3 and facility 44 only 95, the lowest number of children of all facilities sampled. Both facilities are rural health centres situated in Kafue (44) and Lufwanyama (22) districts.
- High level of outreach activity together with high staff participation, (e.g. two health worker and two community health workers on each outreach visit to eight or more outreach zones each month)
- High transport costs comprising bus or taxi fares to reach remote locations or resulting from a longer (in days) vaccine collection and outreach trips.

Figure 9.1: Total unit cost per dose by number of annual doses administered at facility

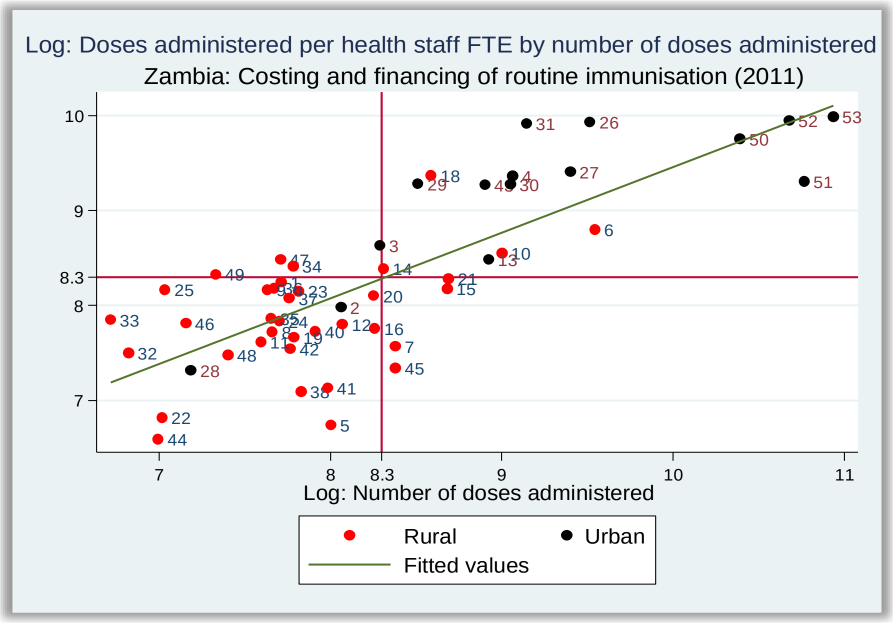


An examination of the difference between other facilities in the small-facility quadrant indicated that facilities above the line have typically recorded higher salaried labour costs for similar numbers of doses. The reason for this is not clear and may be caused by a combination of factors. The clustering of rural observations in the high cost - low volume quadrant does however seem to corroborate the observation of Marschall and Flessa (2011) that in small primary health care facilities a minimum staff complement is required and cannot be reduced beyond a certain threshold when service volumes are very low. For example most Zambian facilities have an immunization day which must be attended by a nurse, but the number of children presenting for immunization may vary significantly from facility to facility. The key predictor of efficiency is thus the number of doses administered.

Figure 9.2 explores the relationship between scale and total number of doses administered by FTE immunization health staff (see also Section 5 of main report for discussion of staff productivity). In these scatter plots, the lower left-hand quadrant is indicative of smaller facilities with lower than average doses or facility attendance respectively, together with low productivity and efficiency in terms of the number of doses delivered per annum per FTE staff member working on immunization. The top right-hand quadrant contains observations with high doses or facility attendance and higher numbers of doses per FTE staff.

Facilities that are placed above the line have more productive staff than those below the line. The graphs indicate a clear increase in productivity correlated with increases in the total number of doses. Closer examination of sites such as 31 and 26 (urban facilities with very low FTE when compared to the average) suggests that in such sites immunization might have been prioritized, and limited staff capacity used efficiently to provide it. If so, similar prioritization and use of staff might help to enhance productivity in other settings. Alternatively, prioritizing immunization with limited resources may also lead to curtailment of other health services.

Figure 9.2 Doses administered per FTE health staff vs total doses



There is no clear indication of why some facilities cope with substantially less staff than others for a similar number of doses. The percentage of children immunized at the facility or during outreach, the number of zones supported and other indicators do not seem to provide a satisfactory explanation

Statistical analysis of performance indicators

The regression analysis used various models to explore the relationship between performance or efficiency 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 facility staff; FTE immunization staff; percentage of immunizations delivered at the facility; number of zones supported; and total facility attendance (Table 9.1). The facility type (rural or urban health centre) was included as an environmental variable (see Annex 11 for confidence intervals).

- The results of the analysis confirm the correlation between *facility attendance* and the unit costs per DTP3 child. Facility attendance is negatively associated with the unit cost per DTP3 child at 1% significance level in both models. The coefficient indicates that a 1% increase in facility attendance is associated with a decrease of approximately 0.3% in the unit cost per DTP3 child in both models. The magnitude of the change highlights the sensitivity of the unit cost to total facility attendance volumes. This relationship is also evident in the analysis of doses per FTE in both models. Increased facility attendance therefore is associated with a significant increase in the number of doses delivered per FTE staff member. In model 1 (Doses) a 1% increase in total attendance generates an increase of approximately 0.75% in the total number of doses per staff FTE.

Table 9.1: Statistical analysis of performance indicators

	Ln Unit cost per DTP3 Child		Ln Annual doses per FTE	
Variable	**Model – 1** **β (std err) p-value**	**Model – 2** **β (std err) p-value**	**Model – 3** **β (std err) p-value**	**Model – 4** **β (std err) p-value**
Ln # Health Staff involved in immunization		0.25 (0.14) 0.08	-0.64 (0.12) **<0.01**	
Ln FTEs	0.32 (0.08) **<0.01**			
Ln % Facility based immunizations (2011)	-0.10 (0.04) **0.03**	-0.08 (0.05) 0.17	0.10 (0.06) 0.11	0.13 (0.08) 0.12
Ln # Zones supported	-0.17 (0.10) 0.09	-0.09 (0.10) 0.39	0.16 (0.14) 0.25	0.02 (0.17) 0.88
Ln facility attendance - total	-0.30 (0.09) **<0.01**	-0.28 (0.10) **0.01**	0.75 (0.13) **<0.01**	0.56 (0.16) **<0.01**
Facility type (binary) Urban Rural	- 0.70 (0.14) **<0.01**	- 0.82 (0.16) **< 0.01**	- -0.52 (0.21) **0.01**	- -0.69 (0.25) **<0.01**
Constant	6.76 (0.86) <0.01	5.98 (0.91) < 0.01	1.28 (1.24) 0.31	3.53 (1.46) 0.02
R – squared (adjusted R-squared)	0.76	0.71	0.77	0.63
F value	F(5, 45) = 29, < 0.01	F(5, 45) = 22, < 0.01	F(5, 45) = 30, < 0.01	F (4, 46) = 20, < 0.01

The importance of the *facility type and setting (rural or urban*) is emphasized in the analysis. In the unit cost models, the difference between settings is significant at the 1% level. In the unit cost analysis the rural setting is associated with an increase in unit cost, while in the doses per FTE models, the there is a negative association, with a decrease in doses per FTE in rural facilities.

In two models number of *health staff* involved in immunization was introduced as an independent variable. In the unit cost model the number of health staff was not statistically significantly associated with unit costs, but the doses per FTE model reflects a negative association which is statistically significant at the 1% level. This relationship suggests that the increase in health staff is associated with a reduction in doses per FTE. In model 4 (doses per FTE) the exclusion of total number of health staff is associated with a decline in the ability of the model to predict efficiency. The facility attendance and the facility type remain statistically associated with doses per FTE at the 1% significance level and this model accounts for approximately 63% of the variability of doses per FTE between facilities.

It is interesting to note that the *percentage of immunizations which take place at the facility* was significantly associated with only model 1 (unit costs) but not with model 2 (unit cost) or the number of doses per FTE staff. In model 1 a 10% increase in facility based immunization is associated with a decrease in unit cost of 1%. *The number of zones supported*, which was selected as a proxy for service delivery method and infrastructure available for immunization, was also not significantly associated with the outcomes in any of the models.

Discussion: determinants of facility unit costs and efficiency

The quadrant analysis identifies associations between facility efficiency, indicated by the unit cost per DTP3 child and doses per FTE staff providing immunization services, and several factors. These include total facility attendance, the difference between urban and rural setting and, in some models, the number of health staff involved in immunization.

The efficiency findings suggest that at low volumes there is inefficiently utilized HR capacity for immunization. There may be opportunities to use existing capacity to increase the number of immunizations administered, and thus efficiency, at smaller facilities. This assumes that the coverage is relatively low and that there is scope for improving the coverage without increasing inputs. Where small facilities are already achieving high DTP3 coverage and given a constant catchment population, efficiencies can only be improved by reducing the number of FTE for immunization, which may not always be possible. However, if achieving higher coverage implies the use of more productive time for travelling to outreach points, efficiency gains may not materialize. The analysis further seems to support the notion that inputs at the smaller facilities, both rural and urban, are inflexible: a reduction in client numbers cannot easily be offset by reducing inputs, resulting in significantly higher unit costs and increased inefficiency. More efficient use of staff time might also result if a broader range of non-immunization PHC services is offered at facilities and staff have to use available time more efficiently.

On the other end of the scale, most large facilities are likely to be functioning at close to maximum capacity and opportunities for improved efficiencies are limited. It is possible that productivity is improved in very busy facilities not just because of improved capacity utilization but because the pressure to assist a large number of out-patients may result in less time-spent on each child during immunization when compared to a rural facility where there may be fewer clients.

This also points to the possibility of available staff capacity in small, low volume facilities, which may be particularly relevant to assessing capacity needs when new vaccines or other services are introduced. However, possible structural limitations on ability to administer higher volumes with given staff time (for example, travel time to sites) would have to be considered further.

Conclusions: determinants of facility unit costs and efficiency

Previous research exploring the efficiency of primary health care centres and in higher level facilities points to a close relationship between efficiency and the level of utilization of facilities. Further, at the primary health care level, for various reasons including the need to provide services in remote locations, staff inputs are typically inflexible in smaller facilities and cannot be adjusted to align with demand and thereby improve overall efficiency. At the same time the need to maintain accessibility, also preclude closing or consolidating less efficient services to boost volumes and staff capacity utilization.

In order to explore factors linked to efficient use of resources a number of efficiency measures were defined including unit costs and child doses delivered per FTE immunization health staff. The correlation between these indictors and a number of independent variables were explored using both quadrant analysis and statistical regression models.

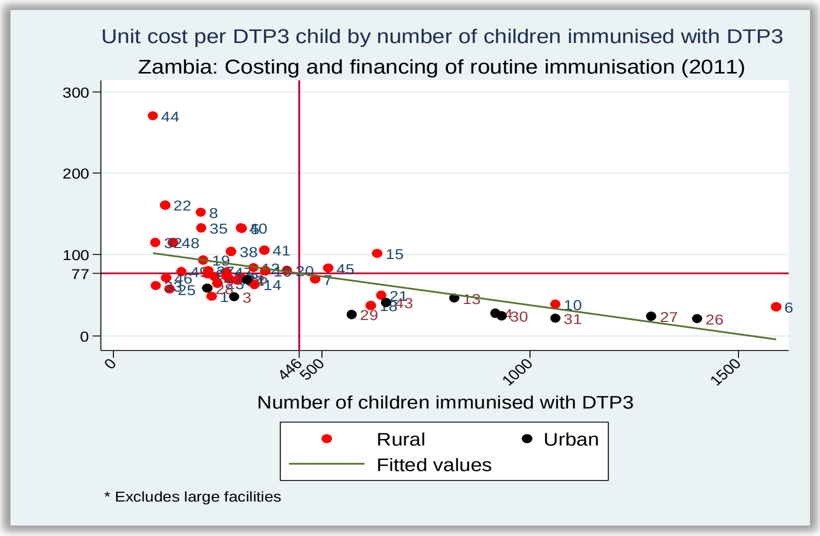
The analysis indicates a close, negative association between the total unit cost per DTP3 child, and the total number of doses administered and total facility attendance. The quadrant analysis further indicates that below a certain volume threshold the unit cost per dose tends to increase quickly and efficiency declines rapidly. The negative relationship between volume and unit costs above the threshold is therefore accelerated. There are marked differences in efficiency between UHCs and RHCs. At the same time, there is high variability in efficiency between sites both within these strata and at similar levels of utilization.

The rapid increase in unit costs at lower volumes is most likely due to the fact that every facility requires a minimum number of staff and that a minimum amount of staff time is dedicated to immunization irrespective of the total number children immunized. In low volume facilities the total immunization cost may be low but the unit cost is particularly high. Similarly, beyond a certain upper limit the increase in number of doses does not result in a decline in unit costs because maximum efficiency, with high utilization of available staff time, has been achieved. Nevertheless, some facilities seem to allocate staff time to immunization in a way that enables them to deliver more doses per FTE, and potential for such efficiencies should be explored further.

