Analyses of Costs and Financing of the Routine Immunization Program and New Vaccine Introduction in the Republic of Moldova

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This study was conducted as part of a multi-country analysis of the costing and financing of routine immunization and new vaccines (EPIC) supported by the Bill & Melinda Gates Foundation. The methods were derived from a Common Approach developed for this exercise

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Table of Content

Acronyms

BMGF	Bill and Melinda Gates Foundation
CNAM	National Health Insurance Company
cMYP	Comprehensive Multi-Year Plan
CPH	Centre of Public Health
DTP	Diphtheria-Tetanus-Pertusis
EVM	Effective Vaccine Management
EPI	Expanded Program for Immunization
FA	Funding Agent
FIC	Fully Immunized Child, which for this report equals to child that received DPT3 dose
FMC	Family Medicine Centre
FS	Funding Source
HC	Health Centre
HF	Financing Scheme Code
HMIS	Health Management Information System
HO	Health Office
HP	Healthcare Provider
IRB	Institutional Review Board
MDL	Moldovan Lei
MoH	Ministry of Health
OFD	Office of a Family Doctor
PHC	Primary Health Care
ULY	Useful Life Year
WHO	World Health Organization
GAVI	Global Alliance for Vaccines and Immunization

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Executive Summary

Introduction and Methodology

The costs and financing of the national immunization programs have been evaluated since 1980s, particularly as part of *Universal Childhood Immunization Initiative*. However, available information is out-dated and up-to-date knowledge on full economic costs and financing of routine immunization programs, as well as the financial cost and financing of a new vaccine introduction is lacking. For going forward and increasing vaccine coverage rates as well as for introduction of new vaccines in national immunization programs, requires better knowledge of costs as well as cost determinants. Therefore, the purpose of this study is to evaluate routine immunization program costs and financing as well as incremental costs and financing of a new vaccine introduction in the Republic of Moldova. Our study is part of a larger effort to evaluate costs and financing of routine immunization in six countries (Moldova, Benin, Uganda, Zambia, Ghana, Honduras) supported by the Bill & Melinda Gates Foundation.

In this study we focus on:

a) Evaluating overall and detailed economic and financial costs (and cost elements) of the routine immunization program in Moldova and describing observed variation in costs and its elements;
b) Evaluating incremental costs for a new vaccine introduction for Rotavirus vaccine;
c) Analyzing the main sources of financing and funds flow for the routine immunization program and for the new vaccine introduction;
d) Evaluating factors determining productivity of the facilities involved in immunization and trying explaining major cost drivers for the immunization program.

Moldova delivers immunization services primarily from 1,318 primary health care facilities[1] using fixed strategy and therefore all costs presented throughout this paper are relevant to this approach. Being part of a multi-country study supported by Gates foundation, we have employed standardized facility based costing approach using similar tools while adjusting to the country context. Consequently this is a cross-sectional facility-based costing study, which looked at total costs of the routine immunization program and estimated incremental costs of a new vaccine introduction, arising at different levels of the health care system (i.e. facility, district and the national level). The study employed multi-stage random sampling to select fifty providers, which included: 8 urban/peri-urban facilities and 42 rural facilities represented by 5 family medicine centres, 10 health centres, 23 offices of family doctors and 12 health offices[2]. Therefore, the findings of this study are representative on a national level. The data was collected with the help of experienced data collectors, who received extensive training. The data collection took place during October 3rd 2012 to January 14th 2013 and included face-to-face interviews with the facility staff and managers, facility observation and record review. Excel™ based database specifically designed for this study was used to transfer the data from questionnaires. The research team validated the data using basic logical links and descriptive statistics, which helped detect odd results and outliers that were followed on and corrected, if necessary.

[1] The only vaccine, which is administered in hospitals, are BCG and first dose of Hep B. Due to low number of doses of BCGs and Hep B administered at the hospital facilities, the study team decided to concentrate most resources on sampling the facilities where vaccination is one of the critical function.

[2] Detailed description and explanation of facility types listed here is provided on page 23 – Routine Immunization in Moldova

This study used retrospective costing for the routine EPI and evaluated both financial and economic costs of the routine EPI program for 2011. All local costs were converted into 2011 $US using average exchange rate of 11.73 MDL per dollar. Calculations were based on Common Approach developed for this exercise, *cMYP Costing Guideline* and WHO *Guideline for Estimating Costs of New Vaccine Introduction.*

The study questionnaire helped capture the costs of all inputs using an ingredients approach and listing all inputs by activity, quantities and prices. Information was collected for all resources used in delivery of EPI services, including value of donated goods and services. The cost data included a comprehensive list of capital as well as recurrent expenditure items. Items with a useful life of more than one year were treated as capital cost elements and EPI related resources consumed or replaced within a period of up to one year were treated as a recurrent cost item.

Considering that Moldova introduced Rotavirus vaccine in July 2012 the cost of Rotavirus vaccine introduction was estimated prospectively. The data collection captured all costs incurred six-month prior and six month following the date of vaccine introduction. Obtained costs in local currency were converted to 2011 $ US using current exchange rate, annualized and used in the analysis. We looked at all costs for capital equipment, trainings of health care providers, social mobilization and etc. Due to the fact that staff does not work exclusively on the Rotavirus vaccine; incremental personnel costs were assessed on the bases of time allocation. Additional salaries provided out of GAVI grant to the personnel of national public health centre and related to the rotavirus vaccine delivery were also included in the estimations.

Finally financial flows for the routine immunization and new vaccines were analyzed by looking at sources and uses of funds using a *System of Health Accounts* (SHA) framework, which allows systematic description of financial flows related to health care. The aim of our analysis was to describe the national immunization program from an expenditure perspective both for international and national purposes. Therefore our study looked at a funding flow for immunization services and for new vaccine introduction, which helped estimate amount of funds provided by the different national and external sources; amount of funds managed by the different financing agents within and outside of the country; funds spent on a provider level by a type of a provider and by function and by type of inputs.

Unit Cost of the Routine Immunization Program and for New Vaccines

The data analysis showed that unit cost of service provision per dose delivered amounted to 18.3 $US. However this average differed by facility type, by facility scale (measured using annual doses delivered by a facility) and by urban-rural location, although in a latter case influence was only obvious when shared human resource costs were not accounted in a unit cost. From all of these factors the scale proved to be having strongest influence on the total unit cost of dose delivered. Cost per dose delivered ranged from 14.5 $US in a high scale facilities to 20.5 $US in a low scale facilities. Our findings were comparable with the available global evidence that scale of immunization services has strong and negative relationship with the unit cost of service provision. This means that facilities with a greater scale are able to deliver services more efficiently, by using available inputs more effectively and therefore reducing costs per unit of output.

Furthermore, our study revealed that the labour costs are main contributors to immunization costs on a facility level, that once again confirms that immunization services are labour-intensive; share of labour cost increases along with increase facility size and scale. Average share of a labour cost contribution was 65.07%, ranging from 54.42% in HOs that are the smallest facilities to 70.48% in FMCs that are the largest facilities and from 55.46% in lower scale to 73.27% in higher scale facilities. Capital costs are the second biggest contributor to costs. The share of recurrent and capital costs differed across facilities. Namely, the share of capital costs was lowest in FMCs - 10.3% and highest in HOs – 22.8%, with the average across all sampled facilities being 16.3%. Furthermore, in the facilities with higher scale share of capital costs was around 9.3% while in a low scale facility it reached 23.1%. Vaccine and injection supplies only accounted for 8.72% of the cost.

Amount of staff time spent on delivering a dose of vaccine reveals strong correlation with the type of a facility. Namely in smaller facilities i.e. health offices, staff time to deliver a dose of immunization amounted to 65.6 minutes, while in FMCs - 8 minutes. This is obviously indicative of a variable productivity of employed staff by a facility type. This could be determined by numerous factors, such as size and/or density of a population in a catchment area, staff quality (nurses vs. doctors), management capacity i.e. availability of immunization plans and supervisory visits, etc. The recent study conducted by the WHO in Moldova showed that staff in rural PHC facilities could be overstretched serving approximately 16.9 patients a day and on average week spending on 42.4 hours at work. Consequently, higher amount of time spend by the staff of small facilities on immunization is indicative that if Moldova decides to increase number of new vaccines introduced in the national immunization program it might become necessary to increase number of FTEs, definitely at smaller PHC facilities in rural areas, unless staff productivity is increased with the help of different tools.

Production and Cost Determinants on a Facility Level

The National Immunization Program in Moldova is performing well and according to the WHO and UNICEF estimates for the last five years Immunization coverage was attained at over 90 percent for all vaccines. In our study we have seen that immunization coverage, measured by DPT3, varied between facility types. The *Health Offices*, located in rural areas, showed the lowest performance – 90.2% and *Offices of Family Doctors* and *Health Centres* showed the best performance 97.8% and 98.1% respectively. Due to the small size of population in the catchment area low performance of the health offices could amount on average to only one child missing its third DPT dose. Consequently most challenging was "low coverage" – 92.7% observed in the *Family Medicine Centres*, which care for the largest catchment population and have on average 430 infants (95%CI: 372-487) to immunize. Based on our findings and available evidence from elsewhere, we hypothesized that facility characteristics as well as management performance on a facility level influence achieved rates of DPT3. Furthermore, coverage rates are also influenced by socio-economic and education status of the population, proximity of clients to health facility, etc. Therefore, the factors determined by our bi-variate analysis were not sufficient for establishing causal links with the facility productivity and costs, unless other contextual determinants (e.g. population characteristics or geography characteristics) were evaluated in a multivariate regression model along with the facility characteristics.

For these purposes we developed the econometric model, which looked separately at production and cost determinants on a facility level. The model once again proved importance of human resources in producing higher outputs (measured as FIC or as total doses administered) for immunization program. In comparison to labor inputs facility infrastructure, such as cold chain equipment or size of a facility measured by square meters retained their statistically significant influence on productivity, but the power of their influence in the multivariate regression model was 48 to 68 times less that of working hours devoted to immunization by the staff.

While labor inputs (hours spent on immunization) are critical for increasing the outputs, the quality of such labor inputs seems to be more important in achieving higher production levels. Namely, our model showed that having a doctor in the facility has more significant influence on the volume of outputs (FICs and doses administered) than having just nurses. In all cases, labor related inputs brought positive and significant coefficients at 99% of significance, while proxies for capital had less revealing influence on production.

Production estimations with the help of multivariate model also point to the importance of the population size in the catchment area, increasing of which allows for cost savings at the same level of production. The distance of health centers from a vaccine distribution point, dummy variables for facility type did not reveal significant effects on production, showing higher importance of other production drivers beyond the general characteristics of health care facilities. Finally, facilities with lower wastage rates, when all other factors are kept constant, were more able to produce higher number of FIC or doses.

Our econometric analysis of *total economic cost determinants* on a facility level proved strong presence of economies of scale in immunization programs. These findings once again re-confirm similar arguments, provided by others studies. We also found that input prices for labor and capital had non-conclusive influence on the immunization costs. Considering that in Moldova central government regulates wages, as well as centrally procures and delivers immunization inputs: vaccines, cold boxes, syringes and safety boxes etc. such inconclusive influence of the prices on the total cost of delivering immunization services was not surprising. Furthermore, the analysis showed that costs arising on a district and national level were not that important and mostly facility level costs determined overall variability seen among facilities. Therefore, factors operating on a facility level seemed more important in influencing the cost of immunization. These findings lead to conclusion that predictability of immunization costs might be higher in the centralized models compared to decentralized ones, although this assumption has not been yet validated, with the help of other studies.

The next important finding of the econometric model was importance of the staff time devoted to immunization in determining costs. Increasing average nurse wage by one unit would cause total immunization costs to increase by 1.4, which re-confirms labor intensity of immunization services and therefore price changes in labor inputs or their productivity would have significant impact on the overall cost of the program. Factors such as the distance between the immunization center and the distribution point (as a proxy for vaccine logistics), urban-rural dummy and size of the facility were not statistically significant factors in explaining immunization costs.

Finally, demand side variables show the explanatory power (positive and significant at 99% of confidence) over immunization costs on a facility level; higher educational levels allow demanding for more immunization, triggering vaccination costs. This finding is also comparable with the evidence arising from literature.

In conclusion, presented analysis of production and costs determinants allows separating the effect of four different factors on immunization outputs: operative capacity at the facility level largely related to human resources, managerial efficiency for vaccine and program management, population scale in the catchment and educational level of the population are seem to have the most explanatory power on the productivity and immunization costs.