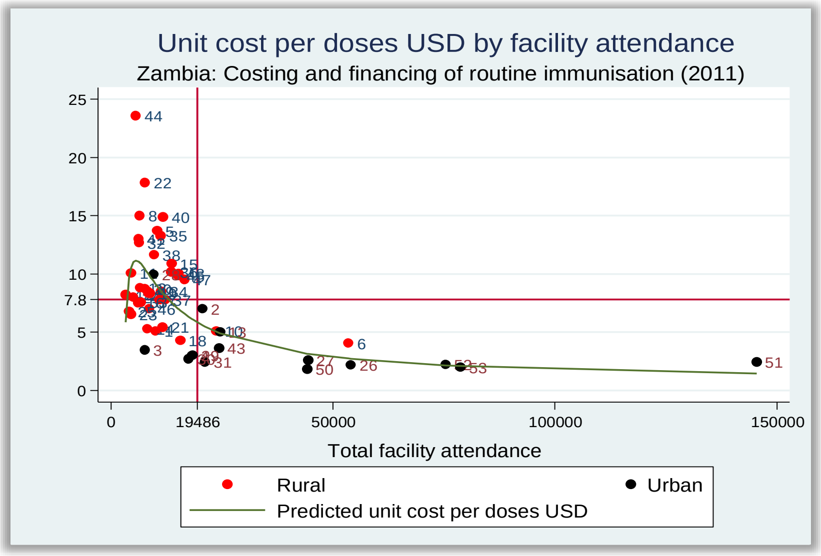
From a planning perspective, unit costs could be a good indication of total immunization cost for facilities above the volume threshold of around 10 000 doses. Below the lower volume threshold it seems desirable to rather consider total facility costs and specific circumstances in budgeting, as unit costs will vary significantly for low volume facilities. In Zambia the majority of additional facilities are likely to be located in remote, rural settings in an effort to reach outlying communities; for these, the latter approach to budgeting (total cost per facility) for new facilities is more likely to be indicative of actual cost

Annex 9 (a): Unit cost scatter plots excluding large facilities

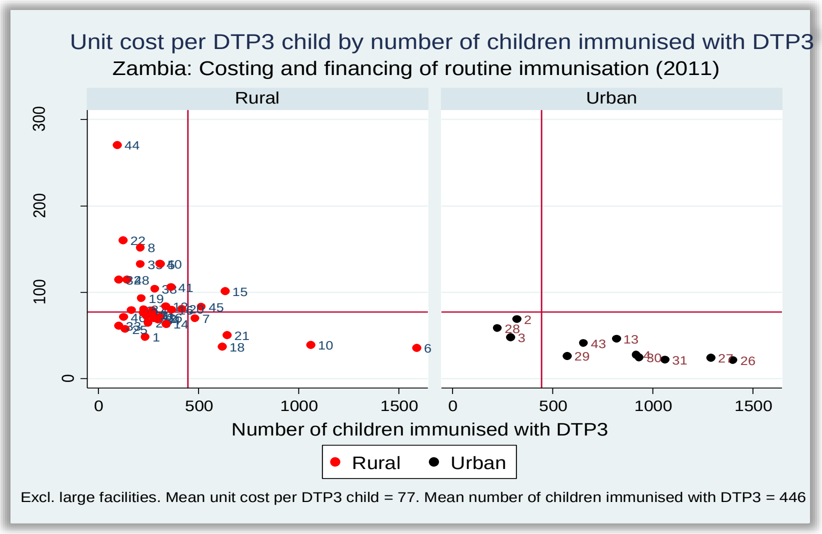
i. Unit Costs per DTP3 child - excluding large facilities 50-53



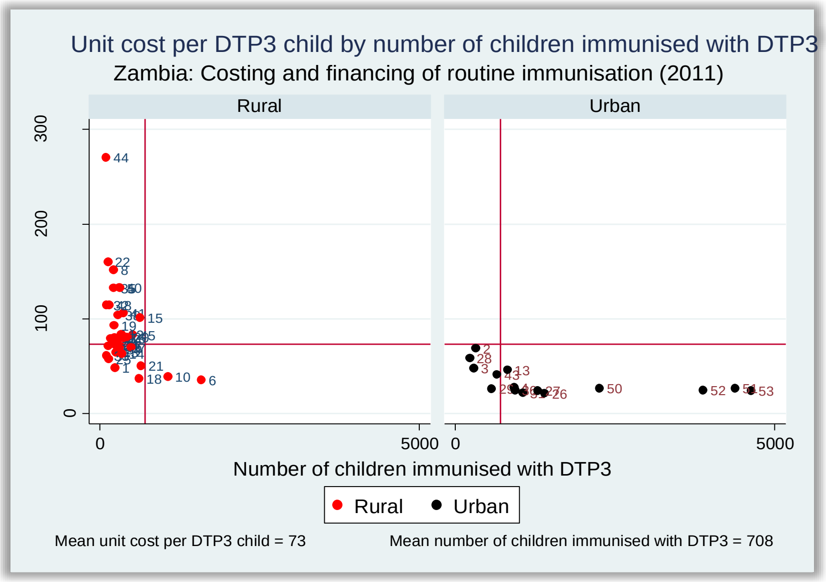
ii. Unit Costs per dose - excluding large facilities 50-53



iii. **Rural & Urban Facility Unit Costs per DTP3 child - excl facility 50-53**

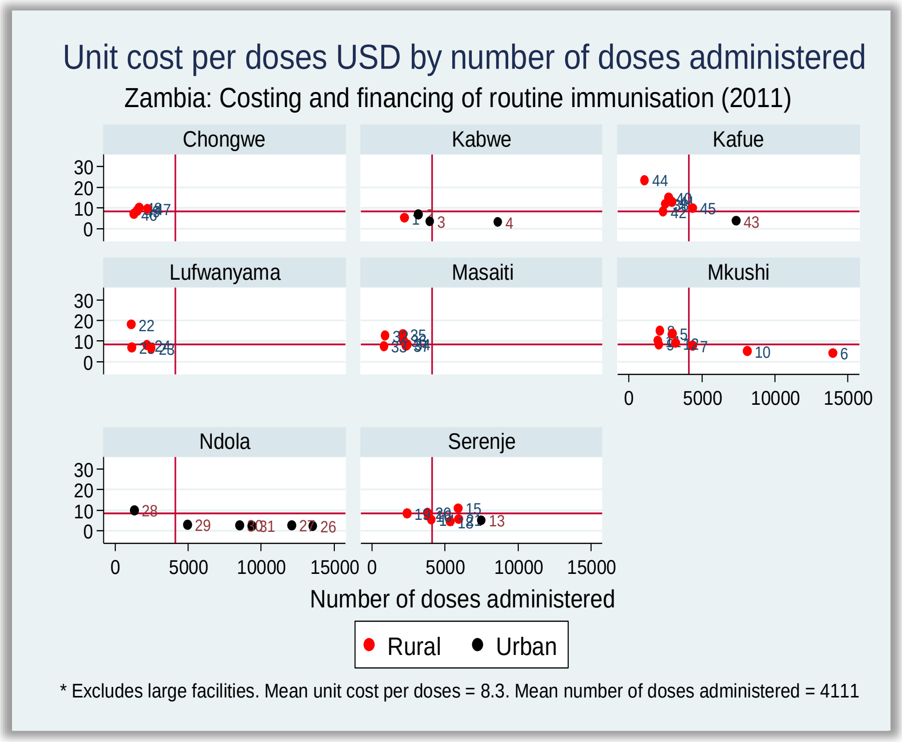


iv. **Rural and Urban Facility Unit Costs per DTP3 child - *in*cluding large facilities 50-53**

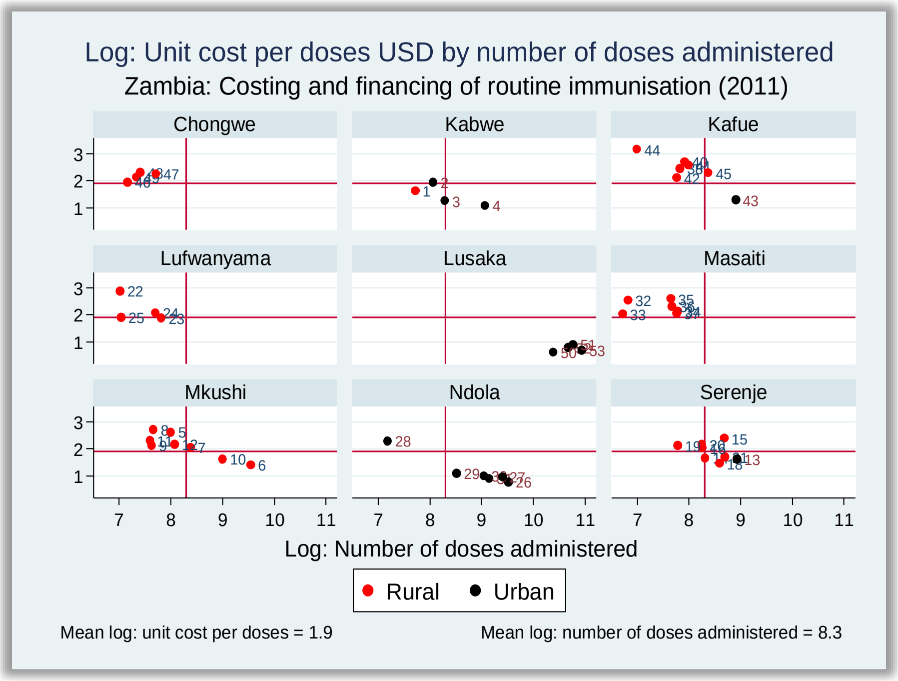

Unit cost per DTP3 child by number of children immunised with DTP3
Zambia: Costing and financing of routine immunisation (2011)
Rural
Urban
0
100
200
300
0
5000
0
5000
Number of children immunised with DTP3
Rural
Urban
Mean unit cost per DTP3 child = 73
Mean number of children immunised with DTP3 = 708

Annex 9 (b): Unit costs by districts

i. Unit costs per dose by District excluding Lusaka facilities



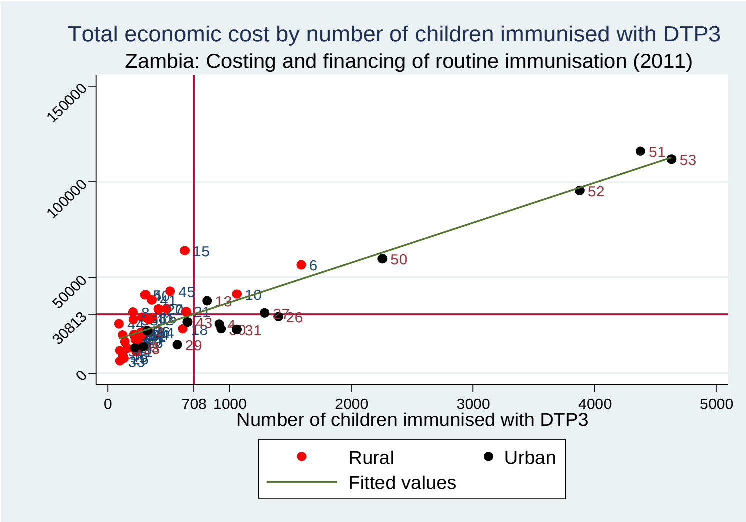
ii. Unit costs per dose by District - log transformed



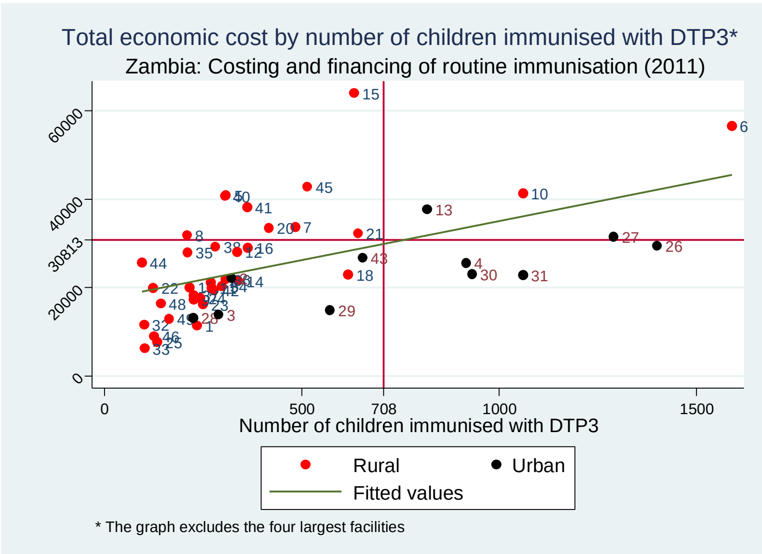
B. Total facility costs: Effects of outliers and distribution of costs

Annex 9 (c): Total facility economic cost vs service volume (untransformed)

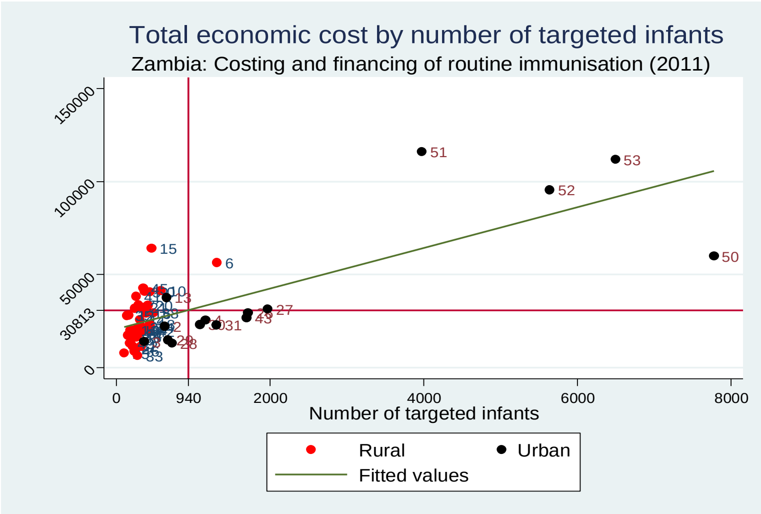
i. Facility Total Economic Cost vs DTP3 Vaccinated Children



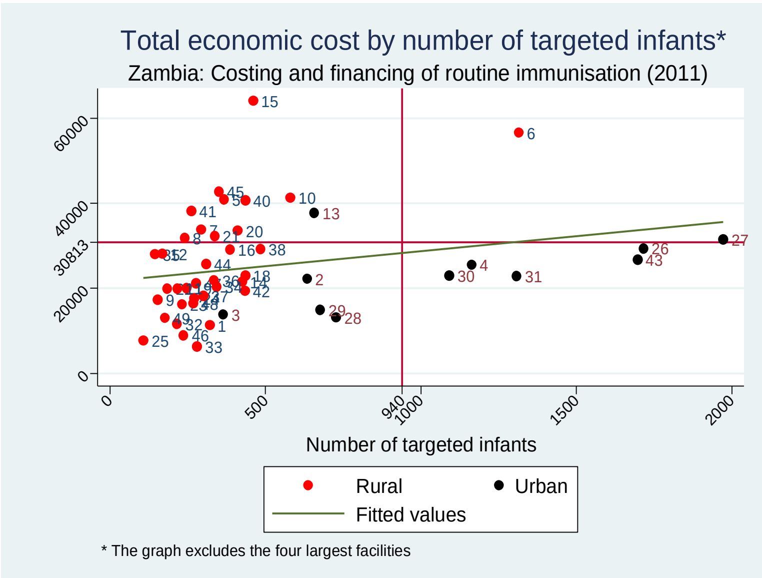
ii. Facility Total Economic Cost vs DTP3 Vaccinated Children - excluding largest facilities



iii. Facility Total Economic Cost vs Total Infants

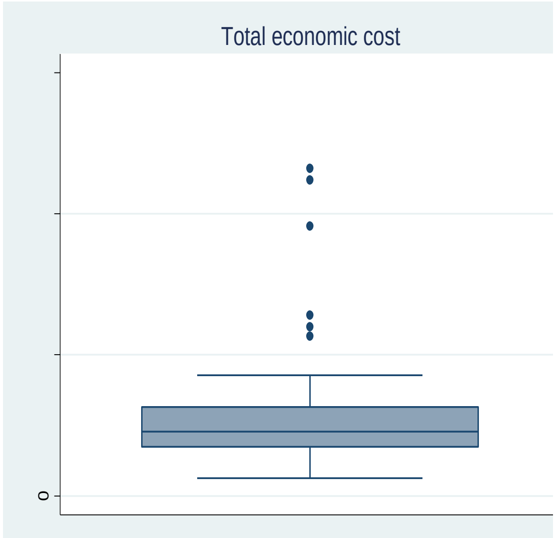


iv. Total Economic Cost vs Total Infants - excluding largest facilities

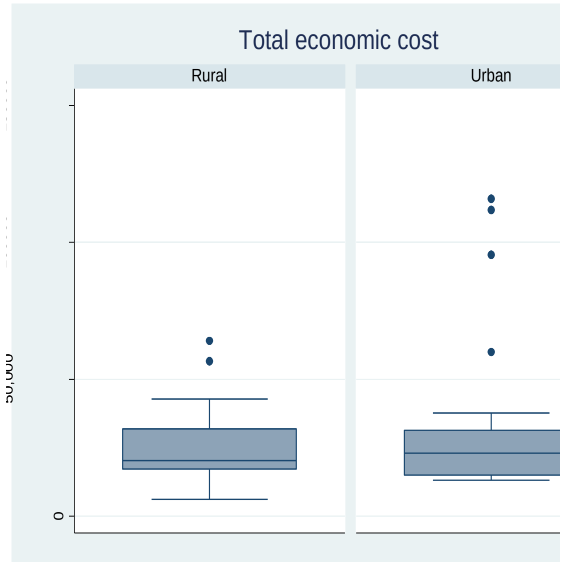


Annex 9 (d): Total facility economic cost distribution

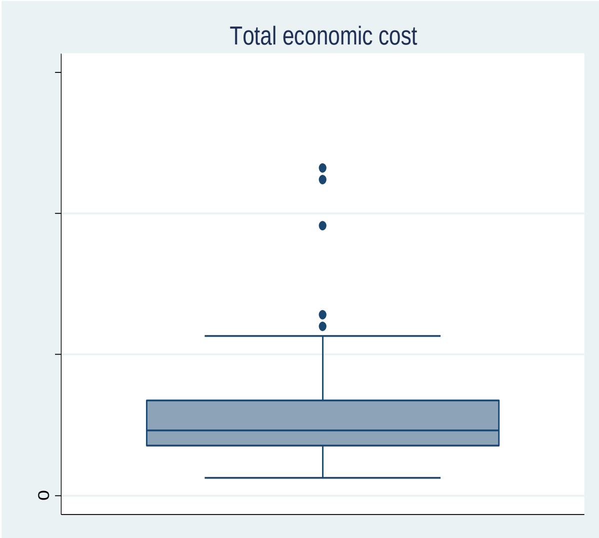
i. Facility Total Economic Cost (Weighted)



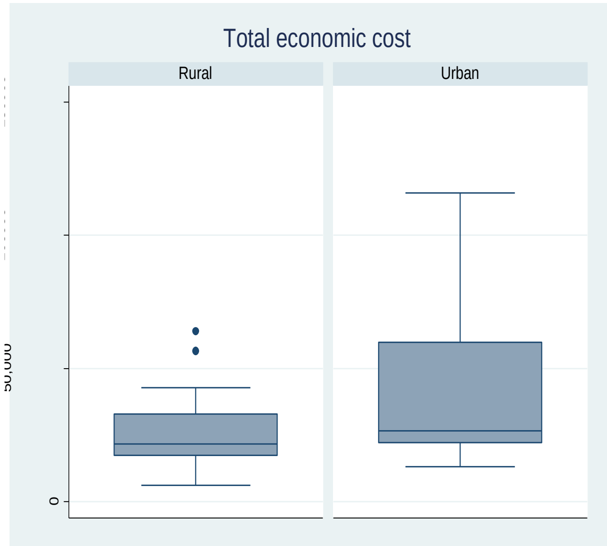
ii. Facility Total Economic Cost Rural vs Urban (Weighted)



iii. Facility Total Economic Cost (Unweighted)



iv. Facility Total Economic Cost Rural vs Urban (Unweighted)



Annex 10 – Regression analysis diagnostics

To assess fitted regression models in productivity models and costing models, residual diagnostics were used. Regression assumptions were also assessed. Because a number of models were fitted for the same dependent variable, the diagnostics for only the first models for productivity and cost are presented here.

1. Regression diagnostics for the Productivity Model

Below are diagnostics assessments for the productivity model with dependent variable (D).

a) Normality Assumptions

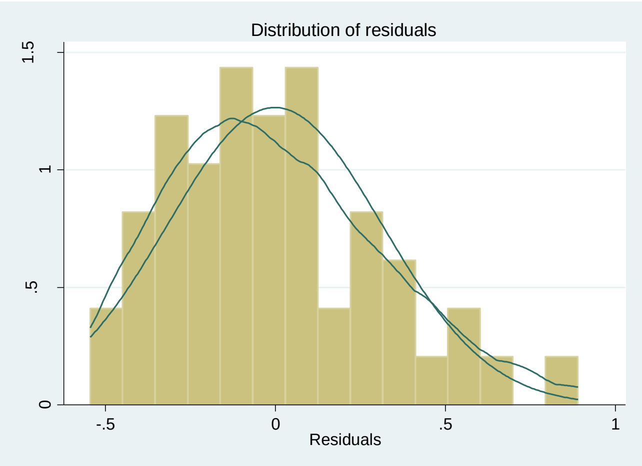
Residuals obtained after fitting the productivity model were used to assess whether the normality assumption was satisfied. Graphical methods (histograms, box and whisker plots as well as normal probability plots) as well as the Shapiro Wilk test for normality were used. The results shown below indicate that the mean of the residuals was slightly larger than the median, as shown by the small positive skewness value. All the graphs and the formal parametric Shapiro Wilk test used to assess normality suggest that the residuals were normally distributed.

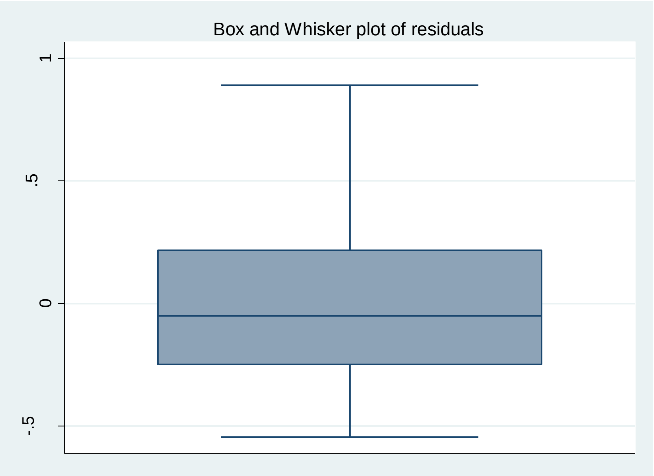
Residuals

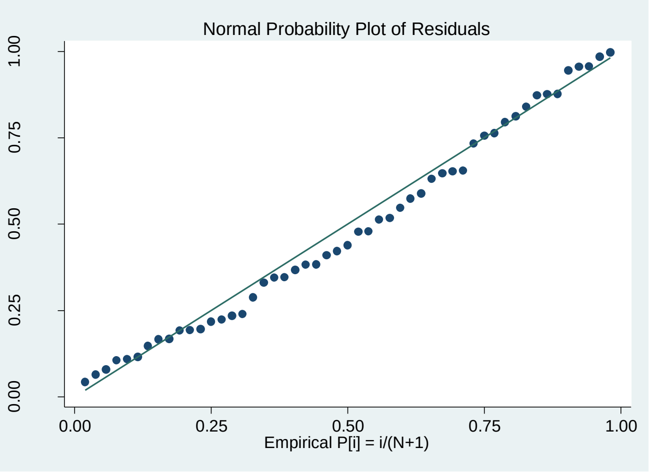
PercentilesSmallest
1% -.5441738-.5441738
5% -.4456627-.4810957
10% -.379395-.4456627 Obs51
25% -.2477424-.3961297 Sum of Wgt. 51
50% -.0497574 Mean -.0013159
Largest Std. Dev..3153524
75% .2168803 .534039
90% .3648757 .5364301 Variance .0994471
95% .5364301 .6842865 Skewness .6226454
99% .8904855 .8904855 Kurtosis 3.03347

Shapiro-Wilk W test for normal data

Variable | Obs W Vz Prob>z
-------------+---
res_dtp3 | 51 0.968951.483 0.842 0.19998







b) Test for homogeneity of variances

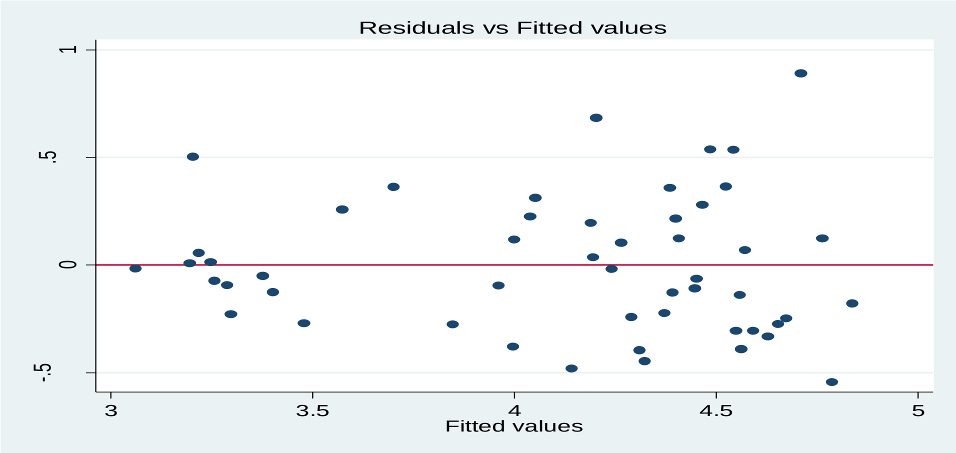
A test to see if there was homogeneity of variance shows that this assumption was not met, as shown by the Breusch – Pagan / Cook-Weisberg test for heteroskedasticity. The Residuals versus Fitted values plot, suggests that the variances increase with increasing unit cost DTP3 facilities. This may be a sample size issue, since there were fewer large facilities.