Cost of New Vaccine Introduction

Our study also looked at the cost of new vaccine introduction, which showed that incremental financial cost of a rotavirus introduction was estimated at 378,831 $US. However, out of this amount only 123,912$ was spent on immunization delivery and the rest was used for vaccine procurement. Costs of Rota virus vaccine introduction in Moldova were low because the country had spare cold chain capacity on the national and district level and was able to meet increased vaccine volume needs without additional investments in the cold chain; also no additional staff was hired to cope with the increased workload.

Unit cost analysis showed that incremental financial cost of delivering Rotavirus vaccine was 4.95$US per dose and 9.96$US per infant in the birth cohort. However, close to 65% of these financial costs were due to vaccines and only 35% were pure delivery costs.

Economic costs per unit of output (with vaccine costs) were 52% higher over comparable financial costs, because they account for annualized costs of additional staff time at the facility and district levels and cold chain. Namely, cost of delivering a single dose of vaccine increases up to 7.48 $US and cost per infant up to 15.20 $US. Health system related vaccine delivery economic costs were found to be 4.29$ per dose and 8.76$ per infant.

As mentioned earlier Incremental financial costs of a rotavirus vaccine introduction (without vaccines) amounted to 123,912$, out of which 100,000 $US was provided through GAVI grant and the rest financed by UNICEF and WHO. These findings may point to the adequacy of GAVI's vaccine introduction grant relative to the financial need of the country in a Moldovan case. However, incremental financial cost per infant (without vaccine) was estimated at 3.52$, which is 4.4 times higher than 80 cents established per infant under GAVI vaccine introduction grant policies. Consequently, adequacy of the introduction grant from GAVI for Moldova was only determined by small size of the birth cohort. Furthermore, as noted earlier costs in Moldova were low because the country had spare cold chain capacity on the national and district level and was able to meet increased vaccine volume needs without additional investments. It is well known that most countries face cold chain capacity constraints when they introduce new or underutilized vaccines. Therefore it is expected that difference between GAVI established amount per infant – 80c under vaccine introduction grants and actual financial costs of delivering new vaccine per infant could be even greater in the countries that have bigger birth cohorts.

Furthermore, financial cost per infant at 9.96$ estimated by our study when vaccine costs are considered translates into 3.1% increase over the cost per infant under the national immunization schedule, which was estimated at 316.6 $ in 2011.

Our estimates for a rotavirus vaccine introduction were based on 2.5$ per dose of Rotarix™, currently being purchased through UNICEF with GAVI co-financing. In 2013 Moldova plans introducing pneumococcal (PCV-13) mono dose vaccine with GAVI assistance, although graduation is expected in 2016. Based on sensitivity analysis, this may result in cost increase per infant by another 10.3% Therefore, 13.4% gradual increase in the total cost of delivering immunization services, which is expected to occur over 2013-2016, seems affordable in the current fiscal context where immunization program accounts to only 2.4% of the recurrent public financing for health. However, after GAVI graduation vaccine prices are expected to increase because of the national public procurement rules, which mandate local tendering and as a consequence for all non-UNICEF supplied vaccines. Moldova pays almost twice the UNICEF price. Also sensitivity analysis revealed that every dollar increase in vaccine price may result in 2.1% increase of immunization costs and doubling the vaccine price will demand almost 24.1% more from the national budget. Consequently, financial sustainability of the immunization program will significantly depend on future vaccine prices, which does not make Moldova much different from many other countries, where cost of new vaccines has been found to drive up to 60% of vaccine introduction costs.

Financial Needs of the Immunization Program and with New Vaccines

Estimating unit close per unit of output allowed estimating total cost of the national immunization program without new vaccines, but with routine vaccines and injection supplies, which amounted to $ 9,856,567 (when economic costs are accounted for) and to $ 9,469,796 when only financial costs are taken into account. Aggregated costs, both financial and economic, show that 82% of costs arise on a facility level (not including cost of vaccines and injection supplies) and around 5% of costs are attributable to district level costs, which includes primarily cost of vaccine storage, supervision-monitoring and program management along with *Vaccine Preventable Disease* surveillance. The costs that arise on a national level amount only to 1.4% of the total immunization program costs and vaccines and syringes contribute 11% of these total costs.

Out of the total amount spent on immunization in 2011 the *National Health Insurance Company* managed 80.3% of funds and primarily paid for recurrent expenses on a facility/provider level, 18.9% of funds were managed by the National Centre for Public Health and were primarily used for the NIP management, storage and distribution of direct inputs, e.g. vaccines, injection supplies and safety boxes. Portion of these funds also paid for surveillance of vaccine preventable disease and for trainings. The UNICEF and WHO managed only contributed 0.2% and 0.5% of funds, respectively. And these funds were primarily used for technical assistance and some other inputs for immunization services.

Analysis of funds flow by provider of care revealed following: FMCs consumed the largest amount of funds – 33.4%, followed by offices of family doctors – 30.9% and health centres – 23.3%. The amount of funds spent on health offices was the lowest – 6.5%, because the volume of immunizations services (number of doses administered) offered by these facilities is the lowest. National and municipal/district public health centres spent only 5.2% of immunization funds and amounts administered by the WHO and UNICEF did not exceed 0.7%.

Analysis of funds flow by functions pointed to the fact that most funds are being spent on a facility-based immunization service delivery - 41%, followed by the program management – 18%. Record keeping & HMIS and social mobilization have absorbed 14% and 12% respectively and the amount of funds spent on all other functions was 4% or below.

Direct inputs related to the immunization program (i.e. vaccines & syringes, transport, maintenance, printing and other inputs) consumed only 25.9% of funds or 2.28 million $US while the rest – 74.1% were used to fund shared health system costs. Consequently this breakdown is useful for planning and budgeting national immunization program.

While the role of the external funding sources in funding immunization services seems marginal – 5.2% of the total funding, when external funding is related to only direct immunization inputs their share increases up to 20% and especially GAVI inputs amount to 17% of direct inputs necessary for the immunization program.

The study shows that total financial needs of the national immunization program in Moldova amounts to approximately 1.27% of the *Total National Health Expenditure* for 2011 or 2.4% of *recurrent public financing* (when capital expenditures are excluded) for health, when direct and shared immunization costs are considered. This estimate is 15% higher than the secured and probable funds estimated in the cMYP for 2011. The largest difference arises from overestimating "Routine Recurrent Costs" in the cMYP and underestimating the "Shared Health Systems Costs" primarily through undervaluation of human resource inputs on a provider level. With regards to the role of different funding sources in financing national immunization program the cMYP and the study estimates were comparable.

Finally and as stated earlier, introduction of Rotavirus vaccine in Moldova did not require purchase of additional cold chain, because the country had spare capacity and neither additional staff was added on a facility level to meet increased service delivery needs. Therefore, financial implication of the NUVI in Moldova was marginal and funding for the Rotavirus vaccine introduction amounted to 406.4 thousand $US. Close to 63% of these additional funds were spent on vaccines and 37% were spent on other inputs.

We also compared cash flow estimates for the new vaccine introduction derived from our study with the New Vaccine Introduction Plan that was developed by the government of Moldova in 2011, which showed marked discrepancies between the study estimates and the plan, which was based on cMYP. The variation, resulting from cMYP are significant and if on a country level (especially for Moldova) they are negligible, on a regional and Global level such weaknesses could result in a significant bias and waste of resources. Based on this comparison we concluded that the cMYP in its current form and as the critical tool for financial planning for NUVI may not be appropriate unless further improvements are introduced or alternative approaches to financial planning are developed.

Major Conclusions

The major conclusions arising from this study could certainly inform the decisions made by the national immunization program managers in Moldova as well as by the Ministry of Health, especially when they relate to increasing program efficiency, expanding immunization coverage and/or when adding new vaccines to the EPI schedule. However, some findings of this work also have value in informing the global debates around new vaccines and immunization programs. Consequently we would like to summarize our study findings around following issues:

- What could be done in Moldova to increase immunization program efficiency?
- What could be done in Moldova to increase immunization coverage and how this could be achieved in a most cost-efficient manner?
- What is important to consider when making decisions about new vaccine introduction in a country?
- What will be important factors to consider when graduating from GAVI support?

Increasing Immunization Program Efficiency

The government of Moldova is focusing on increasing health system efficiency through various means, including infrastructure optimization. Based on our study findings reducing staff time spent on immunization could help increase efficiency of the program. This objective could be achieved either through task shifting i.e. delegating certain immunization related tasks from doctors to nurses, or through reducing time spend on management and/or record-keeping functions. Our study documented that staff time spend on delivering a dose of immunization is significant in rural PHC facilities where close to 33-34% of time at *Health Offices* and *Family Doctor's Offices* is being spent on the HMIS and program management activities. Considering that Moldova is currently designing e-health system for primary health care, the government may want to design and include the modules for immunization. These modules should be designed in a way that they reduce demand on staff time while collecting all necessary data that is needed for adequate management of immunization services on a facility level.

Increasing Immunization Coverage

Available national and international evidence proves that Moldova achieves high immunization coverage rates compared to other countries in the region. However, marked differences still exist when coverage rates are looked at by facility level. Namely rural facilities located in small villages i.e. *Health Offices* have the lowest DTP3 coverage. However due to very small number of infants in the catchment population of those facilities this low coverage translates into at most one child had missed its DTP 3 dose. Therefore focusing on coverage increase in *health offices* may not be most cost-effective strategy and may fail to significantly affect immunization program performance on a national level. Based on our findings, trying to increase coverage in rural facilities will be most costly option due to high cost per FIC and per dose documented by our study on a *Health Office* level. Consequently, in the Moldovan context, it seems more appropriate to place importance on increasing DPT3 coverage rates in FMCs, where immunization program performance is the second poorest after HOs – 92.7%. Improving performance of these facilities seems more feasible on several counts: they have better staffing and more human resources, they have more infants and improving their performance would have greater impact on the national coverage rate. Finally due to their ability to deliver most cost-efficient immunization services it will be less costly option for the national budget.

However, this strategy may raise equity concerns with regards to rural areas. To mitigate these concerns it seems possible to mostly focus efforts on significantly underperforming rural facilities where DTP 3 coverage rates are below 80% and provide supportive supervision or other assistance that will be necessary.

Introducing New Vaccines

Our study documented that for Moldova the total cost of Rotavirus introduction was marginal because it only amounted to financial costs since the country had spare cold-chain capacity and staff on a PHC level. Our estimates for the incremental financial costs that are necessary to introduce a new vaccine in the immunization program proved to be 4.4 times higher compared to 80c currently paid by GAVI. These findings highlighted possible weaknesses in the GAVI policies and call for thorough re-evaluation in light of emerging new evidence.

We have documented that incremental financial costs are not high, when only a rotavirus vaccine introduction is evaluated. However, with expected PCV introduction, with possible vaccine price increases after GAVI graduation and with concurrent reduction in the funding from the GFATM, financial sustainability of immunization and other health programs may be put at risk and Moldova may lose the health gains achieved thus far.

Furthermore, due to the fact that staff inputs are important cost drivers of the immunization program and additional vaccines will demand more human resources, it becomes important to control and/or minimize costs resulting from a new vaccine introduction. As we have observed from a multivariate model staff costs have major impact on the immunization program cost. Consequently the discussions around new vaccine introduction should also center on seniority and diversity of health care personnel involved in immunization and how this may affect labor costs.

Finally, we have seen that when introducing new vaccines, actual cost of a vaccine is the largest portion of an incremental cost. Consequently, price of a vaccine dose that is being considered for introduction becomes critical determinant for making policy decision.

Furthermore, after graduating from the GAVI Moldova is considering reforming its immunization program and decentralizing vaccine procurement responsibilities due to specificity of the national health care financing system and due to rules embedded in the national legislation. Our study shows that the cost of vaccines is critical element of the immunization program. Therefore centralized model for vaccine procurement seems to be more effective and decentralization of this function may drive vaccine prices up and could increase overall program cost.

GAVI Graduation and Possible Policy Implications

The econometric model used in this section contributes to the discussion about centralized health systems that subject providers to uniform rules and its influence on immunization costs. Our findings allow us to assume that centralized model of immunization service delivery might be most effective, when national level controls the prices/costs of centrally provided and or regulated inputs, including those of human resources. However, study findings are not conclusive, unless compared with the set of similar studies supported by the Gates Foundation. All of this attracts interest as after graduation from GAVI Moldova may introduce greater decentralization in its immunization programs. In some quarters there are discussions to allow facilities to purchase immunization inputs on their own while CNAM will only reimburse for the volume of services delivered. In light of our findings such decisions, if implemented, could pose risks of resulting in a greater variability in input prices and consequently in cost increases. Therefore, before acting on such decisions thorough evaluation of their impact on the national immunization program costs is warranted.