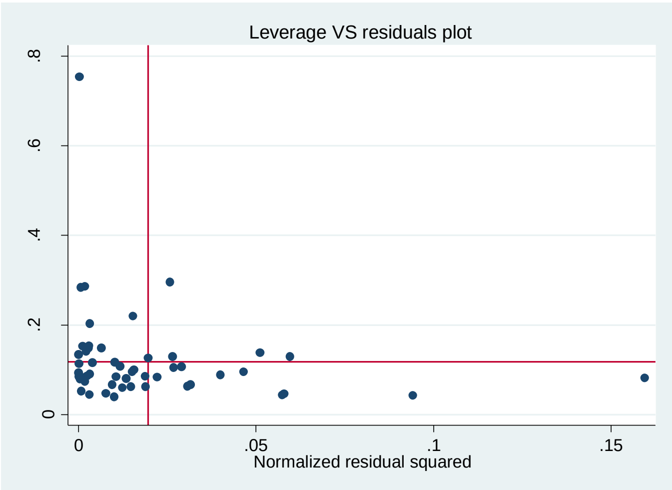
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of usd_totalcost_dtp3_log

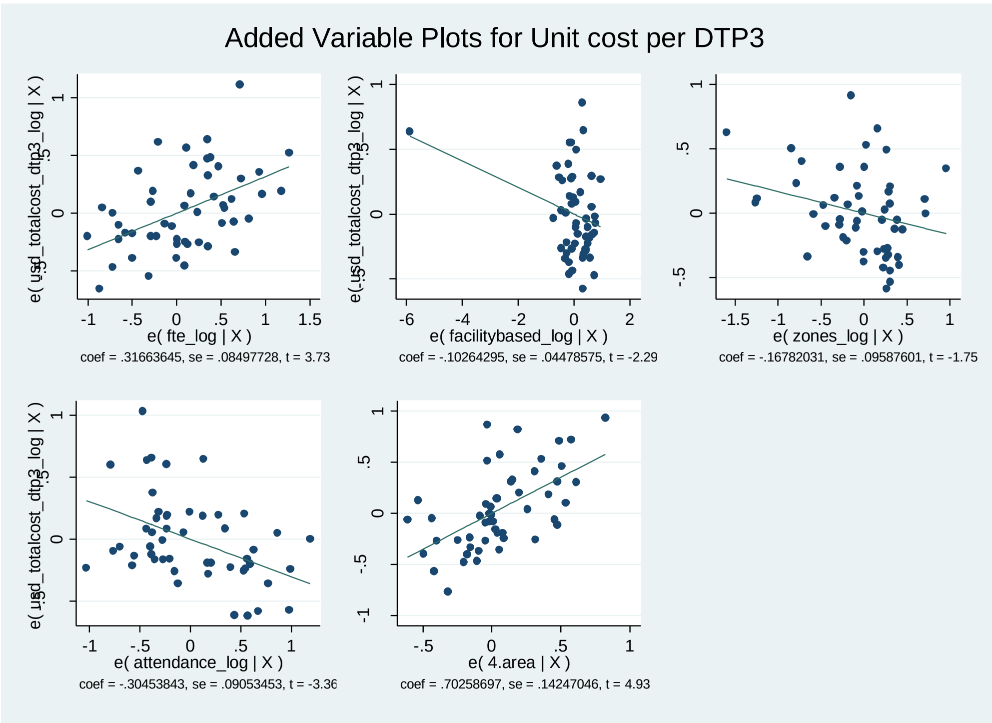
chi2(1)= 5.06
Prob > chi2 =0.0245

c) Assessing high influence values

In order to investigate facilities or observations with values that could have large influences on regression beta coefficients, we explored residuals verses fitted values plots, Leverage verses Residuals plots, Added Variable plots, as well as reporting Variance Inflation Factors. None of the fitted residuals was great than 2 absolute standard deviations, and no facilities had very large leverage values.







d) *Variance Inflation Factors*

To see which variables had the biggest effect on model variances, variance inflation factors were assessed for independent variables in the model. None of the 4 fitted variables had VIF above 3.

```
 Variable | VIF 1/VIF
-------------+----------------------
  fte_log |1.26 0.794636
facilityba~g |1.03 0.974807
zones_log |1.54 0.650528
attendance~g |2.68 0.373133
4.area |2.48 0.402503
-------------+----------------------
 Mean VIF |1.80
```

e) Sensitivity analysis

Sensitivity analyses involved removing observations that appeared to be possible outliers or high leverage values identified in the Added Variable plots. From the added variables plot above, observation 48 had a relatively high unit cost per DTP3 but no outreach immunization happening at the facility which explains its outlier position in the facility-based immunization plot above. Below are results with all the observations included, and the second model excludes this observation. There are some changes in beta coefficients for number of zones supported.

Model with all observations

```
Source | SS df MS  Number of obs =51
-------------+-----------------------------  F(  5, 45) =29.19
 Model |  14.5390842  5  2.90781683  Prob > F=  0.0000
 Residual |  4.48209746 45  .099602166  R-squared  =  0.7644
-------------+----------------------------  Adj R-squared =  0.7382
 Total |  19.0211816 50  .380423632  Root MSE=.3156

------------------------------------------------------------------------------
usd_totalcost_d~g |Coef.Std. Err.t P>|t|  [95% Conf. Interval]
-----------------+----------------------------------------------------------------
 fte_log |.3166365.0849773  3.730.001  .1454834 .4877895
facilitybased_log |  -.1026429.0447857 -2.290.027 -.1928461-.0124398
  zones_log |  -.1678203 .095876 -1.750.087 -.3609245 .0252839
attendance_log |  -.3045384.0905345 -3.360.002 -.4868843-.1221925
  4.area | .702587.1424705  4.930.000  .4156367 .9895372
_cons |6.756685.8618453  7.840.000  5.020839  8.49253
------------------------------------------------------------------------------
```

Model without facility 48

```
Source | SS df MS  Number of obs =50
-------------+-----------------------------  F(  5, 44) =28.64
 Model |  14.1948152  5  2.83896304  Prob > F=  0.0000
 Residual |  4.36136322 44  .099121891  R-squared  =  0.7650
-------------+-----------------------------  Adj R-squared =  0.7383
 Total |  18.5561784 49  .378697519  Root MSE=  .31484

------------------------------------------------------------------------------
usd_totalcost_d~g |Coef.Std. Err.t P>|t|  [95% Conf. Interval]
-----------------+----------------------------------------------------------------
 fte_log |.3136453.0852423  3.680.001  .1418508 .4854398
facilitybased_log |  -.1054631.0450023 -2.340.024 -.1961593-.0147669
  zones_log |-.135153.1028848 -1.310.196 -.3425037 .0721978
attendance_log |  -.3260579.0939186 -3.470.001 -.5153385-.1367774
  4.area |.6654468 .148788  4.470.000  .3655842 .9653094
_cons |6.912644.8814897  7.840.000  5.136118 8.689169
------------------------------------------------------------------------------
```

2. Regression diagnostics for Cost Determinants Model

The regression diagnostics for dependent variable total cost, and independent variables doses, dtp3 per FTE, FTE per hour and facility area size are as follows.

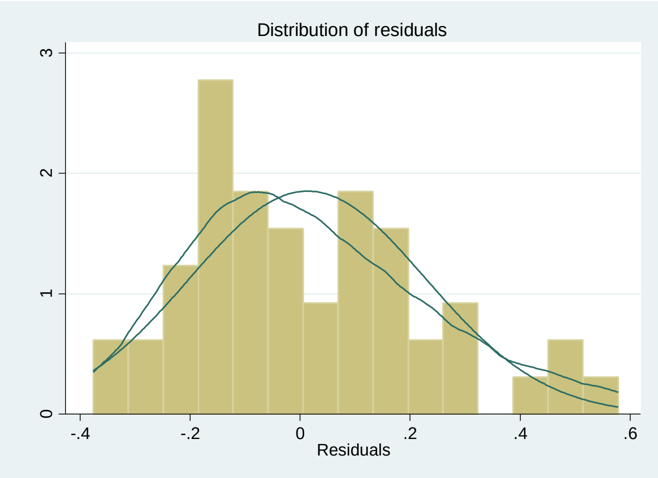
a) Normality Assumptions

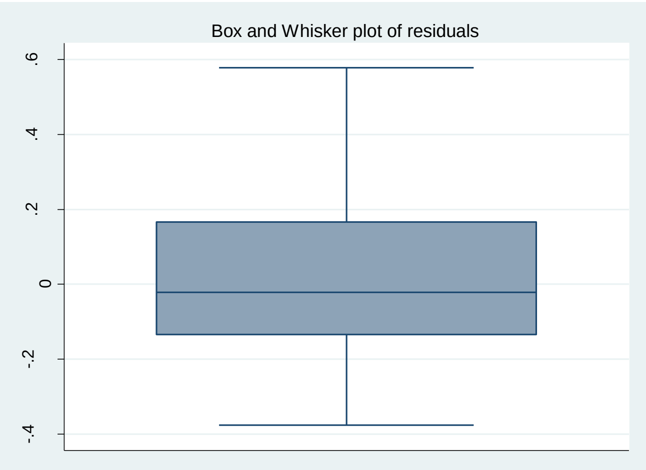
Although there is a slightly positive skewness, the graphs as well as the Shapiro Wilk test suggest that the normality assumption is met.

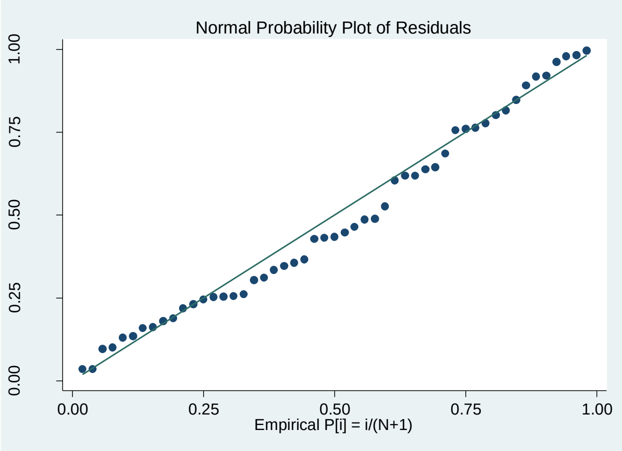
Summary statistics of Residuals

```
-------------------------------------------------------------
PercentilesSmallest
 1% -.3762902-.3762902
 5% -.2677504-.3751965
10% -.2241449-.2677504 Obs51
25% -.1350494-.2612004 Sum of Wgt. 51
50% -.0219798 Mean  .0134449
Largest Std. Dev..2154267
75%.165982 .3955676
90%  .3129453 .4525129 Variance .0464087
95%  .4525129  .470226 Skewness  .566644
99%  .5783706 .5783706 Kurtosis 2.919622
```

```
 Shapiro-Wilk W test for normal data
 Variable | Obs W  Vz Prob>z
-------------+------------------------------------------------
 res_cost |  51 0.969211.471  0.824 0.20506
```







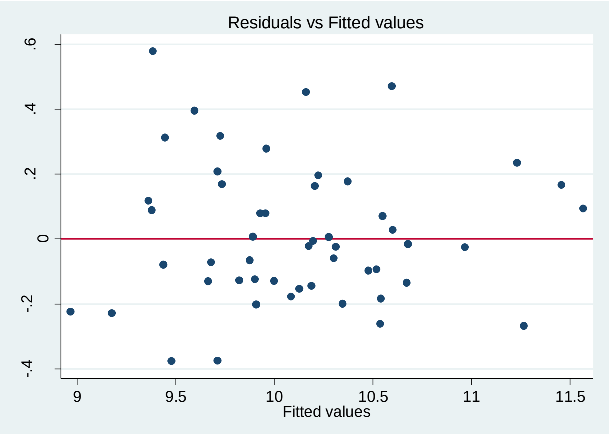
b) *Testing for homogenous variances (Heteroscadascity test)*

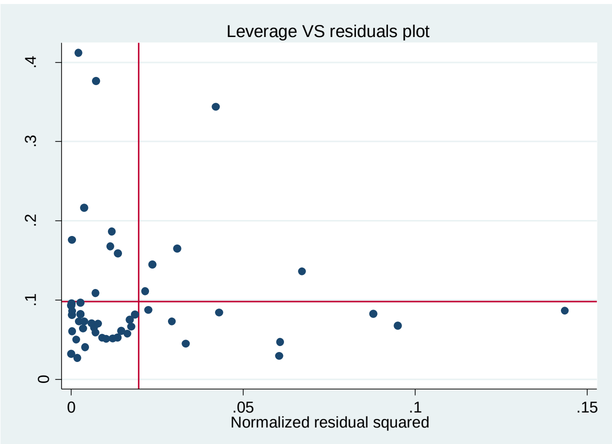
The Breusch-Pagan test for heteroskedasticity was used to assess if there were homogeneous variances, and the results below show that this assumption was met.

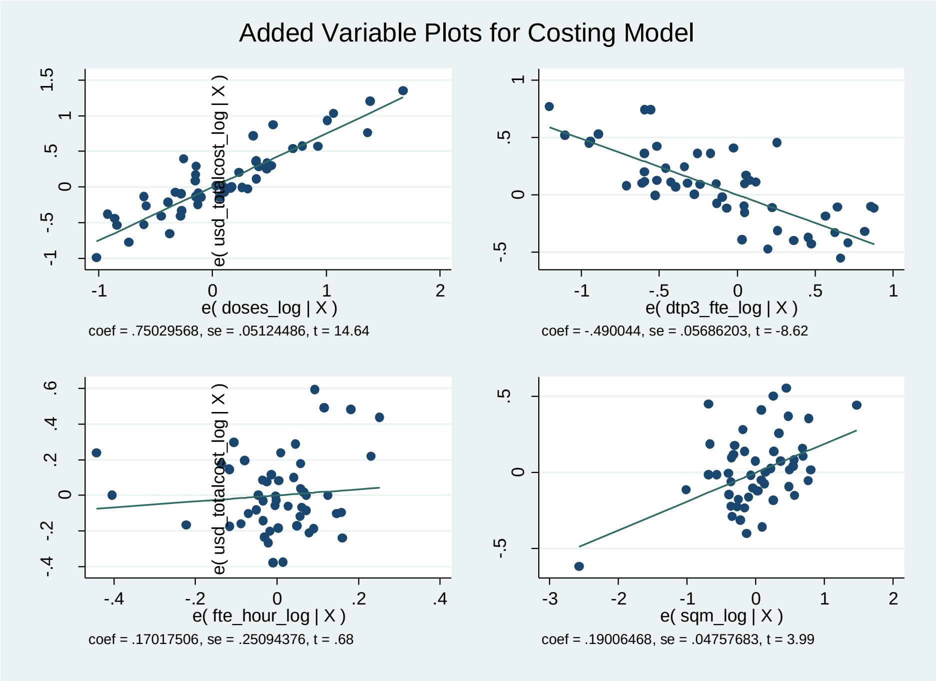
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of usd_totalcost_log
chi2(1)= 1.14
Prob > chi2 =0.2856

c) *High Influence values*

To assess whether some observations were likely to have high influence on the regression models, residual plots, Cook's distance plots as well as Added Variable plots were used. The results are shown below:







d) Variance Inflation Factors

To see which variables had the biggest effect on model variances, variance inflation factors were assessed for independent variables reported in the model. None of the 4 fitted variables had VIF above 5.

```
 Variable | VIF 1/VIF
-------------+----------------------
doses_log |3.02 0.331331
dtp3_fte_log |2.89 0.346205
fte_hour_log |1.19 0.840340
  sqm_log |1.15 0.872698
-------------+----------------------
 Mean VIF |2.06
```

e) Sensitivity Analysis

Observation 3 had a relatively low total floor area, but high total cost (see Added Variable plot with sq m above), thus we carried out sensitivity analysis looking at a model with all the observations, and comparing it with a model where observation 3 was taken out. Taking this observation had a small influence on all other beta coefficients except for the floor area variable that decreased from 0.19 to 0.15.

Model with all observations

```
Source | SS df MS  Number of obs =51
------------+----------------------------  F(  4, 46) =88.81
 Model |  15.1822665  4  3.79556663  Prob > F=  0.0000
 Residual |  1.96584029 46  .042735658  R-squared  =  0.8854
------------+----------------------------  Adj R-squared =  0.8754
 Total |  17.1481068 50  .342962136  Root MSE=  .20673

------------------------------------------------------------------------------
usd_to~t_log |Coef.Std. Err.t P>|t|  [95% Conf. Interval]
------------+-----------------------------------------------------------------
doses_log |.7502957.0512449 14.640.000  .6471451 .8534462
dtp3_fte_log |-.490044 .056862 -8.620.000 -.6045013-.3755867
fte_hour_log |.1701751.2509438  0.680.501 -.3349485 .6752987
  sqm_log |.1900647.0475768  3.990.000  .0942975 .2858319
 _cons | 6.00386.4932859 12.170.000  5.010927 6.996793
------------------------------------------------------------------------------
```

Model without observation 3, with low total floor area

```
Source | SS df MS  Number of obs =50
-------------+------------------------------  F(  4, 45) =86.71
 Model |  14.9313068  43.7328267  Prob > F=  0.0000
 Residual |  1.93724589 45  .043049909  R-squared  =  0.8852
-------------+------------------------------  Adj R-squared =  0.8749
 Total |  16.8685527 49  .344256178  Root MSE=  .20748

------------------------------------------------------------------------------
usd_to~t_log |Coef.Std. Err.t P>|t|  [95% Conf. Interval]
-------------+----------------------------------------------------------------
doses_log |.7655648.0540668 14.160.000  .6566687 .8744609
dtp3_fte_log |  -.5004941.0581432 -8.610.000 -.6176005-.3833876
fte_hour_log |.1930106.2527243  0.760.449 -.3160024 .7020235
  sqm_log |.1534468 .062614  2.450.018  .0273357 .2795579
 _cons | 6.02187.4946906 12.170.000  5.025512 7.018228
------------------------------------------------------------------------------
```

Annex 11 – Correlation Matrix and Regression tables: productivity & cost determinants

Annex 11 (a): Correlation matrix of variables considered for regression models (Ln Transformed)

	total cost	hr cost	recurrent cost	total cost	nohr	Atten-dance	doses	dtp3	Imm _week	zones	Hlth staff	FTE	CHW	Dis-tance	population	collection	dtp_coverage	doses _fte	doses _n	dist_ pop
total cost	1.00																			
hr cost	0.86**	1.00																		
recurrent cost	1.00**	0.87**	1.00																	
total cost	-0.24	-0.07	-0.27	1.00																
nohr	0.74**	0.47**	0.70**	0.13	1.00															
attendnce	0.67**	0.53**	0.69**	-0.68**	0.28	1.00														
doses	0.80**	0.60**	0.81**	-0.76**	0.40*	0.86**	1.00													
dtp3	0.80**	0.60**	0.81**	-0.78**	0.40*	0.86**	0.99	1.00												
Imm _week	0.48**	0.44*	0.50**	-0.23	0.26	0.52**	0.47**	0.45**	1.00											
zones	0.51**	0.41*	0.50**	-0.15	0.46**	0.31	0.37	0.42*	0.12	1.00										
healthstaf	0.43*	0.45**	0.45**	-0.31	0.00	0.60**	0.50**	0.47**	0.36*	0.07	1.00									
fte	0.81**	0.89**	0.82**	0.07	0.51**	0.35	0.50**	0.48**	0.44*	0.40*	0.41*	1.00								
chw	0.01	-0.01	0.06	0.12	0.16	-0.21	0.04	-0.02	-0.22	0.41*	-0.34	0.04	1.00							
distance	-0.22	-0.05	-0.23	0.49	-0.76	-0.45	-0.04	0.45*	-0.22	-0.07	-0.25	-0.04	-0.02	1.00						
populatn	0.65*	0.50**	0.68**	-0.74**	0.20	0.85	0.90**	0.88**	0.50**	0.28	0.55**	0.38	-0.10	0.44*	1.00					
collection	0.13	0.04	0.13	-0.22	0.90	0.26	0.22	0.22	0.09	0.12	-0.36	0.04	-0.07	-0.09	0.15	1.00				
dtp_coverage	0.36*	-0.34	0.36	-0.22	0.3*	0.21	0.34*	0.37**	0.16	0.22	-0.02	0.33*	0.03	0.00	0.00	0.11	1.00			
doses_fte	0.33*	0.05	0.34*	-0.91**	0.09	0.73**	0.79**	0.78**	0.22	0.14	0.27	-0.15	-0.07	-.46**	0.74**	0.22	0.16	1.00		
doses_n	0.32*	0.11	0.32*	-0.52**	0.28	0.26	0.52**	0.54**	-.37**	0.30*	-0.26	0.02	0.38	-.19	0.35*	0.21	0.28*	0.58**	1.00	
dist_ populatn	0.57**	0.51**	0.60**	-0.62**	0.1	0.74**	0.77**	0.76**	0.44**	-0.03	0.48**	0.36**	-0.18	-.31**	0.87**	0.22	0.01	0.62**	0.30*	1.0
dist_sup	0.13	0.27	0.14	0.32*	0.06	-0.18	-0.12	-0.12	-0.03	0.02	0.04	0.28*	0.16	0.03	-0.02	-0.26	-0.18	-0.33	-0.14	0.04
dist_cover	0.05	0.05	0.02	0.42**	0.35*	-.40**	-0.24	-0.23	-0.05	0.32*	-.48**	0.20	0.36**	0.2	-.49**	-0.01	0.39**	0.42**	0.03	.57**

*** Statistically significant at 5% ** Statistically significant at 1%**

Annex 11 (b): Statistical analysis of performance indicators (ß, Confidence Intervals and p-value)

	Ln Unit cost per DTP3 Child		Ln Annual doses per FTE	
Variable	**Model - 1 ß (95% CI) p-value**	**Model - 2 ß (95% CI) p-value**	**Model - 1 ß (95% CI) p-value**	**Model - 2 ß (95% CI) p-value**
Ln # Health Staff involved in immunization		0.25 (-0.03;0.53) 0.08	-0.64 (-0.89;-0.39)< 0.01	
Ln FTEs	0.32 (0.15;0.49) <0.01			
Ln % Facility based immunizations (2011)	-0.10 (-0.19;-0.01) 0.03	-0.08 (-0.18;0.03) 0.17	0.10 (-0.03;0.23) 0.11	0.13 (-0.04;0.29) 0.12
Ln # Zones supported	-0.17 (-0.36;0.03) 0.09	-0.09 (-0.30;0.12) 0.39	0.16 (-0.12;0.44) 0.25	0.02 (-0.32;0.37) 0.88
Ln facility attendance -total	-0.30 (-0.49;-0.12) <0.01	-0.28 (-0.49;-0.07)0.01	0.75 (0.49;1.01) <0.01	0.56 (0.24;0.88) < 0.01
Facility type (binary) Urban Rural	- 0.70 (0.42;0.99) <0.02	- 0.82 (0.51;1.14) <0.01	- -0.52 (-0.93;-0.11) 0.01	- -0.69 (-1.20;0.18) <0.01
Constant	6.76 (0.42;0.99) <0.01	5.98 (4.14;7.82)< 0.01	1.28 (-1.23;3.78) 0.31	3.53 (0.58;6.47) 0.02
R-squared (adjusted R2)	0.76	0.71	0.77	0.63
F value	F(5, 45) = 29, < 0.01	F(5,45) = 22, <0.01	F(5, 45) = 30, < 0.01	F (4, 46) = 20, < 0.01

Annex 11 (c) : Statistical analysis of facility productivity (ß, Confidence Intervals and p-value)

	Ln Total number of DTP3 children			**Ln Total number of facility doses**		
Variable	**Model - 1 ß (95% CI) p-value**	**Model - 2 ß (95% CI) p-value**	**Model - 3 ß (95% CI) p-value**	**Model - 1 ß (95% CI) p-value**	**Model - 2 ß (95% CI) p-value**	**Model - 3 ß (95% CI) p-value**
Ln FTE Immunisation staff	0.22 (-0.09;0.52) 0.16	0.22 (-0.08;0.52) 0.14	0.22 (-0.09;0.52) 0.15	0.26 (-0.07;0.58) 0.12		0.25 (-0.07;0.57) 0.12
Ln # CHWs	-0.004 (-0.07;0.06) 0.91	-0.002 (-0.06;0.06) 0.93		0.01 (-0.06;0.07) 0.85		0.004 (-0.06;0.07) 0.89
Ln # Zones supported (outreach)	0.62 (0.32;0.92) < 0.01	0.62 (0.33;0.92) < 0.01	0.61 (0.33;0.90) < 0.01	0.57 (0.24;0.89) < 0.01	0.62 (0.33:0.91)< 0.01	0.56 (0.24;0.88) < 0.01
Ln Distance to vaccine collection point (km's)	-0.01 (-0.13;0.12) 0.89		-0.01 (-0.13;0.59) 0.91	0.01 (-0.12;0.15) 0.83		
Facility type & Area Urban Rural	- -1.04(-1.69;-0.40) <0.01	- -1.08 (-1.46;-0.70)<0.01	- -1.05 (-1.66;-0.44) < 0.01	- -1.12 (-1.81;-0.42) < 0.01	- -0.91 (-0.32;-0.50) <0.01	- -1.06 (-1.47;-0.65) < 0.01
Ln District poverty index	-0.12 (-0.24;-0.01) 0.04	-0.12 (-0.22;0.02) 0.02	-0.12 (-0.24;-0.01) 0.03	-0.14 (-0.26;-0.01) 0.03	-0.21 (-0.31;-0.11) < 0.01	-0.14 (-0.25;-0.04) 0.01
Roads Good/Fair Poor/very poor	- 0.23 (-0.14;0.59) 0.23	- 0.24 (-0.07;0.55) 0.13	- 0.23 (-0.13;0.59) 0.20	- 0.36 (-0.04;0.75) 0.08		- 0.33 (0.001;0.67) 0.05
Constant	5.48 (4.81;6.16) <0.01	5.47 (4.84;6.09) < 0.01	5.49 (4.83;6.15 <0.01	7.74 (7.01;8.47) < 0.01	7.70 (7.12;8.29) < 0.01	7.77 (7.10;8.44) < 0.01
R-squared (adjusted R^2)	0.75	0.75	0.75	0.74	0.69	0.74
F statistics	F(7, 43) = 18, < 0.01	F(6, 44) = 22, < 0.01	F(6, 44) = 22, <0.01	F(7, 43) = 18, < 0.01	F(3, 47) = 35, <0.01	F(6, 44) = 21, ,0.01