Furthermore, the study proved that the role of the external sources in the overall funding of the national immunization program is marginal – 5.2%. However, when external funding is related to only direct immunization inputs their share increases up to 20% and especially for the GAVI inputs reach 17%. This share is expected to grow significantly during 2012 and 2013 when new vaccines are introduced and are expected to significantly increase pressure on the national budget when Moldova graduates from the GAVI in 2016.

This financial pressure will be further aggravated by concurrent graduation from the Global Fund, which currently provides funding for most TB and HIV/AIDS inputs. Based on the preliminary estimates provided in the *Medium Term Budgetary Framework for 2014-2016*, Moldova expects that graduation from the GAVI and the Global Fund will increase demand for national public health budget by 2.45 times in 2016 compared to 2011 levels. Due to limited fiscal space and weak economic growth prospects for the same period, this could pose significant challenges for the government during coming years and may put at risk adequate financing of the immunization, TB and HIV/AIDS programs.

In light of this it is thought that when the GAVI and Global Fund boards determine graduation policies, it should not be only linked to a country GDP, as reaching GDP threshold triggers sudden and simultaneous graduation from donor support and places challenges for fiscally constrained governments to pick the price tag of donor funded programs. Such graduations run the risk of inadequate financing from national budgets since graduation, and entails risks of negatively affecting public health achievements realised with the help of GAVI and Global Fund. Consequently, it seems more appropriate for the GAVI and Global Fund to develop phasing out plans for each country in a more coordinated manner, considering different factors and not only GDPs, and while implementing these plans helping health and finance sectors of a country to gradually transition towards the national funding. Such approach seems to have better potential for obtaining durable public health impacts.

Purpose of the Study

The costs and financing of the national immunization programs have been evaluated since 1980s, particularly as part of Universal Childhood Immunization initiative. However, available information is out-dated and up-to-date knowledge on full economic costs and financing of routine immunization programs, as well as the financial cost and financing of a new vaccine introduction is lacking. For going forward and increasing vaccine coverage rates as well as for introduction of new vaccines in national immunization programs, requires better knowledge of costs as well as cost determinants. Therefore, the purpose of this study is to evaluate routine immunization program costs and financing as well as incremental costs and financing of a new vaccine introduction in the Republic of Moldova. Most importantly the study is focused on identifying the factors explaining productivity and variations in total and unit costs on a facility level. Our study in Moldova is part of a larger effort to evaluate costs and financing of routine immunization in six countries (Moldova, Benin, Uganda, Zambia, Ghana, Honduras) supported by the Bill & Melinda Gates Foundation.

Therefore, this study had following objectives:

e) Evaluate overall and detailed economic and financial costs (cost elements) of the routine immunization program in Moldova and describe observed variation in costs and cost elements;
f) Evaluate incremental costs for a new vaccine introduction for Rotavirus vaccine using prospective approach;
g) Evaluate factors determining productivity of facilities involved in the immunization and also try to explain what are major cost drivers for the immunization program;
h) Analyze the main sources of financing and funds flow for the routine immunization program and for the new vaccine introduction.

The findings of the study are expected to help EPI managers and MoH representatives in Moldova to better plan and manage immunization services and a new vaccine introduction. Furthermore, it is hoped that the study results will also contribute to a global knowledge about vaccines, about cost of immunization programs and new vaccine introduction. It is expected that the results of this study could inform future policies aimed at expanding immunization coverage, and therefore estimating and allocating adequate financial and other resources necessary for the coverage expansion.

Background

The Republic of Moldova is a country located in Eastern Europe established as an independent state in 1991 following the collapse of the Soviet Union. Moldova has a surface area of 33,700 square kilometres and shares a border with Romania and Ukraine. The total population is 3.5 million with 58.4 percent living in rural areas [1].

Moldova is divided into 2 municipalities, 32 districts and 2 autonomous territories: Gagauzia, which consists of 3 districts and Transnistria that includes 2 towns and 5 districts [2].

Since claiming independence, there has been civil strife in Transnistria, which sought to maintain its links with the Russia and declared independence from Moldova. In 1992, there was an armed conflict in Transnistria between the Moldovan and Soviet army troops. This conflict has not yet been resolved, and status of Transnistria is being negotiated since [3].

Since 1991 Moldova faced serious economic challenges, losing 66% of its GDP in first decade of independence, followed by sustainable growth starting from 2000 and being challenged again in 2008-2009 by the global economic crises [2].

Moldova is one of the largest net emigration countries in the world, with 39% of the economically active population working abroad [4]. Large-scale labour emigration of young male and female population has negatively affected population growth, as well as the social and economic structure of the society. While crude birth rates were growing and crude mortality was declining, overall population growth rates were negative due to the significant migratory flows. Obviously these demographic shifts have major influence on the cost of the national immunization program and also on the new vaccine introduction costs in the country, as they affect birth cohorts and require constant adjustments in immunization delivery systems.

Fact Sheet1	
Area ('000 km^2)	33,700
Population (million)	3.5
0-14 years (%)	16.4%
15-64 years (%)	73.6%
Over 65 years (%)	10%
Infant mortality rate	10.09
Birth rate per 1000 population	11.0
Growth rate	0.0%

Routine immunization in Moldova

The Ministry of Health (MoH), through the National Centre of Public Health coordinates and manages the Expanded Program for Immunization (EPI) from a national level. And at the city/district level the program is managed by the city/district Centres of Public Health (CPH) in close cooperation with the Primary Health Care (PHC) services that deliver immunization to the population.

In urban areas immunization is delivered through Family *Medicine Centres* (FMC), that serve a population ranging from 40,000 to 80,000 inhabitants; in rural areas through *Health Centres* (HC) usually established for 4,500 inhabitants, *Family Doctor Offices* (OFD) serving between 900-3,000 inhabitants and *Health Offices* (HO) being smallest in size, employing only family medicine nurse and serving up to 900 residents.

Managers of primary healthcare facilities are in charge of organization and delivery of immunization services to a population living in a facility catchment area. And private facilities, which are yet small in numbers, though growing in big cities, do not engage in a delivery of the routine immunization services funded by the state.

Personnel involved in immunization activities are paediatricians, family doctors, and patronage and vaccination nurses. Doctors are responsible for setting individual child's immunization schedule, conducting pre-immunization check-ups, supervising nurses in defining target groups and in undertaking monthly planning and reporting. Patronage nurses have their own catchment's area and they are responsible for informing parents about vaccination, vaccine and supply provision, recordkeeping and delivering vaccine shots. Family Medicine Centres with large catchment population usually have special immunization cabinets staffed with a vaccination nurse. Immunization service delivery is fully integrated with other components of the PHC. **In Moldova in all primary health care facilities immunization is delivered as a fixed strategy and no outreach activities are being carried out**. Therefore, costs captured in this study only relate to the fixed strategy.

Immunization services are organized by sessions. Their frequency varies by facility type and depends on a facility's target population. For example, FMCs organize immunization sessions daily, HCs twice a week, OFDs once a week and HOs once or twice per month.

In Moldova the first National Immunization Program was approved for 1994-2000. This program introduced universal immunization of newborns against Hepatitis B. The latest program covered 2011-2015 and guaranteed free of charge immunization services against ten infectious diseases: poliomyelitis, diphtheria, tetanus, pertusis, hepatitis B, measles, mumps, rubella, tuberculosis, and hemophilus influenza type B. The vaccination schedule, which was in forcein2011, is described in Table 1below. Implementation of immunization against Haemophilus influenza type b using combined tetravalent vaccine DTP-Hib was initiated in 2009, but in May 2010 primary vaccination with DTP-Hib vaccine was temporarily halted because of supply challenges faced by the UNICEF Supply Division; as a result, country re-applied to the GAVI Alliance to change formulation of Hib containing vaccine to pentavalent. In July 2011the pentavalent DTP-Heb B-Hib vaccine, introduction of which did not require changes in the vaccination schedule, replaced DTP-Hib vaccine.

Table 1: The National Vaccination Schedule of 2011 with Rotavirus addition in 2012

ANTIGEN	24 h	2-5 d	2 month	4 month	6 month	12 month	22-24 month	6-7 y	15-16 y	26,36, 46,56 y
BCG		■						■		
DTP							■			
DTP Hib/DTP-Hep B-Hib			■	■	■					
Rotavirus vaccine			■	■						
DT								■		
OPV			■	■	■			■	■	
Hep B	■									
MMR						■			■	
TD									■	■

The National Immunization Program in Moldova is performing well and according to the WHO and UNICEF estimates for the last five years Immunization coverage was attained at over 90 percent for all vaccines. Coverage rates for different antigens are presented in Table 2 below

Table 2: Vaccination coverage (in %) by antigens and years (2007-2011) [5]

Vaccine	Year				
	2007	2008	2009	2010	2011
BCG	98	98	96	99	99
DTP1	96	93	88	96	97
DTP3	93	90	85	95	96
OPV	96	97	87	97	97
Hep B3	96	98	89	98	98
Measles	91	97	90	94	95

Introduction of new vaccines in Moldova

In May 2011 Republic of Moldova applied to the GAVI Alliance for support of Rotavirus vaccine introduction. Gastroenteritis caused by a Rotavirus is a significant public health problem in Moldova. Starting from 2008 WHO supported rotavirus sentinel surveillance, which showed that about 39% of hospitalized diarrheal cases among children under age of five years (or about 2700 children per year) was due to a rotavirus infection[6]. Based on these findings the Government decided to introduce single dose Rotarix™ vaccine into the routine immunization schedule starting from July 2012. Vaccination against Rotavirus is being conducted along with the DTP-Hep B-Hib and OPV vaccines at 2 and 4 months of age. The revised vaccination schedule reflecting rotavirus vaccine addition to the National schedule is provided in Table 1 above.

Prior to introduction of the new vaccine cascade trainings were delivered, starting from the national level and proceeding to a health care facility level. Immunization records, vaccination coverage and vaccine stock monitoring forms were adapted according to the new schedule. Micro-planning activities for the introduction of the new vaccine were carried out. The European immunization week conducted during 2011 and 2012 was used as an opportunity for informing population and for creating demand for a new vaccine.

In 2011 Effective Vaccine Management Assessment was carried out and evidence-based plan to improve management, monitoring and supervision of the country immunization supply chain was developed. The assessment revealed that existing cold chain capacity at the national as well as at a district and facility level was sufficient to accommodate new *Rotavirus* vaccine and introduction did not require procurement of additional cold chain equipment [7].

Current knowledge on costs and financing of immunization globally

As stated earlier, going forward and increasing vaccine coverage rates as well as for introduction of new vaccines in national immunization programs, requires better knowledge of costs as well as cost determinants. Therefore, provided study is aimed at contributing to this body of evidence and informing future policies on a country and global level.

Most facility based costing studies conducted in different parts of the world show that service volume or scale [8] [9] [10] (e.g. number of doses administered per session), number of staff involved and their salaries, number of immunization sessions [11], type of immunization strategy, vaccine wastage rate [8] [9] [12] and local prices affect total immunization program cost. Similar conclusions, although with slight difference, were reached by the study, which looked at financial sustainability of immunization programs in 50 countries by using their *Comprehensive Multi Year Plans* (cMYP) submitted to GAVI. This study showed that country variability and drivers of immunization program cost were linked to: a) difference in schedules, b) labour cost differences, c) population size, d) country development status and income, e) immunization coverage rates and f) delivery strategies (fixed, mobile services, mass campaigns) [13].

Brenzel et al (2006) found in Tajikistan that public resources allocated to health and number of hours facility staff spent on immunization per month was positively associated with facility outputs i.e. number of doses administered. Also several studies highlighted the role other factors i.e. maternal education, hospital births, etc. had also determining impact on the use of immunization services [14][15][16][17][18][19]and consequently its costs.

While the evidence is diverse, up to date very little analysis is available that looked at immunization program costs and their determinants using facility level costing and multivariate approaches. Therefore in this study we tried to evaluate overall cost of the immunization program and its cost elements arising on different levels of health service provision (i.e. facility level, district and national level). Furthermore we tried to look at facility level productivity as well as evaluate collective influence of various factors in determining overall cost on a facility level and on unit costs.

Current knowledge on costs and financing of immunization in Moldova

For time being the best evidence about cost of immunization services and volume of financing in Moldova is available from the *Comprehensive Multi-Year Plan* (cMYP) for 2011-2015, which shows that total cost of the

Table 3 Moldova cMYP: Costs and indicators

Main cost indicators	2011
Total immunization cost without shared cost	$3,405,963
Per capita	$0.8
Per DTP 3 child	$78.2
Total immunization cost with shared cost	$7,839,496
Per capita	$1.9
Per DTP 3 child	$191.0

National Immunization Program without shared costs was estimated at $US 3.405 million in 2011. The shared health system costs were the largest part (≈57%) of the total program cost estimated at $US 7.839 million (see Table 3). And more than 60% of the total immunization program costs were attributable of human resources (including shared personnel costs) and the share of vaccines and injection supply was only 18%. Based on these estimates cost per DTP 3 child was $ US78.2, when shared cost were not considered and to $USD 191 when shared costs were included (see Table 3).