Annex 11 (d): Regression results for total facility cost and costs excluding HR and vaccines (ß, Confidence Intervals and p-value)

	Ln Total facility cost (n=51)				Ln Total cost excluding vaccines and salaried labour (n=51)			
	Model 1 **ß (95% CI) p-value**	Model 2 **ß (95% CI) p-value**	Model 3 **ß (95% CI) p-value**	Model 4 **ß (95% CI) p-value**	Model 5 **ß (95% CI) p-value**	Model 6 **ß (95% CI) p-value**	Model 7 **ß (95% CI) p-value**	Model 8 **ß (95% CI) p-value**
Quantity Ln Dose	0.75 (0.65;0.85)<0.01			0.55 (0.42;0.69) < 0.01	0.38 (0.14;0.63) < 0.01		0.49 (0.24;0.74) < 0.01	0.38 (0.17;0.59) < 0.01
Ln Doses estimated		0.58 (0.38;0.77)< 0.01						
Quality Ln DTP3 / FTE	-0.49 (-0.60;-0.38)< 0.01	-0.27 (-0.46;-0.07)0.01	0.05 (-0.19;0.29) 0.68		-0.36 (-0.63;-0.08)0.01	0.08 (-0.19;0.35) 0.54	-0.23 (-0.51;0.06) 0.11	
Price Ln cost / FTE Hour	0.17 (-0.33;0.68) 0.51	-0.61 (-1.48;0.26) 0.16	-0.92 (-2.05;0.21) 0.11	-0.58 (-1.27;0.11) 0.10	-0.63 (-1.85;0.58) 0.30	-1.40 (-2.66;-0.13) 0.03	-0.71 (-1.87;0.45) 0.22	-1.07 (-2.16; 0.01) 0.05
Capital Ln SQM	0.19 (0.09;0.29)< 0.01	0.27 (0.10;0.44) < 0.01	0.46 (0.23;0.68)< 0.01	0.13 (-0.03;0.29) 0.11	0.58 (0.35;0.81) , 0.01	0.64 (0.39;0.90) < 0.01	0.43 (0.18;0.68) < 0.01	0.42 (0.42;0.12) < 0.01
Facility type urban rural			- -0.28 (-0.69;0.13) 0.17	- 0.43 (0.12;0.74) <0.01		- 0.24 (-0.22;0.69) 0.31	- 0.65 (0.15;1.16) 0.01	- 0.78 (0.30;1.27) < 0.01
Distance to vaccine collection point				-0.01 (-0.07;0.05) 0.76			-0.05 (-0.14;0.04) 0.27	-0.05 (-0.14;0.04) 0.28
Constant	6.00 (5.01;7.00)< 0.01	7.10 (5.32;8.87) < 0.01	10.06 (7.92;12.19)< 0.01	5.80 (4.17;7.43) < 0.01	6.77 (4.39;9.16) <0.01	8.18 (5.79;10.58) <0.01	5.44 (2.92;7.98) < 0.01	5.54 (2.97;8.11) < 0.01
R-Squared	0.89	0.63	0.38	0.76	0.56	0.48	0.62	0.60
F statistic	F(4, 46) = 89, < 0.01	F(4, 46) = 19, <0.01	F(4, 46) = 7, < 0.01	F(5, 45) = 28, < 0.01	F(4,46)= 15, < 0.01	F(4,46)= 11, < 0.01	F(6,44) = 12, < 0.01	F(5,45)= 13, < 0.01

Annex 12 - Detailed human resource time allocations and FTEs by facility type

Annex 12 (a): Total FTEs and staff time allocation by facility type and staff category

Line Items	Urban (Range)	Rural (Range)	All Facilities (Range)
Sample (n)	14	36	50
Total FTEs	1.83 (0.46, 8.25)	1.78 (0.42, 6.21)	1.80 (0.42, 8.25)
Total FTEs excl. CHWs	1.05 (0.46, 4.30)	1.08 (0.32, 3.53)	1.07 (0.32, 4.30)
Doses/FTE	8673 (891, 20 300)	1977 (415, 4886)	4562 (415, 20 300))
Doses/FTE excl. CHWs	11542 (1504, 21839)	3118 (730, 11731)	6370 (730, 21829)
Time spent per dose delivered	31 (6, 140)	85 (26, 301)	64 (6, 301)
Time spent per dose deliveredexcl. CHWs	20 (6, 83)	54 (11, 171)	41 (6, 171)
Share of time spent on immunization: support staff	0.3% (0, 0.058)	9.6% (0, 0.831)	6.0% (0, 0.831)
Share of time spent on immunization: CHWs	5.3% (0, 0.4)	6.5% (0, 0.18)	6.0% (0, 0.4)
Share of time spent on immunization: health centre in-charge	0 (0, 0)	0 (0, 0)	0 (0, 0)
Share of time spent on immunization: registered nurse (6 & 7)	10.7% (0, 0.427)	3.6% (0, 0.3)	6.4% (0, 0.427)
Share of time spent on immunization: enrolled nurse (8 & 9)	30.4% (0.110, 0.870)	48.6% (0.108, 1.5)	41.5% (0.108, 1.5)

Annex 12 (b) : Total FTEs by type of facility and activity

Activities	Facility Type Urban	%	Facility Type Rural	%	All Facilities	%
Sample (n)	**14***		**36**		**50**	
- Routine Facility-Based Services	0.37 (0.05, 2.09)	20.4%	0.27 (0.06, 1.11)	15.2%	0.31 (0.05, 2.09)	17.2%
- Record-Keeping/HMIS	0.05 (0.01, 0.17)	2.5%	0.22 (0.01, 1.72)	12.5%	0.15 (0.01, 1.72)	8.6%
- Supervision	0.08 (0.01, 0.31)	4.5%	0.05 (0.01, 0.24)	2.9%	0.06 (0.01, 0.31)	3.5%
- Outreach Services	0.30 (0.09, 1.33)	16.4%	0.40 (0, 1.28)	22.5%	0.36 (0, 1.33)	20.1%
- Social mobilization	0.48 (0.02, 4.02)	26.3%	0.34 (0.01, 2.2)	19.0%	0.39 (0.01, 4.02)	21.8%
- Cold chain maintenance	0.04 (0.01, 0.19)	2.1%	0.05 (0.01, 0.28)	2.6%	0.04 (0.01, 0.28)	2.4%
- Vaccine collection & distribution	0.03 (0, 0.14)	1.4%	0.10 (0, 0.5)	5.4%	0.07 (0, 0.5)	3.9%
- Program management	0.24 (0.01, 3.54)	13.1%	0.23 (0.01, 2.65)	13.2%	0.24 (0.01, 3.54)	13.1%
- Training	0.18 (0.02, 0.8)	10.1%	0.08 (0, 0.83)	4.4%	0.12 (0, 0.83)	6.6%
- Other	0.04 (0, 0.62)	2.0%	0.00 (0, 0.03)	0.0%	0.01 (0, 0.62)	0.8%
- Surveillance	0.02 (0, 0.09)	1.0%	0.04 (0, 0.23)	2.2%	0.03 (0, 0.23)	1.7%
Total facility staff & CHW FTE	1.83	100%	1.78	100%	1.80	100%
	(0.46, 8.25)		(0.42, 6.21)		(0.42, 8.25)	

* One UHC (Chipata) was excluded from the FTE analysis: its unconventional use of CHW distorts results for urban sites.

Annex 13 – Detailed facility level, District and unit costs

Annex 13 (a) - Total Routine Immunization Economic Costs an Unit Costs by Line Item by Facility Type ($2011)

Line Items	Facility Type Urban (Range)	%	Facility Type Rural (Range)	%	Total Facility (Range)	%
Sample (n)	15		36		51	
- Salaried Labor	13 381 (5 396, 45 990)	38.85%	13 209 (3 758, 30 276)	54.44%	13 277 (3 758, 45 990)	46.94%
- Volunteer Labor	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
- Per Diems	1 907 (363, 6 843)	5.54%	2 671 (42, 17 914)	11.01%	2 369 (42, 17 914)	8.38%
- Vaccines	16 044 (1 981, 67 127)	46.58%	3 912 (1 125, 17 882)	16.12%	8 708 (1 125, 67 127)	30.79%
- Injection supplies	487 (52, 2 033)	1.42%	116 (33, 524)	0.48%	263 (33, 2 033)	0.93%
- Other supplies	275 (38, 1 014)	0.80%	64 (9, 196)	0.26%	147 (9, 1 014)	0.52%
- Transport & fuel	361 (0, 1 429)	1.05%	1 454 (0, 8 239)	5.99%	1 022 (0, 8 239)	3.61%
- Vehicle maintenance	1.69 (0, 12.5)	0.00%	194 (0, 1 538)	0.80%	118 (0, 1 538)	0.42%
-Cold chain energy costs	142 (36, 1 534)	0.41%	72 (0, 321)	0.30%	99 (0, 1 534)	0.35%
- Printing	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
- Building overheads	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
- Other recurrent	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
Subtotal recurrent	32 598 (12 589, 112 505)	94.65%	21 692 (5 574, 54 973)	89.41%	26 004 (5 573, 112 505)	91.93%
- Cold chain equipment	379 (201, 1 765)	1.10%	363 (181, 1 666)	1.49%	369 (181, 1 765)	1.31%
- Vehicles	3 (0, 24)	0.01%	1 066 (0, 6 301)	4.39%	646 (0, 6 301)	2.28%
- Lab equipment	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
- Other equipment	735 (22, 2 382)	2.13%	389 (0, 1 368)	1.60%	526 (0, 2 382)	1.86%
- Other capital	0 (0, 0)	0.00%	0 (0, 0)	0.00%	0 (0, 0)	0.00%
-Buildings	726 (49, 1 673)	2.11%	752 (251, 2 477)	3.10%	742 (49, 2 477)	2.62%
Subtotal capital	1 843 (514, 5 642)	5.35%	2 570 (687, 9 046)	10.59%	2 283 (514, 9 046)	8.07%
Total Facility Immunization Cost	34 441 (13 102, 115 938)	100.00%	24 262 (6 261, 64 019)	100.00%	28 286 (6 261, 115 938)	100.00 %
- Total Child Doses	13 325		2 974		7 066	

Line Items	Facility Type Urban (Range)	%	Facility Type Rural (Range)	%	Total Facility (Range)	%
	(1 319, 56 168)		(826, 13 970)		(826, 56 168)	
- Total DTP3 Vaccinated Children	1 271		330		702	
	(225, 4 634)		(95, 1 590)		(95, 4 634)	
- Infant population	1 868		319		931	
	(365, 7 780)		(108, 1 315)		(108, 7 780)	
- Total population	44 156		7 536		22 013	
	(8 632, 183 932)		(2 544, 31 084)		(2 544, 183 932)	
- Cost per Dose	3.73		9.43		7.18	
	(1.84, 9.93)		(4.05, 23.57)		(1.84, 23.57)	
- Cost per child	22.85		83.17		59.32	
	(7.69, 57.39)		(22.36, 194.51)		(7.69, 194.51)	
- Cost per DTP3 Vaccinated child	33.38		87.14		65.89	
	(20.98, 68.83)		(35.58, 270.48)		(20.98, 270.48)	
- Cost per capita	0.97		3.52		2.51	
	(0.33, 2.43)		(0.95, 8.23)		(0.33, 8.23)	
Total Delivery Cost (Total – vaccines and injection supplies)	17 910		20 234		19 315	
	(8 067, 58 258)		(5 103, 56 081)		(5 103, 58 258)	
- Delivery Cost per Dose	2.43		8.07		5.84	
	(0.76, 8.39)		(2.73, 22.25)		(0.76, 22.25)	
- Delivery Cost per child	13.79		70.56		48.12	
	(3.85, 41.57)		(18.22, 174.11)		(3.85, 174.11)	
- Delivery Cost per DTP3 Vaccinated child	21.07		74.72		53.51	
	(8.47, 56.12)		(24, 255.32)		(8.47, 255.32)	
- Delivery Cost per capita	0.58		2.98		2.04	
	(0.16, 1.76)		(0.77, 7.37)		(0.16, 7.37)	

Annex 13 (b) - Total Routine Immunization Economic Costs and Unit Costs by Activity by Facility Type ($2011)