Financing immunization services in Moldova is shared between central budget and National Health Insurance Fund (CNAM). Central Government is responsible for procurement of vaccines, injection supplies, cold chain and laboratory equipment as a part of targeted national budgetary program. It also maintains all facilities at the national level (e.g. National Centre for Public Health). Donor support is mainly used for trainings, strengthening program management and for enhancing *Vaccine Preventable Disease* (VPD) surveillance. GAVI supports procurement of new vaccines and injection supplies [6]. The National Health Insurance Fund (CNAM) funds all recurrent costs related to vaccination on a health care provider level. Based on the cMYP projections for 2011 the Ministry of Health and the National Health Insurance Fund were supposed to be the main financiers of the EPI contributing 88.8% of the total financing that is necessary for the routine immunization program.

Immunization Costing

The Study Methodology

Sampling

This is a cross-sectional facility-based costing study, which looked at total costs of the routine immunization and estimated incremental costs of a new vaccine introduction, arising at different levels of the health care system (i.e. facility, district and the national level).

The study used multistage stratified random sampling. At the first stage we selected 6 districts from total 37 districts of the Republic of Moldova[3]. The Ministry of Health provided the list that included all districts and big cities, which formed the basis of the sampling frame. The total number of vaccine doses delivered helped stratifying districts in three groups. Such stratification assures equal probability of selection of the districts with low, medium and high numbers of vaccine doses administered. Low doses denote districts where up to 20,700 doses were administered in 2011, the districts with annually administered doses were between 20,700 – 30,499 were attributed to medium strata and finally all districts/cities with annual doses more than 35,000 were grouped into high dose strata. In each stratum two districts were chosen by a simple random sampling approach. Consequently, following six districts were selected for the study: Bricheni, Leova, Vulkanesti, Calarasi, Ungheni and Chisinau - the capital city.

The second stage included random selection of facilities within each sampled district. For this purposes only primary health care facilities were selected, as they are the only providers of the immunization services in Moldova[4]. A total list of the facilities in each sampled district/municipality was obtained from the Ministry of Health. The list consisted of 215 primary care facilities and excluded maternity houses and private primary care clinics, which do not participate in the national immunization program. In order to calculate the number of urban and rural facilities in a sample, proportional allocation technique was used. Firstly, proportions of urban/peri-urban and rural facilities from the total number of facilities in sampled districts were estimated: Rural 181 (215) – 84.5%; Urban/peri-urban 34 (215) -15.8%; then these proportions were applied to calculate the number of rural and urban/peri-urban facilities to be included in the sample. Consequently 42 (84.5% of 50 facilities) rural facilities and 8 urban/peri-urban (15.8% of 50) facilities were selected for survey. One peri-urban facility was selected in each of the five sampled districts Briceni, Calarasi, Leova, Ungheni and Vulcanesti and the remaining three urban facilities were randomly selected in the capital city Chisinau. If more than one peri-urban facility existed in a district, simple random sampling approach was used for facility selection. Rural facilities were selected using systematic random sampling. For each selected facility a replacement was identified. In total 50 primary health care facilities were included in the study: 8 urban/peri-urban and 42 rural facilities, which included 5 family medicine centres, 10 health centres, 23 offices of family doctors and 12 health offices[5]. Such selection assures representativeness of the study findings on a national level. The number and location of facilities in which the costs were measured are given in Table 4 and further details of sampling could be found in Annex 1 to this document.

[3] Transnistria, that is a conflict affected zone and access to facilities is problematic, was excluded from the sampling frame.

[4] The only vaccine, which is administered in hospitals is BCG. Due to low number of doses of BCGs administered at the hospital facilities, the study team decided to concentrate most resources on sampling the facilities where vaccination is one of the critical function.

[5] Detailed description and explanation of facility types listed here is provided on page 7 – Routine Immunization in Moldova

Table 4: Number of facilities in which data collection took place by district

District	Sampled Urban facilities	Total Urban Facilities in a District/Municipality	Sampled Rural facilities	Total Rural Facilities in a District/Municipality
Briceni	1	2	7	31
Calarasi	1	1	8	35
Chisinau	3	26	2	9
Leova	1	2	7	32
Ungheni	1	2	17	70
Vulcanesti	1	1	1	4
Total	**8**	**34**	**42**	**181**

The survey tool and data collection

A generic questionnaire for cost data collection was developed and provided by the BMGF to all country teams involved in this research. The questionnaires underwent significant adjustments to a county context and were translated into Russian prior to implementation. Questionnaires were field-tested and further adjustments were incorporated. The data was collected with the help of experienced data collectors, who received two-day long on the job training. Overall data collection, which took place during October 3rd 2012 to January 14th 2013, was closely supervised by the survey coordinator and quality assured by CIF researchers.

Prior to the survey initiation, CIF research team carried out introductory meeting with the Government officials. The MoH provided official letter, which requested the facility managers to support the research team during the data collection process. The MoH for a specific approval and cooperation contacted directors of *District Public Health Centres*.

District and facility level data collection included interviews with facility administrators and health workers, facility observation, and record review. Manual for data collectors was prepared for use as a reference material. The manual provided detailed instructions for completion of each questionnaire, proposed list of key informants for interviews and required logbooks and statistical forms to be reviewed during facility visit. The survey implementation plan was prepared and agreed with data collectors.

Each facility visit required at least one working day, while larger facilities were visited for more than once. Four facilities were replaced according to the predetermined list, because no vaccinations were performed there (see Annex 1).

Data Quality Assurance

Data quality and verification process implied different strategies. As a first step research team developed Excel™ based data entry form, which replicated the paper-based data collection tool. The data collectors were requested to fill electronic questionnaire individually for each facility soon after the facility visit and submit to the survey coordinator. The Excel™ based questionnaire allowed checking for logical consistency, data completeness and for data accuracy immediately after a facility visit. In case of a missing or data errors the questionnaire was sent back for correction.

Excel™ based database was created and data from electronic questionnaires were transferred into the database at the CIF premises. Following the data entry CIF research team validated the data using basic logical links, descriptive statistics, which helped detect odd results and outliers. Such inconsistencies were further verified with the questionnaires first and with the data collectors, where necessary.

Data weighting

Data weighting used in the study was informed by the multi-stage random sampling approach, described earlier in the document. The first stratum (low number of doses administered) consisted of 12 districts, the second stratum (medium number of doses) included 13 and the third one (high number of doses) - 12 districts. The Capital city Chisinau was included in the third stratum. Total population in Chisinau is 10 times higher compared to other districts and the size of urban facilities in Chisinau is significantly bigger. Therefore, for weighting purposes facilities located in Chisinau were separated in a fourth stratum. As a result urban/peri-urban facilities were divided between urban (Chisinau) and peri-urban (other districts) locations.

Weights for ***selected districts*** were calculated by calculating probability of district selection in each stratum (see Table 5).

Table 5: District weights by strata

N	Strata	Total No of Districts	No of sampled districts	District Weight
		A	B	W=B:A
1	Low doses administered	12	2	0.16667
2	Medium doses administered	13	2	0.15385
3	High doses administered	11	1	0.09091
4	Capital City	1	1	1.00000

Weights *for the facilities* were calculated using probability of selecting a facility within a relevant stratum (see Table 6).

Table 6: Facility weights by strata

N	Strata 1	Strata 2	Total N of Facilities	No. of Sampled Facilities	Facility Weight
	A	B	C	D	W=D:C
1	Low doses administered	Rural	257	8	0.03113
		Semi-urban	15	2	0.13333
2	Medium doses administered	Rural	464	15	0.03233
		Semi-urban	17	2	0.11765
3	High doses administered	Rural	508	17	0.03346
		Semi-urban	22	1	0.04545
4	Capital City	Rural	9	2	0.22222
		Semi-urban/urban	26	3	0.11538

Approaches used for cost estimation

Approach to estimating routine immunization costs

Retrospective costing for 2011 of the routine EPI was conducted in this study. We evaluated both financial and economic costs of the routine EPI program and all local costs were converted into 2011 $US using average exchange rate of 11.73 MDL per 1 $US. Calculations were based on common approach methodology for the costing and financing analysis of routine immunization program [20] and cMYP costing guideline [21].

The routine EPI cost includes both a) immunization specific costs that include monetary values of all inputs and activities which are exclusively used for immunization and b) shared costs, which include costs of different inputs utilization of which for EPI is less than 100%.

Costs of all inputs were captured using an ingredients approach listing all inputs by activity and quantities and prices for each input element [12] [22]. Information was collected for all the resources used for delivery of EPI services, including value of donated goods and services.

The cost data included a comprehensive list of capital as well as recurrent expenditure items. Items with a useful life of more than one year were treated as capital cost elements and EPI related resources consumed or replaced within a period of up to one year were treated as a recurrent cost item.

Table 7: Useful Life Years for different capital items

Capital Item	ULY
Buildings	40
Vehicles	
Van	13
Passenger car	10
Cold chain equipment	
Refrigerators/freezer	15
Cold boxes	10
Office equipment	5

Capital costs were annualized using straight line depreciation method i.e. a replacement value of a capital items was divided by a number of *Useful Life Years* (ULY) and for the economic cost estimation capital costs were annualized using a 3% discount rate[23][**Error! Bookmark not defined.**].Country specific ULYs for different capital items used in the cost analysis are presented in Table 7.

Following approaches were used for estimating different costs

For estimating different cost categories as a reference material we used a *Common Approach* document that was supplied by the Gates Foundation [20] and detailed descriptions of used categories/variables are provided below:

Cost of labour includes salaries and other allowances for staff involved in the EPI. Costs were calculated based on a percentage of time spent by a staff on different EPI activities.

Cost of Vaccines and syringes for routine immunization were calculated for each antigen/vaccine using stock records. The total vaccine costs for 2011 were estimated by multiplying a number of doses used by a facility in 2011 by a vaccine price per dose, which includes freight costs as well. The number of doses used includes both number of doses administered and doses of a vaccine wasted. The wastage rate was calculated for each antigen using following formula:

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

Where: Doses supplied = (stock at the beginning of the year + Quantities received during the year) – stock remaining at the end of a given year.

Cold Chain equipment cost was calculated using a number of cold chain equipment by type and equipment prices obtained from the WHO Products Information Sheets [24]. These costs were annualized to obtain replacement costs for the equipment.

Cold Chain energy cost was estimated based on energy consumption characteristics of equipment. Electricity usage according to the type of equipment was collected from the WHO Products Information Sheets. A unit price of $US 0.095 per kilowatt/hour were used for energy cost estimation.

For those costs that are not exclusive to immunization, different cost allocation methods were used, which are summarized in Table 8below:

Table 8: Approaches for allocating shared costs to the routine immunization

Line Item	Approach for allocating shared costs to the total immunization	Approach for allocating immunization cost to different immunization activities
Personnel cost	% Of staff time spent on the immunization	% Of staff time spent on different immunization activities
Cold chain equipment cost		Cost of refrigerators and freezers was allocated to the facility based service delivery, cost of cold boxes was allocated to the vaccine collection and distribution function
Other office equipment and furniture cost	% Of staff time used for routine immunization	% Of staff time spent on different immunization activities. At a facility level cost was allocated to a facility based service delivery, at a district and national levels cost was allocated to a program management, HMIS and surveillance
Cost of vehicles	Proportion of km travelled for routine immunization out of total km travelled in 2011	Proportion of km travelled for each immunization activity out of the total km travelled for routine immunization
Vehicle maintenance cost	Proportion of km travelled for routine immunization out of total km travelled in 2011	Proportion of km travelled for each immunization activity out of the total km travelled for routine immunization
Building cost	Proportion of square meters designated for routine immunization (where vaccines are administered, stored) out of total facility square meters	At the facility level cost was allocated to a facility based service delivery, at a district and national levels cost was allocated to program management and surveillance; cost allocation to these two functions was done using the ratio of staff time spent on program management and surveillance
Building overhead cost	Same as above	Same as above
Transport/fuel cost	Sum of transport/fuel cost of all immunization activities	Allocated directly to the relevant activity; when the trip was used for multiple purposes, % of time spent on each activity was used as a proxy for allocation

Total EPI costs were further distributed by different immunization activities, which included: facility based routine immunization service delivery, record keeping & HMIS, supervision, training, social mobilization, surveillance, cold chain maintenance, vaccine collection and distribution, program management and other immunization activities.

Using total costs of the EPI program, we have also estimated cost per dose delivered, cost per *Fully Immunized Child* (FIC[6]) and cost per infant**. The cost per dose** was computed by dividing total facility cost by total number of doses administered at a given facility. **The cost per Fully Immunized Child (FIC)** was computed by dividing a total facility cost by a number of children that received three DPT doses at this facility. **The cost per Infant** was calculated by dividing a total facility cost by a total number of infants in a facility catchment area.

[6] FIC in our report denotes the number of children who have received three doses of DTP vaccine (DTP3)

Approach to estimating a new vaccine introduction cost

We have estimated economic, financial and cash-based incremental cost of a new vaccine introduction whether financed by the government or through other sources. Considering that Moldova introduced Rotavirus vaccine in July 2012 the cost of Rotavirus vaccine introduction was estimated prospectively. The data collection captured all costs (for capital equipment, for surveillance, for trainings, for social mobilization and etc.) incurred six-month prior and six month following the date of vaccine introduction. Obtained costs in local currency were converted to 2011 $US using current exchange rate and annualized.

We used WHO recommended methodology for estimating costs of introducing a new vaccine that entails identifying all inputs required for the introduction along with quantities and unit costs (so called ingredients approach to costing) [25] [26].Resource items required for the Rotavirus vaccine introduction were identified through review of the national plan for Rotavirus vaccine introduction and by interviewing key informants.

Due to the fact that staff does not work exclusively on the Rotavirus vaccine; incremental personnel costs were assessed on the bases of time allocation. The survey tool allowed collecting information about additional time spent by a staff on any stage of the Rotavirus vaccine introduction (planning, social mobilization, vaccine delivery, etc.). Consequently, additional human resource costs were estimated and considered in the economic cost analysis. Additional allowances provided to personnel of the national public health centre and related to the rotavirus vaccine were also included in our estimations[7].

Cost of Rotavirus vaccine was estimated/projected using the following formula:

$$\textbf{Cost} = \textbf{P} \times \textbf{C} \times \textbf{B} \times \textbf{D} \times (1/(1-\textbf{W})) \times (1+\textbf{R});$$

Where **P** denotes costs per vaccine dose (including freight expenses), **C** denotes predicted vaccination coverage rate of the first dose for the Rotavirus vaccine, **B** denotes target population, **D** denotes number of doses per child, **W** denotes wastage rate and **R** denotes the reserve stock. No correction was made for anticipated dropout rates [27]. Considering that Rotavirus vaccine is administered along with the DTP-Hep B-Hib and OPV vaccines, the coverage rate for the first dose of DTP-Hep B-Hib vaccine was used. A birth cohort for 2012 and 25% of reserve stock were applied during cost estimation. A wastage rate of 5% was predicted for a single dose vial of the Rotavirus vaccine per WHO recommendation [28]

Information on cold chain investments necessary for the rotavirus vaccine introduction was obtained from the National EPI manager. An Effective Vaccine Management Assessment Report, undertaken in 2011 was also used for this estimation [7]. Existing cold chain capacity was sufficient to accommodate additional space/volume demand; therefore no additional cold chain equipment was purchased prior to introduction. Although no additional investments were made in the cold chain, for **economic costing** we allocated cold chain cost to the Rotavirus vaccine based on the % of space need for the new vaccine. A two-step method was used for these purposes: firstly, the percentage increase in overall vaccine volume was estimated using the WHO vaccine volume calculator [28]; secondly, percentage generated by the new vaccine volume calculator was used to allocate cold chain equipment cost to the Rotavirus vaccine.

In 2012 new investments related to the new vaccine introduction were made only in office equipment. GAVI funds for the new vaccine introduction were used to purchase server and computers for the National Public Health office. These investments were included in cash flow analysis, while for financial costs the value of this equipment was annualized using straight-line depreciation method and for economic costs using discount rate and ULY (as described earlier).

Incremental transportation costs associated with the Rotavirus vaccine introduction were assessed using the specific question in the survey tool: whether the frequencies of vaccine

[7] These allowances were covered by the funds of GAVI Alliance

collection and supervisory visits have changed due to the vaccine introduction and if yes, by how much. Cost of training delivered for the Rotavirus introduction was treated as a capital cost with the useful life of 2 years and 3% discount rate.

Data analysis

Excel database was used to estimate/calculate various cost elements (described earlier in this section). Calculated cost variables were eventually transferred to SPSS version 19.0 for descriptive statistical analysis and to STATA for regression analysis.

The Study Limitations

This study has several limitations. Namely:

Recall bias related to a time spent on immunization activities could affect the study results. Although the survey tool was constructed in a way to minimise such biases, findings of the study may still differ from realities on the ground. The study team used different approaches to minimise recall bias by:

- Developing the survey tool in a manner that all respondents were forced to break down their daily activities and allocate a percentage time spent on each activity with the objective that total sum would equal to 100%;
- Whenever possible (mostly in large facilities) doctors or nurses were asked to sit in small groups and discuss time allocation together and reach group consensus. Data collectors facilitated these discussions to avoid over or underestimation of the time spent on each activity.

Furthermore, by not including maternities, where only the first BCG dose and Hepatitis B is administered, total cost of immunization could be underestimated, although due to very small size of the birth cohort, this underestimation would not be significant.

A comprehensive analysis of surveillance costs was beyond the scope of this study. The study is focused only on a) estimating the value of activities related to case detection and outbreak response; b)estimation of the proportion of time and value of time spent at the facility, district, and national levels on surveillance activities, c) estimation of the transportation/fuel cost for surveillance activities. Costs of laboratory services and the cost of capital equipment for surveillance are not estimated; therefore surveillance costs are underestimated in our study.

Therefore, these limitations should be considered when interpreting the study results.

Ethical Issues

CIF tried to secure the national Institutional Review Board (IRB) approval. However, following preliminary review of the study documentation and according to the current legislation in Moldova, IRB decided that the study did not need such approval.

Results of routine immunization costs

In this section of the report we will initially evaluate obtained results on a facility level and will try to look at total and unit costs of the routine immunization program (financial and economic), we will describe observed variation and its explaining factors with the help of univariate analysis. Then we move onto cost aggregation to estimate district and national level costs of the national routine immunization program. Finally, we will dissect the unit cost of immunization into cost elements to better understand cost of various inputs as well as functions carried out by facilities involved in the immunization service delivery in Moldova.

However, prior to describing obtained results on a provider level it is important to understand taxonomy of health care facilities involved in immunization service provision. Text Box 1 lists all those providers that deliver vaccinations in Moldova. Understanding their nature, size, and principles of their establishment is necessary to understand results of the analysis detailed in this report.

Text Box 1 Taxonomy of Providers Involved in Immunization Service Provision

- **Family medicine centres (FMC)** are established in urban locations or district centres and serve a population ranging from 40 000 to 80 000 inhabitants. The National Health Insurance Company (CNAM)directly contract family medicine centres for the provision of basic and specialized outpatient services to district/city inhabitants. They also serve as methodological and organizational centres for all primary care facilities in a district and collate all health care related statistical data for primary care level in a district.
- **Health centres (HC)** usually serve at least 4500 inhabitants and have at least three family doctors. Health centres can be organized as subordinated unit of a FMC or as autonomous entity (public or private). The autonomous health centres are contracted directly by the CNAM for the provision of basic services in their catchment area.
- **Office of a family doctor (OFD)** serves a population between 900–3000 inhabitants and can employ one or two family doctors.
- **Health offices (HO)** are organized in communities with fewer than 900 inhabitants (mostly found in rural areas) and are staffed with only family medicine nurses.

Total Costs and Cost Variation on a facility level

Total facility level immunization costs varied broadly, between 449$US and 97,572$US, mean being 10,532 $US and median 3,372 $US. Total cost obviously varied and was strongly correlated with the size and scale of a facility (measured by the total number of doses delivered at the facility in 2011). Figure 1 describes relationship between total facility level costs and facility scale on a facility level. Log transformed variables reveal strong positive linear correlation between these two (r=0.95).

Figure 2 presents variability of these costs by facility type and shows that due to size of a facility and due to number of infants in a catchment population total facility level costs grow from Health Offices (HO that are the smallest) to Family Medicine Centres (FMC – that are the largest). Variability within facility types is not major with the exception of FMCs where total facility level costs vary within a broader range 28,335 – 112,548 $US. There are also two exceptions within HOs and HCs namely facility No.12 and facility No. 45 seem to have significantly higher costs when compared to their peers (see Figure 2 and for more details see Figure 14 on page 79). Both these facilities were found to be high performing ones delivering more doses annually and achieving high coverage rates. The figure also shows that most sampled facilities achieve highest DTP3 coverage rate, but due to number of underperforming ones the average DTP3 coverage in the sample was 94.8%. HCs and OFDs showed better performance 98.1-97.8% respectively and HOs have the poorest performance - 90.2% followed by FMCs - 92.7%.

Figure 1 Total Economic cost on a facility level by facility scale (i.e. number of annual doses delivered)

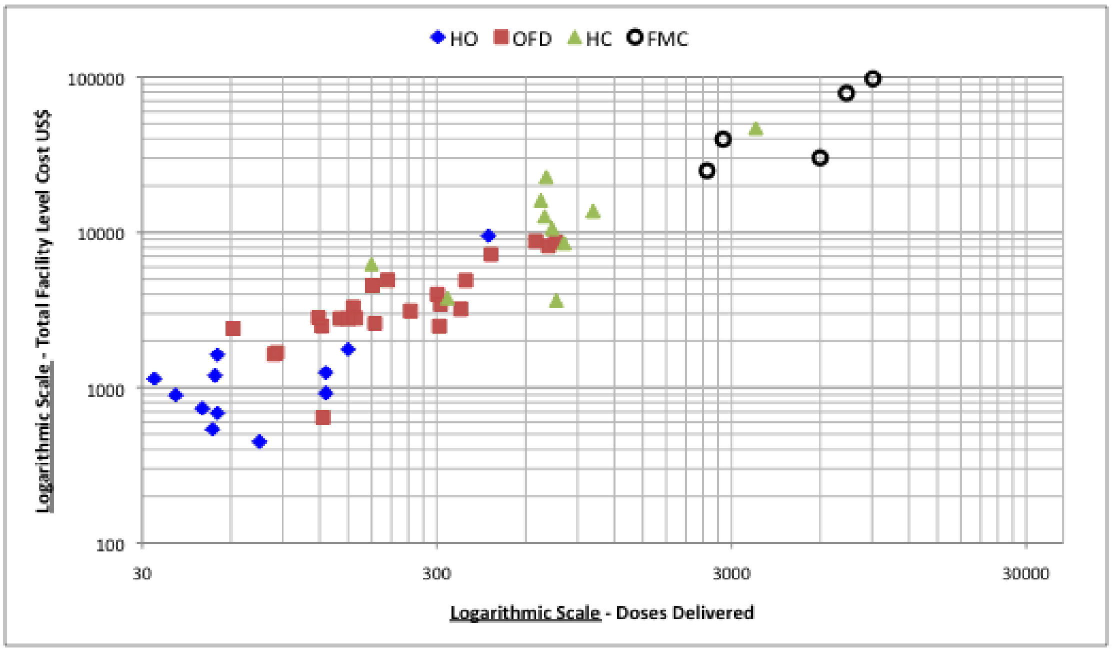
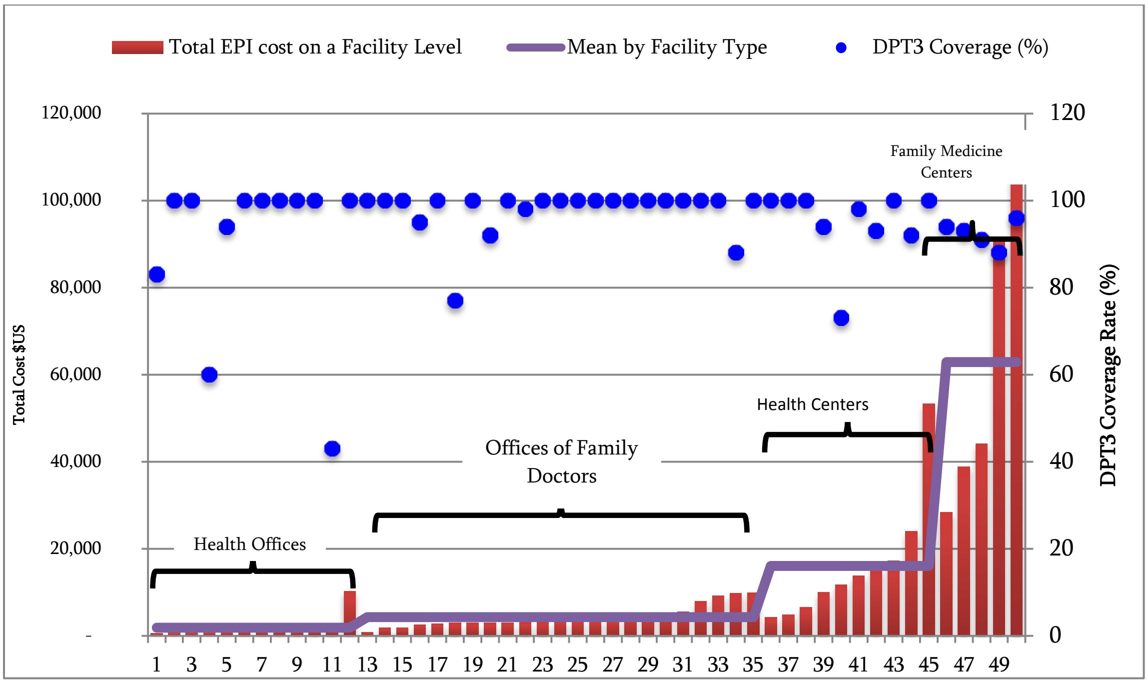