Activities	Facility Type Urban (Range)	%	Facility Type Rural (Range)	%	Total Facility(Range)	Percent
Sample (n)	**15**		**36**		**51**	
- Routine Facility-Based Service Delivery	14 985	43.51%	6 216	25.62%	9 683	34.23%
	(5 128, 64 320)		(2 050, 23 141)		(2 050, 64 320)	
- Record-Keeping/HMIS	746	2.17%	833	3.43%	799	2.82%
	(137, 6 601)		(73, 6 912)		(73, 6 912)	
- Supervision	1 023	2.97%	1 372	5.66%	1 234	4.36%
	(273, 3 868)		(70, 16 912)		(70, 16 987)	
- Outreach Services	12 116	35.18%	8 035	33.12%	9 649	34.11%
	(2 812, 37 998)		(0, 21 896)		(0, 37 998)	
- Social mobilization	2 236	6.49%	2 501	10.31%	2 396	8.47%
	(52, 10 604)		(214, 17 500)		(52, 17 500)	
- Cold chain maintenance	651	1.89%	611	2.52%	627	2.22%
	(173, 4 792)		(73, 2 956)		(73, 4 792)	
- Vaccine collection and distribution	621	1.80%	2 207	9.09%	1 580	5.59%
	(203, 2 357)		(393, 5 667)		(203, 5 667)	
- Program management	858	2.49%	1 380	5.69%	1 174	4.15%
	(291, 2 379)		(333, 4959)		(291, 4 959)	
- Training	970	2.82%	576	2.38%	732	2.59%
	(191, 3 074)		(0, 2729)		(0, 3 074)	
- Other	25	0.07%	50	0.21%	40	0.14%
	(0, 167)		(0, 1 003)		(0, 1 003)	
- Surveillance	210	0.61%	480	1.98%	374	1.32%
	(0, 955)		(0, 2 920)		(0, 2 920)	
Total Facility Immunization Cost	34 441	100.00%	24 262	100.00%	28286	100.00%
Total Facility Immunization Cost range	(13 102, 115 938)		(6261, 64 019)		(6 261, 115 938)	

Annex 13 (c):Details of Total Routine District, Provincial and National Health Office Immunization *Economic* Costs by Line Item ($2011)

	Districts									Weighted Average District	Weighted Average Provincial Level	National Level EPI Administration
Line Items	**Chongwe**	**Kabwe**	**Kafue**	**Lufwanyama**	**Lusaka**	**Masaiti**	**Mkushi**	**Ndola**	**Serenje**	n=9	N=3	
- Salaried Labor	18 381	71 558	38 635	20 491	43 287	29 721	21 983	33 329	49 574	34 922	53 802	238 999
- Volunteer Labor	0	0	0	0	0	0	0	0	0	0	0	0
- Per Diems	31 213	10 007	18 419	18 351	35 978	18 477	9 387	13 614	17 158	17 770	20 692	160 545
- Vaccines	0	0	0	0	0	0	0	0	0	0	0	0
- Injection supplies	0	0	0	0	0	0	0	0	0	0	0	0
- Other supplies	1 044	1 491	1 743	3 560	24 267	1 493	3 206	6 093	375	4 169	1 063	0
- Transport & fuel	14 596	9 949	16 273	13 412	34 405	19 367	1 499	18 314	22 099	16 222	12 017	91 992
- Vehicle maintenance	2 960	4 332	3 058	4 476	4 492	3 948	403	6 825	9 516	4 667	2 636	22 283
-Cold chain energy costs	1 533	106	169	313	266	549	133	1 579	605	622	403	6 961
- Printing	0	4 052	0	142	12 319	0	0	0	731	1 323	0	0
- Building overheads	32 670	7 781	17 477	7 225	118 943	11 807	2 636	19 172	4 765	19 158	7 727	15 821
- Other recurrent	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal recurrent	102 398	109 277	95 776	67 971	273 956	85 361	39 249	98 926	104 822	98 853	98 341	536 601
- Cold chain equipment	680	2 920	962	3 458	1 063	2 531	1 418	6 148	2 944	2 931	3 392	14 346
- Vehicles	14 166	28 177	15 499	13 534	26 818	20 872	1 477	29 483	20 154	19 394	11 223	87 134
- Lab equipment	0	0	0	0	0	0	0	0	0	0	0	0
- Other equipment	137	470	60	146	0	759	391	1 532	773	583	1 370	9 151
- Other capital	0	0	0	0	0	0	0	0	0	0	0	0
-Buildings	1 062	1 924	1 450	6 059	1 579	1 371	1 051	6 662	589	2 978	10 821	35 938
Subtotal capital	16 046	33 491	17 971	23 197	29 460	25 533	4 336	43 824	24 459	25 886	26 806	146 569
Total Immunization Economic Cost	118 443	142 768	113 746	91 168	303 416	110 894	43 586	142 750	129 282	124 739	125 147	683 170

Annex 13 (d): Total Routine Immunization District and National Health Office *Financial* Costs by Line Item ($2011)

	Districts										Province	National
Expenditure line Item	**Serenje**	**Ndola**	**Mkushi**	**Masaiti**	**Lusaka**	**Lufwanyama**	**Kafue**	**Kabwe**	**Chongwe**	**Weighted Average**	**Weighted Average**	**Weighted Average**
										n =9	**n= 3**	
Salaried Labor	49 574	33 329	21 983	29 721	43 287	20 491	38 635	71 558	18 381	34 922	53 802	238 999
Volunteer Labor	-	-	-	-	-	-	-	-	-	-	-	-
Per Diem & Travel Allowances	17 158	13 614	9 387	18 477	35 978	18 351	18 419	10 007	31 213	17 770	20 692	160 545
Vaccines	-	-	-	-	-	-	-	-	-	-	-	-
Vaccine Injection & Safety Supplies	-	-	-	-	-	-	-	-	-	-	-	-
Other Supplies	375	6 093	3 206	1 493	24 267	3 560	1 743	1 491	1 044	4 169	1 063	-
Transport/Fuel	22 099	18 314	1 499	19 367	34 405	13 412	16 273	9 949	14 596	16 222	12 017	91 992
Vehicle Maintenance	9 516	6 825	403	3 948	4 492	4 476	3 058	4 332	2 960	4 667	2 636	22 283
Cold Chain Energy Costs	605	1 579	133	549	266	313	169	106	1 533	622	403	6 961
Printing	731	-	-	-	12 319	142	-	4 052	-	1 323	-	-
Building overhead, Utilities, Communication	4 765	19 172	2 636	11 807	118 943	7 225	17 477	7 781	32 670	19 158	7 727	15 821
Other recurrent	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal recurrent costs	**104 822**	**98 926**	**39 249**	**85 361**	**273 956**	**67 971**	**95 776**	**109 277**	**102 398**	**98 853**	**98 341**	**536 601**
Cold Chain Equipment	2 705	5 378	1 322	2 351	908	3 165	825	2 882	596	2 662	2 046	10 756
Vehicles	18 460	27 047	1 361	19 170	24 563	12 476	14 217	25 904	13 103	17 813	18 940	79 810
Lab equipment	-	-	-	-	-	-	-	-	-	-	-	-
Other Equipment	701	1 400	354	695	-	131	54	408	123	529	353	8 178
Other capital	-	-	-	-	-	-	-	-	-	-	-	-
Building	410	4 640	732	955	1 100	4 220	1 010	1 340	740	2 074	1 385	25 032
Subtotal capital costs	**22 276**	**38 464**	**3 768**	**23 171**	**26 572**	**19 992**	**16 105**	**30 534**	**14 561**	**23 078**	**22 725**	**123 775**
Total Immunisation Financial Costs	**127 098**	**137 390**	**43 017**	**108 532**	**300 528**	**87 963**	**111 881**	**139 811**	**116 959**	**121 931**	**120 159**	**660 376**

Annex 13 (e) Total Routine Immunization District, Provincial and National Level *Economic* Costs by Activity ($2011)

	Districts									Weighted Average District	Weighted Average Provincial Level	NationalLevel EPIAdministra-tion
Line Items	**Chongwe**	**Kabwe**	**Kafue**	**Lufwanyama**	**Lusaka**	**Masaiti**	**Mkushi**	**Ndola**	**Serenje**	**n=9**	**n=3**	
- Routine Facility-Based Service Delivery	8 118	10 192	0	9 693	0	14 951	0	16 495	0	8 417	4 477	0
- Record-Keeping/HMIS	1 212	4 969	2 654	983	10 359	1 828	1 774	1 298	2 126	2 520	2 586	0
- Supervision	18 899	40 686	25 487	20 654	69 036	21 768	5 803	24 837	26 102	26 030	45 955	116 158
- Outreach Services	3 115	2 796	8 506	7 460	39 766	7 085	6 440	10 324	18 979	10 392	6 509	0
- Social mobilization	8 958	19 486	6 592	2 053	4 321	11 730	6 347	11 517	5 056	8 630	11 764	41 776
- Cold chain maintenance	2 016	9 942	2 894	2 270	733	2 525	1 407	1 986	7 638	3 405	2 088	42 901
- Vaccine collection and distribution	5 351	13 981	12 893	7 322	6 884	6 551	5 350	35 296	34 817	15 285	13 702	243 040
- Program management	47 826	26 186	47 781	26 242	163 992	30 609	10 936	36 244	24 839	39 019	22 945	177 256
- Training	22 078	9 590	2 084	13 772	7 864	12 066	2 497	3 393	9 248	9 140	7 742	54 757
- Other	0	0	0	0	0	251	251	125	476	135	0	0
- Surveillance	871	4 940	4 856	719	463	1 530	2 781	1 235	0	1 765	7 378	7 282
Total Immunization Economic Cost	118 443	142 768	113 746	91 168	303 416	110 894	43 586	142 750	129 282	124 739	125 147	683 170

Annex 13(f): Total Routine Immunization District and National Health Office *Financial* Costs by Activity ($2011)

	Districts										Province	National
Expenditure line Item	**Serenje**	**Ndola**	**Mkushi**	**Masaiti**	**Lusaka**	**Lufwanyama**	**Kafue**	**Kabwe**	**Chongwe**	**Weighted Average**	**Weighted Average**	**Weighted Average**
										n =9	**n= 3**	
- Routine Facility-Based Service Delivery	-	16 495	-	14 625	-	9 693	-	10 192	8 118	8 362	4 477	-
- Record-Keeping/HMIS	2 126	1 298	1 774	1 828	10 359	983	2 654	4 969	1 212	2 520	2 586	-
- Supervision	25 774	24 020	5 749	21 053	67 007	20 032	24 569	39 030	18 264	25 229	45 295	113 451
- Outreach Services	18 979	10 324	6 440	7 085	39 766	7 371	8 495	2 693	3 115	10 366	6 509	-
- Social mobilization	4 980	11 446	6 340	11 380	4 208	2 053	6 492	19 486	8 918	8 535	11 741	41 776
- Cold chain maintenance	7 638	1 986	1 407	2 525	733	2 270	2 894	9 942	2 016	3 405	2 088	42 901
- Vaccine collection and distribution	33 478	32 812	5 101	6 187	6 268	6 845	12 453	13 544	5 126	14 443	10 933	226 317
- Program management	24 399	34 256	10 679	30 003	163 861	24 226	47 383	25 426	47 241	38 030	21 457	174 085
- Surveillance	-	1 235	2 781	1 530	463	719	4 856	4 940	871	1 765	7 331	7 089
- Training	9 248	3 393	2 497	12 066	7 864	13 772	2 084	9 590	22 078	9 140	7 742	54 757
- Other	476	125	251	251	-	-	-	-	-	135	-	-
Total Immunisation Financial Costs	**127 098**	**137 390**	**43 017**	**108 532**	**300 528**	**87 963**	**111 881**	**139 811**	**116 959**	**121 931**	**120 159**	**660 376**

Annex 14 - New Vaccine Introduction

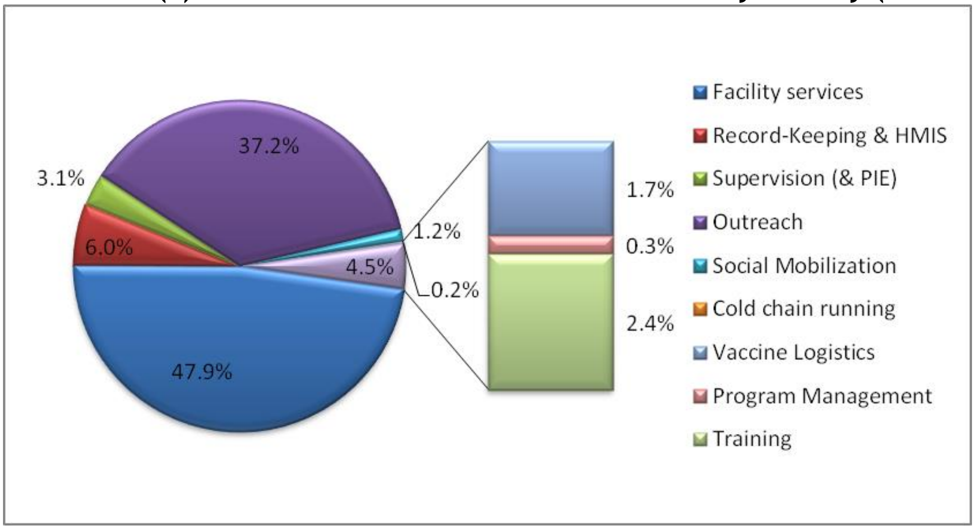
Annex 14 (a): Start-Up and Ongoing New Vaccine Introduction Costs by Line Item (Zambia)

Total Amounts by Line Item	Economic costs	Economic costs	Financial costs	Financial costs	Fiscal cost	Fiscal cost
Line Item	**Start up**	**Ongoing**	**Start up**	**Ongoing**	**Start up**	**Ongoing**
Salaried Labor	176 648	2 159 131				
Per Diem & Travel Allowances	286 782	2 598	286 782	2 598	286 782	2 598
Vaccines	1 177 636	4 710 544	1 177 636	4 710 544	1 177 636	4 710 544
Vaccine Injection & Safety Supplies	27 998	111 994	27 998	111 994	27 998	111 994
Other Supplies	197 570	-	197 570		197 570	
Transport/Fuel	145 283	5 496	145 283	5 496	145 283	5 496
Vehicle Maintenance	9 769	721	9 769	721	9 769	721
Cold Chain Energy Costs	-	16 741	-	16 741	-	16 741
Printing	531 909	-	531 909		531 909	
Building overhead, Utilities, Communication		-				
Other services-External PIE	25 346		25 346		25 346	
Sub-total recurrent costs	**2 578 940**	**7 007 226**	**2 402 292**	**4 848 094**	**2 402 292**	**4 848 094**
Cold Chain Equipment		91 981		80 717	89 202	-
Vehicles	-	5 385		4 932	-	
Building	-	-		-		
Sub-total capital costs		97 366	**-**	**85 649**	**89 202**	**-**
Total Costs	**2 578 940**	**7 104 591**	**2 402 292**	**4 933 744**	**2 491 494**	**4 848 094**
Total doses administered	1 280 800	1 280 800	1 280 800	1 280 800	1 280 800	1 280 800
Surviving infant pop. - 60% coverage	388 803	388 803	388 803	388 803	388 803	388 803
Total population (2012)	13 787 341	13 787 341	13 787 341	13 787 341	13 787 341	13 787 341
Incremental NUVI cost per dose	2.01	5.55	1.88	3.85	1.95	3.79
Incremental NUVI cost per child	6.63	18.27	6.18	12.69	6.41	12.47
Incremental NUVI cost per capita	0.19	0.52	0.17	0.36	0.18	0.35

Annex 14 (b): Start-Up and Ongoing New Vaccine Introduction Costs by Activity (Zambia)

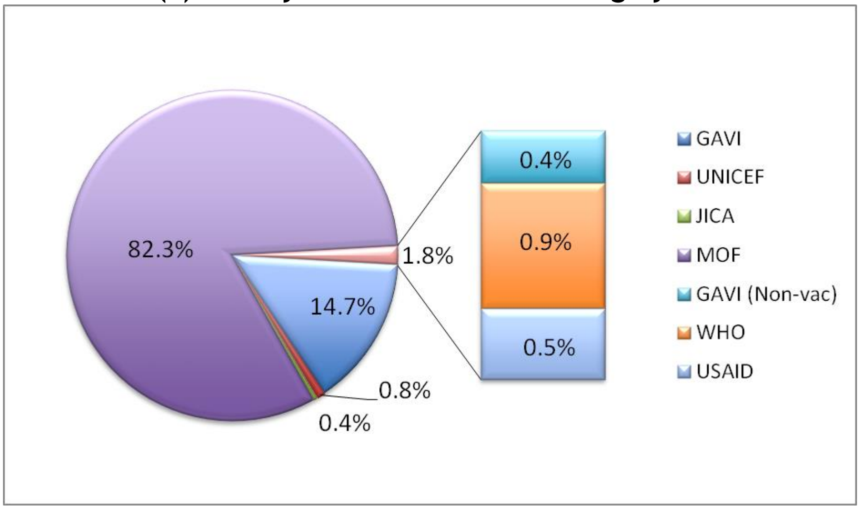
Total NUVI costs by activity	Economic costs	Economic costs	Financial costs	Financial costs	Fiscal cost	Fiscal cost
Line Item	**Start up**	**Ongoing**	**Start up**	**Ongoing**	**Start up**	**Ongoing**
Routine Facility-based Service Delivery	724 853	3 909 319	724 853	2 700 621	724 853	2 700 621
Record-Keeping & HMIS	580 622	-	580 622	-	580 622	-
Supervision (& PIE)	300 614	-	186 443	-	186 443	-
Outreach Service Delivery	530 479	3 071 608	530 479	2 121 917	530 479	2 121 917
Social Mobilization & Advocacy	118 064	-	115 825	-	115 825	-
Cold Chain energy and running costs	-	16 741		16 741	-	16 741
Vaccine Collection, Distribution, & Storage	57 129	106 924	52 701	94 465	141 904	8 816
Program Management	30 714	-	1 529	-	1 529	-
Training	236 466	-	209 840	-	209 840	-
Surveillance						
Other						
Total	**2 578 940**	**7 104 591**	**2 402 292**	**4 933 744**	**2 491 494**	**4 848 094**

Annex 14 (c) : Distribution of NUVI economic costs by activity (Zambia)



Annex 15 - Financial mapping: further analysis

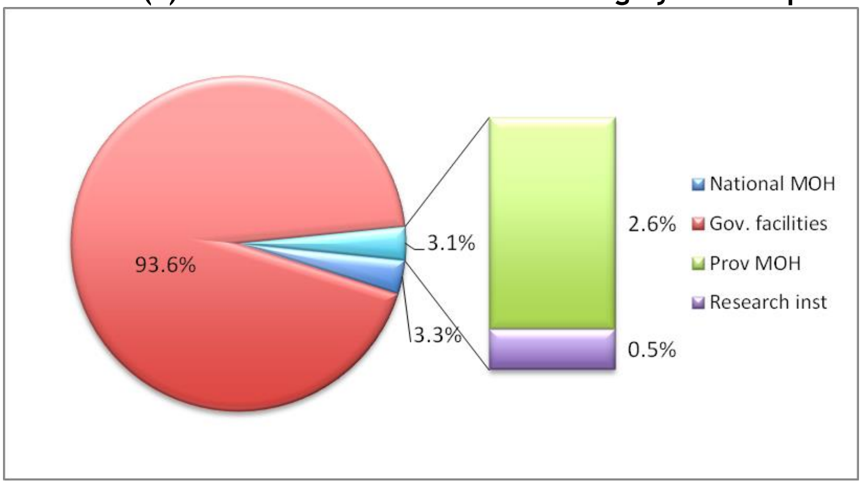
Annex 15 (a) : Analysis of total EPI financing by source of funding in Zambia (2011)



Annex 15 (b) : Allocation of sources of funding to financing agents in percentages in Zambia (2011)

Source of funding (FS) / Financing agent (FA)	MOH EPI	USAID	Central Med Store	Grand Total
GAVI	0.0%	0.0%	14.7%	**14.7%**
UNICEF	0.8%	0.0%	0.0%	**0.8%**
JICA	0.0%	0.0%	0.4%	**0.4%**
MOF	76.1%	0.0%	6.1%	**82.3%**
GAVI	0.4%	0.0%	0.0%	**0.4%**
WHO	0.9%	0.0%	0.0%	**0.9%**
USAID	0.0%	0.5%	0.0%	**0.5%**
Grand Total	**78.3%**	**0.5%**	**21.2%**	**100.0%**

Annex 15 (c): Allocation of total EPI financing by service provider (Zambia 2011)



Annex 15 (d) : Allocation of funding to service providers from financing agents (percentages, 2011)

Service providers (HP) / Financing agent (FA)	MOH EPI	USAID	Central Med Store	Total
National MOH	3.3%	0.0%	0.0%	**3.3%**
Governemtn facilities	72.4%	0.0%	21.2%	**93.6%**
Provincial MOH	2.6%	0.0%	0.0%	**2.6%**
Research institutions	0.0%	0.5%	0.0%	**0.5%**
Gand total	**78.3%**	**0.5%**	**21.2%**	**100.0%**

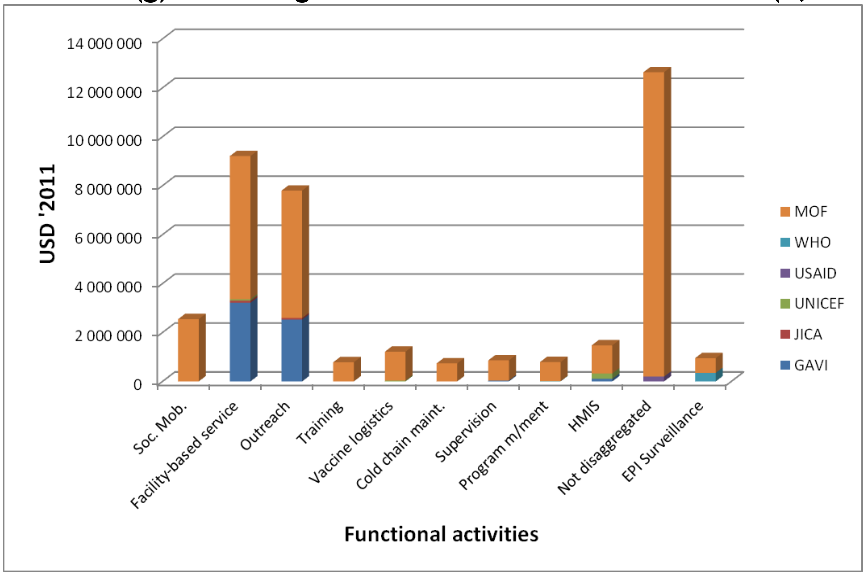
Annex 15 (e): Analysis of funding to financing agents by health financing scheme (HF) ($,2011)

Row Labels	Rest of the world	Central government	Total	% Allocation
Central Med Store		8 282 041	8 282 041	21.2%
MOH EPI		30 509 001	30 509 001	78.3%
USAID	195 000		195 000	0.5%
Grand Total	**195 000**	**38 791 041**	**38 986 041**	**100.0%**

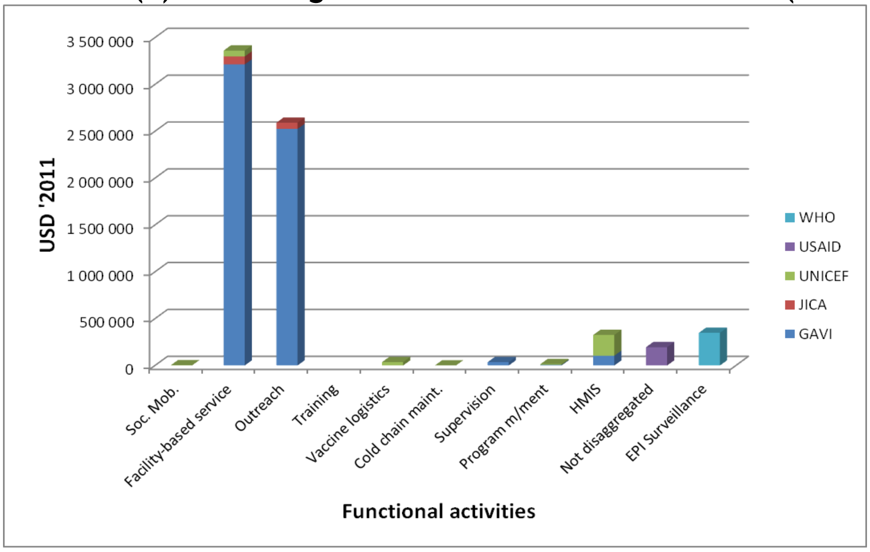
Table 16 (f) : Financing sources to health care functions ($,2011)

Functional activity (FP) / Source of funding (FS)	GAVI	JICA	UNICEF	USAID	WHO	MOF	Grand Total
Social mobilization, advocacy			2 490			2 541 114	2 543 604
Facility-based routine immunization service delivery	3 212 677	85 308	62 667			5 845 712	9 206 364
Outreach routine immunization service delivery	2 524 246	67 028				5 203 550	7 794 824
Training						781 658	781 658
Vaccine collection, storage and distribution			35 964			1 178 369	1 214 333
Cold chain maintenance			-			736 243	736 243
Supervision	35 476					826 759	862 235
Program management	6 253		8 321			774 552	789 126
Record-keeping and HMIS	104 262		221 501			1 148 188	1 473 951
Not disaggregated				195 000		12 438 418	12 633 418
EPI Surveillance					348 000	602 283	950 283
	5 882 915	**152 336**	**330 943**	**195 000**	**348 000**	**32 076 848**	**38 986 041**

Annex 15(g) Financing sources to health care functions ($,2011)



Annex 15(h): Financing sources to health care functions (excluding MOF, $2011)



Annex 15(i): Allocation of funding sources to functional activities (%)

Functional activity / Source of funding	GAVI	JICA	UNICEF	USAID	WHO	MOF	Grand Total
Social mobilization, advocacy	0%	0%	0%	0%	0%	6.5%	**6.5%**
Facility-based routine service delivery	8.2%	0.2%	0.2%	0%	0%	15.0%	**23.6%**
Outreach routine delivery	6.5%	0.2%	0%	0%	0%	13.3%	**20.0%**
Training	0%	0%	0.0%	0%	0%	2.0%	**2.0%**
Vaccine collection, storage, distribution	0%	0%	0.1%	0%	0%	3.0%	**3.1%**
Cold chain maintenance	0%	0%	0.0%	0%	0%	1.9%	**1.9%**
Supervision	0.1%	0.0%	0.0%	0%	0%	2.1%	**2.2%**
Program management	0%	0%	0%	0%	0%	2.0%	**2.0%**
Record-keeping and HMIS	0.3%	0.0%	0.6%	0%	0%	2.9%	**3.8%**
Not disaggregated	0%	0%	0%	0.5%	0%	31.9%	**32.4%**
EPI Surveillance	0%	0%	0%	0%	0.9%	1.5%	**2.4%**
	15.1%	**0.4%**	**0.8%**	**0.5%**	**0.9%**	**82.3%**	**100.0%**