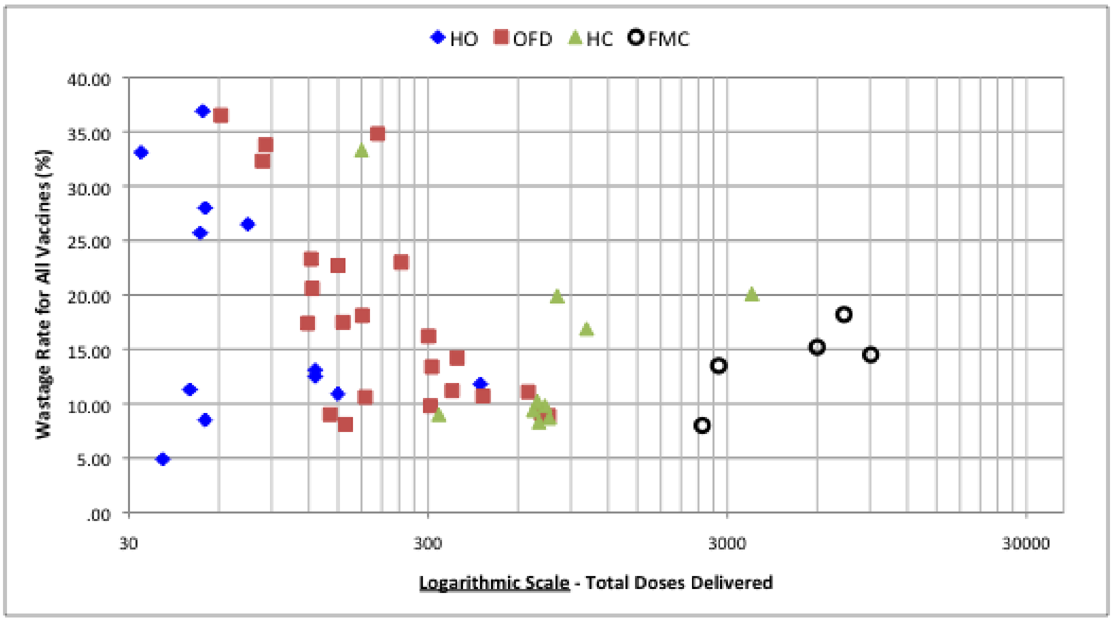
Figure 2: Total economic costs by facility type and DTP3 coverage (%)



It was interesting to understand what drives these differences in performance. When looked at communities where these facilities operate, OFDs on average have 17.2 infants (95%CI: 16.1 – 18.3) and serve on average a population of 1,555 people; HCs have 47 (95%CI: 39-54) infants and a population of 3,737 and they both are staffed with doctors and nurses. It could be assumed that small size of catchment population with adequate staffing probably allows them to better identify, plan and follow-up infants and consequently achieve higher coverage rates. Contrary to these facilities, FMCs serve higher number of infants 430 (95%CI: 372-487) in a community with an average population size of 32,616 (95%CI: 28,693 – 36,539). While they also have doctors and nurses they may face challenges in finding, following up and immunizing children due to size of catchment population. Health offices that reveal the poorest performance serve on average 7 infants (95%CI: 6.7-7.9) with 535 inhabitants in catchment area, and should be able to produce better immunization results. However, their DPT3 coverage at 90.2% means that they may not be able to vaccinate with DPT3 only one kid out of seven and DPT3 coverage may not be the best measure for such facilities.

Finally through bi-variate correlation we also looked at overall vaccine wastage rate on a facility level and DPT3 coverage rates. The analysis showed that facilities with higher DPT3 coverage are expected to have lower wastage rate (corr. coefficient = -0.154; p<0.01) although the strength of this correlation was weak. We also looked at the relationship between wastage rate and annual doses of immunization delivered by a facility (see Figure 3), which showed that with increasing scale the wastage rate tends to decline, although in a small facilities (HOs and OFDs) we also notice significant variability in a wastage rate, which is not directly related to a scale. Wastage rate could possibly be explained by different factors e.g. by quality of managerial decision-making, by vial size of vaccines delivered, etc. Consequently, influence of staffing patterns, the size of a catchment population and influence of wastage rate on immunization program performance on a facility level has to be thoroughly evaluated using multivariate regression analysis.

Figure 3 Wastage rate for all vaccines by facility scale (i.e. number of annual doses delivered)



Unit Costs and Cost Variation on a facility level

As stated earlier, when looking at a unit cost of immunization we used several indicators:

- Cost per dose
- Cost per FIC and
- Cost per infant

We estimated both: financial and economic costs and used t-test for statistical significance. Statistical tests were applied only to un-weighted dataset. Furthermore, when estimating unit costs we looked at *Total Unit Cost* (TUC), which includes salaries for shared labour as well as at *Unit Costs* (UC) without these salaries to see what differences between these two were. We evaluated unit cost variations by looking at three dimensions: a) location i.e. urban-rural differences, b) type of facilities (see details in Text Box 1 above) and c) facility scale (measured by the annual doses delivered at the facility)

Thorough analysis of financial and economic costs across different dimensions revealed that when TUCs were compared, economic costs were always higher by about 6%, although this percentage was different depending on a dimension used. However, looking at UCs, which does not include cost of shared labour, the difference between financial and economic costs becomes more pronounced around 20%. Therefore, for ease of presentation we primarily concentrate on presenting economic costs in this section, unless otherwise stated. However, detailed presentation of financial and economic costs could be found in Annex 2 to this report.

Table 9 provides unit cost analysis by location, which shows consistent and declining trend of a unit cost from rural to urban facilities; however observed differences did not have statistical significance and point to the fact that location does not have influence on a unit cost of immunization services. Furthermore, TUC comparison with UC, in the same table, shows that on average, when shared labour costs are being considered, unit costs become almost three times higher, and these differences range from 2.8 for rural facilities to 3.7 in semi-urban. This indicates that labour costs have significant contribution to a unit cost and consequently to total cost of the national immunization program. We will try more thoroughly evaluating the impact of shared labour cost later throughout the analysis.

Table 9: Unit Costs by Location on a Facility Level

Unit Cost $US	Rural	Semi-urban	Urban	Total	Sig.
TUC per dose	18.6	14.5	13.1	**18.3**	*n.s.*
TUC per Infant	325	207	165	**317**	*n.s.*
TUC per FIC	340	222	180	**332**	*n.s.*
UC per dose	6.6	4.0	3.7	**6.4**	*n.s.*
UC per Infant	116	56	47	**112**	*n.s.*
UC per FIC	122	60	51	**118**	*n.s.*
TUC/UC ratio per dose	2.8	3.6	3.5	2.9	*n.s.*
TUC/UC ratio per infant	2.8	3.7	3.5	2.8	*n.s.*
TUC/UC ratio per FIC	2.8	3.7	3.5	2.8	*n.s.*
N weighted	**1,238**	**54**	**26**	**1,318**	

n.s. = not significant

In Table 10 unit costs are analyzed by facility type. From the table we observe that unit costs increase when facility size declines i.e. when providers start serving less population in a catchment area. However, this trend becomes statistically significant only when shared labour costs are removed and only for UC per dose (at 99% level) and for UC per FIC, but in the latter case the level of statistical significance is low at 90% level only.

When looking at UCs, costs are lowest in FMC, which are largest facilities, mainly located in Chisinau and highest in HOs - located in rural areas. Mean costs in HCs and OFDs are in the same range and are almost two times higher compared to unit costs in FMCs. Based on a literature [9][10][13] observed differences could be explained by numerous factors which include: size of a population served by a facility; scale of a facility itself i.e. number of doses delivered per annum, or by other factors such as education or income level of a catchment population, which could determine demand for services[14][16][18].

Table 10: Unit Costs by Facility Type on a Facility Level

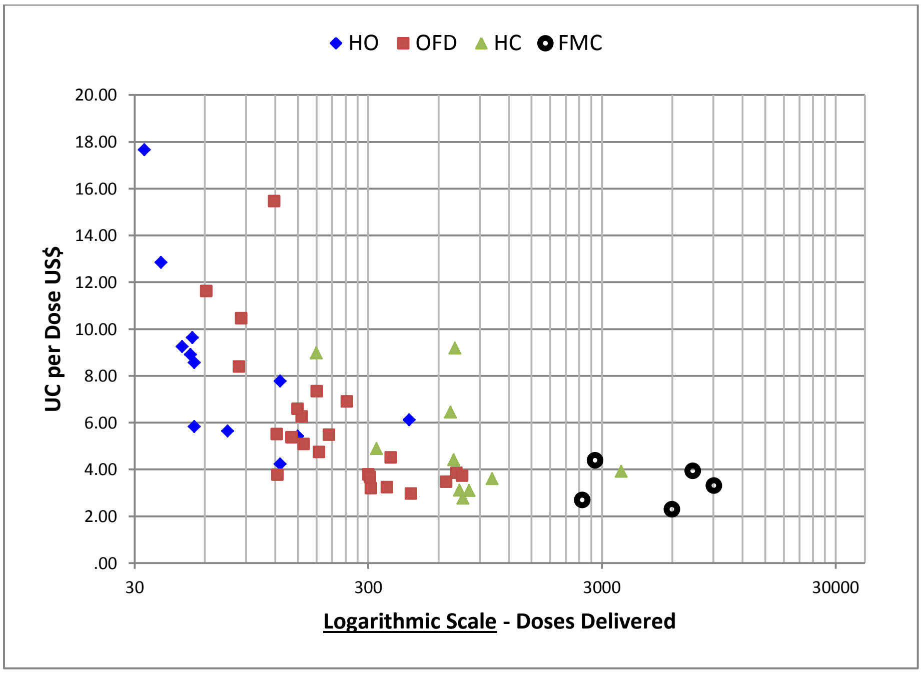
Unit Cost $US	FMC	HC	OFD	HO	Total	Sig.
TUC per dose	10.4	19.4	18.5	18.7	18.3	*n.s.*
TUC per Infant	143.9	322.9	338.7	296.5	316.6	*n.s.*
TUC per FIC	155.1	328.8	347.2	332.2	332.3	*n.s.*
UC per dose	3.1	5.2	5.9	8.5	6.4	*p<0.01*
UC per Infant	42.6	88.5	110.6	138.7	112.3	*n.s.*
UC per FIC	45.9	89.9	113	152.4	117.8	*p<0.1*
TUC/UC ratio per dose	3.4	3.7	3.1	2.2	2.9	*p<0.01*
TUC/UC ratio per infant	3.4	3.6	3.1	2.1	2.8	*p<0.01*
TUC/UC ratio per FIC	3.4	3.7	3.1	2.2	2.8	*p<0.01*
N weighted	**55**	**190**	**708**	**365**	**1318**	

n.s. = not significant

The ratios of TUC/UC costs, presented in Table 10 show that shared labour costs are relatively higher in HCs and FMCs and their contribution in the unit cost of immunization declines in smaller facilities i.e. OFDs and HOs, and the latter ones have the lowest ratio.

We also analysed unit costs by the facility scale. Total number of vaccine doses delivered by a facility was used to stratify facilities in three groups. Stratification was done using frequency analysis. Low scale facilities denote facilities where up to 126 doses were delivered in 2011, the facilities where between 127-309 doses were administered were attributed to the medium scale facilities and finally, all facilities with annual doses more than 310 doses were grouped into high scale facilities. Going further and looking at unit costs by facility scale we see that the higher the scale (i.e. more doses a facility delivers a year) the lower the unit cost of immunization (Figure 4). This association is statistically weak for TUC, but when shared labour costs are removed statistical significance of the influence increases up to 99% level

Figure 4: Facility unit costs without shared labour cost by facility scale



From Table 11 it becomes evident that difference in TUC between low and medium scale facilities is marginal and the magnitude of difference increases when shared labour costs are removed. At the same time partial contribution of shared labour costs is highest in a high scale facilities and lowest in low scale ones. All of this leads to a conclusion that labour costs as well as other facility specific factors may play significant role in determining a unit cost of immunization, which requires simultaneous evaluation of various factors with the help of a multivariate regression analysis (described later in the document). Finally, univariate analysis presented in Table 11 proves that scale of a facility (measured in doses delivered) has strong influence on a unit cost and deserves further evaluation in a multivariate model.

Table 11: Unit Costs by Facility scale

Unit Cost $US	Low	Medium	High	Total	Sig.
TUC per dose	20.5	18.3	14.5	18.3	*n.s.*
TUC per Infant	331.5	352.8	216.1	316.6	*p<0.1*
TUC per FIC	357.5	359.7	231.2	332.3	*p<0.1*
UC per dose	9.1	5.2	3.9	6.4	*p<0.01*
UC per Infant	157.3	99.8	57.4	112.3	*p<0.01*
UC per FIC	167.3	101.7	61.6	117.8	*p<0.01*
TUC/UC ratio per dose	2.3	3.5	3.7	2.9	*p<0.01*
TUC/UC ratio per infant	2.1	3.5	3.8	2.8	*p<0.01*
TUC/UC ratio per FIC	2.1	3.5	3.8	2.8	*p<0.01*
N weighted	**489**	**556**	**273**	**1318**	

n.s. = not significant

Table 12: Correlation Matrix

Variables	Facility Location	Facility type	Scale	Unit Cost per Doze	Unit Cost per FIC	Unit Cost per Infant	DPT3 Coverage rate (%)	Population in catchment area
Facility location (Rural =0)								
Facility Type (HO = 4)	-.232**							
Scale (low =1)	.375**	-.486**						
Unit Cost per Doze	-.131**	.069*	-.263**					
Unit Cost per FIC	-.166**	.027	-.217**	.678**				
Unit Cost per Infant	-.168**	-.034	-.192**	.635**	.962**			
DPT3 Coverage rate (%)	-.067*	-.27**	.083**	-.027	-.040	.214**		
Population in catchment area	.883**	-.322**	.446**	-.213**	-.219**	-.22**	-.057*	

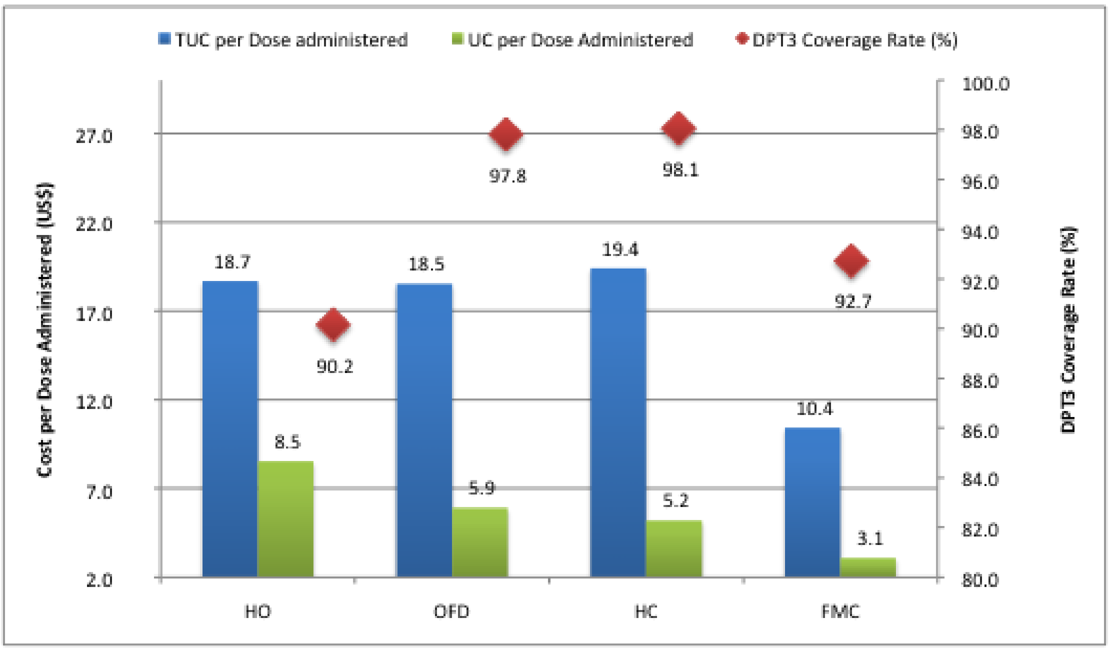
** Correlation significant at the 0.01 level (2-tailed).
* Correlation significant at the 0.05 level (2-tailed).

Finally, Pearson's bi-variate correlation results presented in Table 12 revealed weak relationship between explored influences of facility characteristics on the unit cost. While Pearson's coefficients are weak, statistical significance of most findings are strong and Table 12 shows that facilities located in urban areas could be bigger in size i.e. HCs or FMCs (r=-0.232; p<0.01), could have greater scale (r=0.375; p<0.01), and could be able to deliver immunization services at a relatively lower costs. However, facilities in urban areas are quite likely to serve larger catchment population (r=0.883; p<0.01).

Unit Costs and Immunization Program Performance on a Facility Level

Obtained unit costs were also related to a facility performance measured by facility-specific DPT3 coverage rate. We measured coverage based on a number of children who have received three doses of DTP vaccine (DTP3), reasoning that DTP3 is a close measure of a routine immunization program performance [29]. For our analysis we grouped facilities by type and tried to evaluate relationship between TUC, UC and DPT3 coverage rates. Results are presented in Figure 5, which shows that HOs that have lowest DPT3 coverage rate (although as mentioned earlier this could be just one child out of seven that missed the third dose of DPT) spend comparable amount per dose delivered with OFDs and HCs, however amount of non-labour inputs are highest in HOs when compared to other facilities. HCs spend highest amount per dose delivered but also achieve highest coverage rates. And FMCs seem to be most efficient facilities being able to deliver immunization at a lowest cost per dose as well as use least amount of labour and non-labour inputs. Finally, while HCs spend highest amount per dose delivered they spend least (after FMCs) on non-labour inputs.

Figure 5 DPT3 Coverage on a facility level and unit costs of service provision



Therefore with increased scale, labour and non-labour inputs are more effectively used and smaller facilities are more prone to be more inefficient. However, observed tendency of declining use of non-labour inputs when increasing scale (see Figure 5) as well as variable contribution of labour inputs in achieving high DTP3 coverage points to the fact that labour inputs might be as well important in determining DTP3 coverage rates i.e. facility performance. This hypothesis was further analysed by looking at hours and minutes spent on delivering a dose of immunization or administering three DPT doses to a child.

Results of this analysis are presented in Figure 6 and Figure 7 and show that health offices use the largest amount of staff time to deliver a dose of immunization (65.6 minutes) or to immunize a child with three doses of DPT vaccine (19 hours). Effectiveness of human resource use improves as the facilities become bigger and scale of immunization services increase. Consequently FMCs spent the least amount i.e. 8 minutes for delivery of a dose and 2 hours for immunizing a child with three doses of DPT vaccine (see Figure 7 for details).

Figure 6 Time spent on immunization services by type of a facility and doses administered

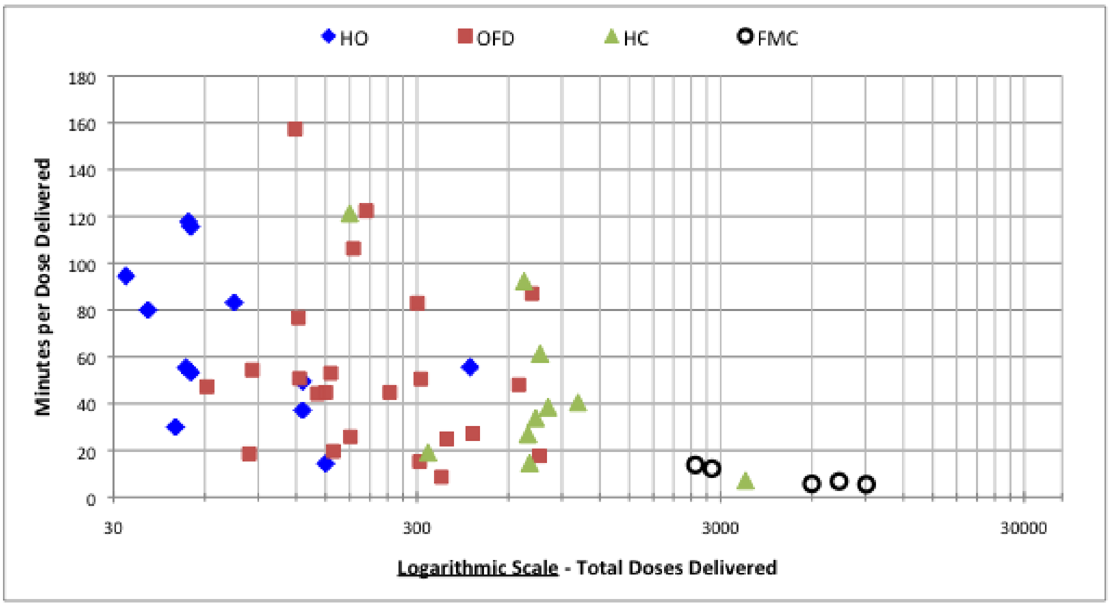
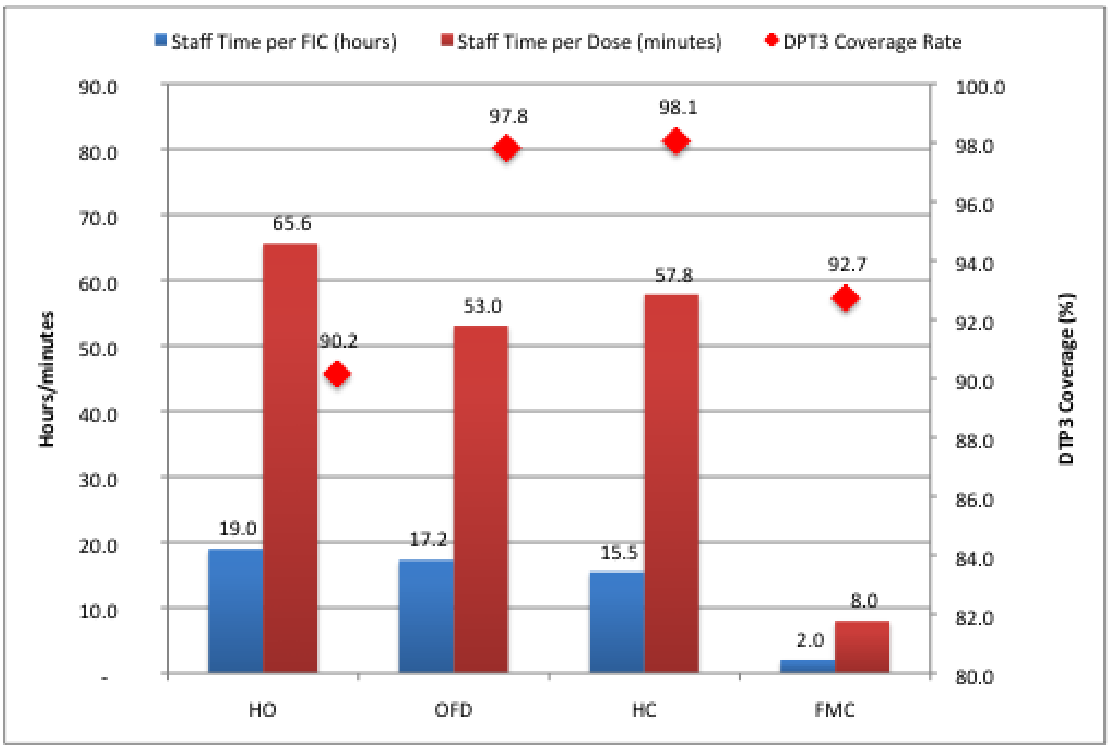


Figure 7 Time spent on immunization services by type of a facility



All of these points to the need that in a multivariate analysis influence of labour related as well as non-labour related factors have to be carefully evaluated. This could help explain, what may be required for improving facility level productivity as well as will help understand what needs to be done, in terms of financing and management on a facility level that will help increase coverage rates.

Unit Cost Structure on a Facility Level

Detailed unit cost structure by a facility type and scale was analyzed and results are reflected in Table 13 and Table 14 below. Analysis of a cost drivers revealed that the labour costs are main contributors to immunization costs on a facility level and their share increases along with increase in facility size and scale. Average share of a labour cost contribution was 65.07% for the sample, ranging from 54.42% in HOs to 70.48% in FMCs and from 55.46% in lower scale to 73.27% in higher scale facilities. Figure 8 provides simplified visualization of observed tendencies by recurrent and capital costs. From the figure it is clear that share of recurrent and capital costs vary across type and scale of providers.. Namely, share of capital costs in a unit cost of FMCs is lowest - 10.3% and highest in HOs – 22.8%, which are the smallest facilities in their size and capacity and which deliver lowest number of dozes per year.

Figure 8 Unit Cost Structure by facility type and scale

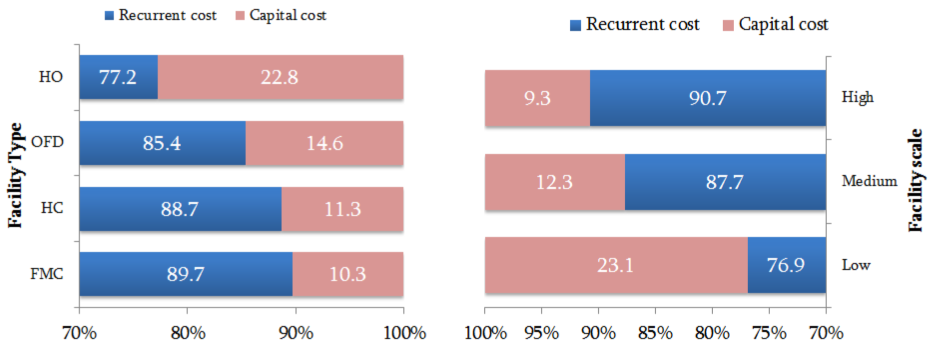
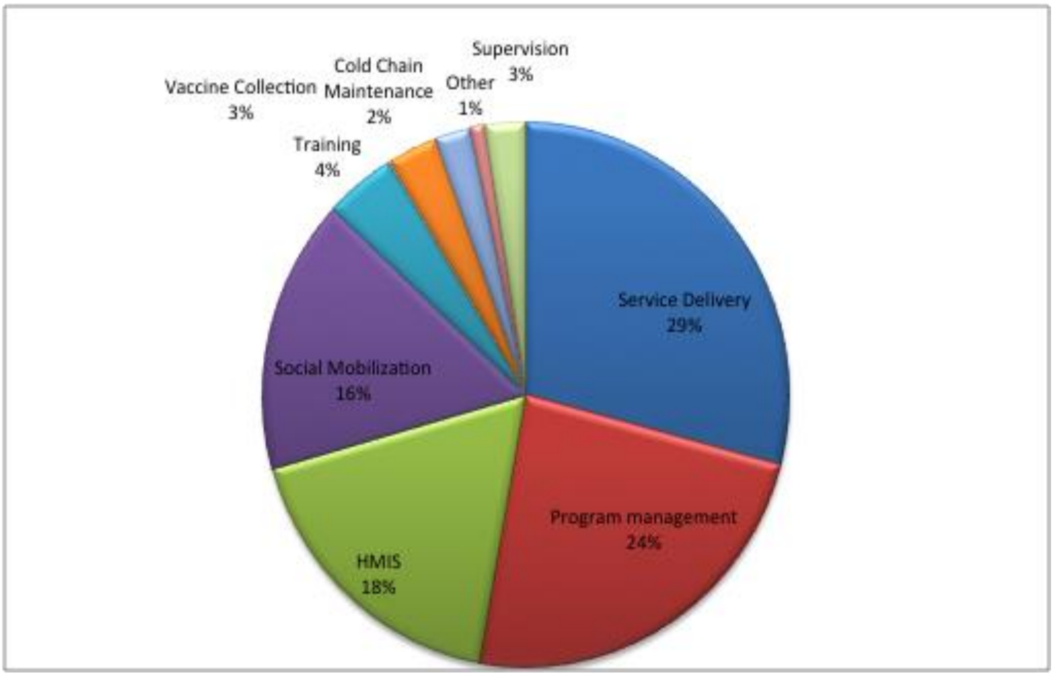


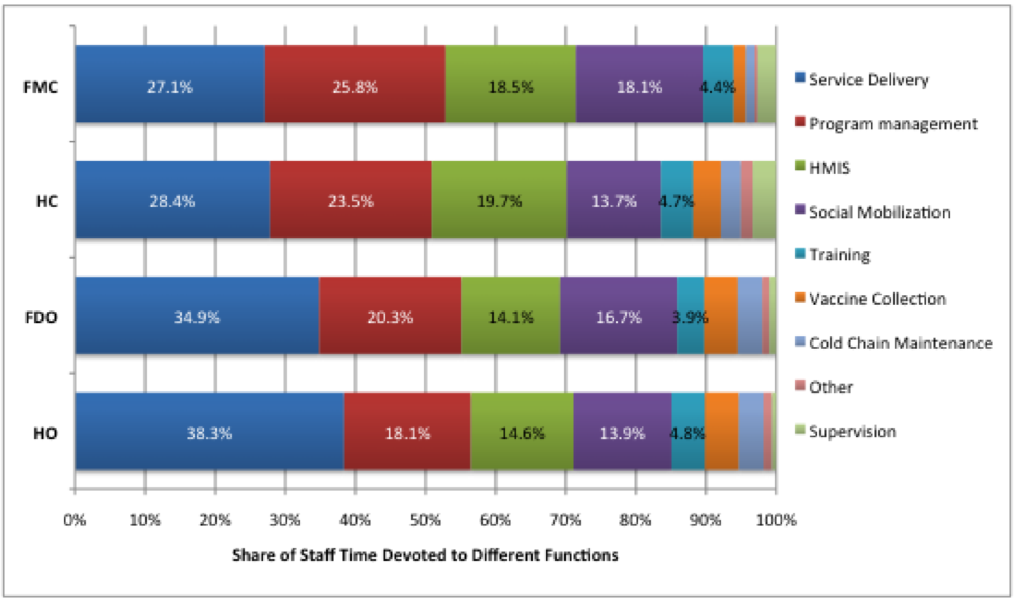
Figure 9 Staff time by immunization specific functions for the sample



Furthermore, in a unit cost of a high scale facility the share of capital costs is around 9.3% while in low scale facility it reaches 23.1%. Higher share of capital in a unit cost is also accompanied by a higher unit cots per dose delivered (see in Table 13 and Table 14 below), which may lead to a conclusion that cost of capital may determine cost of immunization services and more effective use of capital (if this is possible) could help reduce costs. Furthermore, when structure of a recurrent cost is analyzed it becomes obvious that share of a facility related costs (i.e. utilities and communications) do correlate with a facility type as well as with facility scale and consequently with a unit cost of immunization.

Earlier we also presented relationship between labour inputs and facility-specific DTP3 coverage. We have further explored breakdown of staff time by immunization specific functions (see Figure 9) and by type of a facility, which is detailed in Figure 10.

Figure 10 Breakdown of staff time by immunization specific functions



This analysis shows that largest amount of time is spent on delivering immunization services in a facility and health offices devote the highest share - 38.3% and lowest is in FMCs – 27.1%. However, the time spent on immunization management and planning issues is highest in FMCs and lowest in HOs, 25.8% and 18.1% respectively and it is 24% for the whole sample. Time spent on HMIS and social mobilization is the third and fourth most labour intensive activities in Moldovan PHC facilities.

In previous section we observed close link between facility type and DPT3 coverage rates, which was also closely associated with the use of labour and non-labour inputs. Therefore, it becomes important to evaluate influence of a facility characteristic (taking into account capital as well as operations related indicators) along with labour inputs in a multivariate model to objectively establish causality between facility characteristics (used as inputs) along with labour use and immunization costs on a facility level and immunization program performance.

Table 13 Unit Cost structure by Facility Type

Item	FMC	HC	OFD	HO	Total
Recurrent cost (%) of Total	**89.7**	**88.7**	**85.4**	**77.2**	**83.71**
Salaried Labor	70.48	73.25	68.11	54.42	70.48
Vaccines and injection supplies	14.42	8.14	8.79	8.3	14.42
Utilities and communications	2.69	4.85	5.94	8.46	2.69
Printing	1.06	0.46	0.11	0.00	1.06
Cold chain energy	0.1	0.46	0.49	1.77	0.1
Other recurrent	0.97	1.53	2.01	4.23	0.97
Capital cost (%) of Total	**10.3**	**11.3**	**14.6**	**22.8**	**16.29**
Building	7.12	5.77	9.23	15.32	10.35
Cold chain equipment	0.19	0.77	2.27	4.61	2.67
Other capital costs	2.98	4.74	3.07	2.89	3.27
TOTAL %	**100**	**100**	**100**	**100**	**100**
TUC Cost per Dose US$	**10.4**	**19.4**	**18.5**	**18.7**	**18.4**

Table 14 Unit Cost structure by Facility scale

Item	Low	Medium	High	Total
Recurrent cost(%) of Total	**76.9**	**87.7**	**90.7**	**83.71**
Salaried Labor	55.46	71.37	73.27	55.46
Utilities and communications	8.04	8.56	10.63	8.04
Vaccines and injection supplies	8.28	5.13	5.04	8.28
Transportation/fuel	2.44	1.47	0.48	2.44
Cold Chain energy	1.41	0.49	0.21	1.41
Other recurrent	1.22	0.7	1.11	1.22
Capital cost(%) of Total	**23.1**	**12.3**	**9.3**	**16.29**
Building	15.16	7.47	5.66	10.35
Cold chain equipment	4.53	1.64	0.55	2.67
Other equipment	2.83	2.29	1.86	2.45
Vehicles	0.63	0.87	1.17	0.82
TOTAL %	**100**	**100**	**100**	**100**
TUC Cost per Dose US$	**20.5**	**18.3**	**14.5**	**18.4**

In conclusion in Table 15 we summarize financial and economic unit costs on a facility level, which could be used in budget estimation as well as for further analysis. The table also reflects observed differences in economic and financial costs noted by our study, more details could be found in Annex 2.

Table 15 Financial and Economic Unit Costs

Unit costs on a facility level US $	Financial	Economic	Difference (%)
TUC per dose	17.4	18.3	5.17%
TUC per infant	299.5	316.6	5.71%
TUC per FIC	314.3	332.3	5.73%
UC per dose	5.5	6.4	16.36%
UC per Infant	95.2	112.3	17.96%
UC per FIC	99.8	117.8	18.04%
Total doses administered	680,877		
Total Infants	47,537		
Total FICs	44,571		

Total Cost and Cost Structure of the National Immunization Program

To calculate total annual costs (financial and economic) of the EPI program on a national level we carried out cost aggregation using bottom-up aggregation approach. Firstly, we calculated a facility mean cost, without cost of vaccines and injection supplies on a facility level where immunization is delivered and multiplied these cost by the total number of facilities in the country. Secondly, we calculated mean district level cost for district public health centres without cost of vaccines and injection supplies and multiplied by the total number of districts in Moldova. Finally we estimated national level costs and cost of vaccines and injection supplies and added up all costs to arrive to the national EPI program cost (see Table 16).

Table 16: Economic and Financial Cost aggregation for the National EPI

Cost Element	Economic Costs	Financial Costs	Difference
Average facility cost without vaccines and injection supplies	$ 6,160	$ 5,906	$ 254
Total number of facilities in the country	1318	1318	
Total facility level immunization program cost without vaccines and injection supplies	**$ 8,119,394**	**$ 7,784,266**	**$ 335,128**
Average district cost without vaccines and injection supplies	$ 14,497	$ 13,360	$ 1,137
Total number of districts	37	37	
Total district cost without vaccines and injection supplies	**$ 536,404**	**$ 494,335**	**$ 42,069**
National cost without vaccines and injection supplies	**$ 142,063**	**$ 132,489**	**$ 9,574**
Cost of vaccines and injection supplies	**$ 1,058,706**	**$ 1,058,706**	**-**
Total National level immunization economic cost with vaccines and injection supplies	**$ 9,856,567**	**$ 9,469,796**	**$ 386,771**

Aggregated costs, both financial and economic, show that 82% of costs arise on a facility level (not including cost of vaccines and injection supplies) and around 5% of costs are attributable to district level costs, which includes primarily cost of vaccine storage, supervision-monitoring and program management and also VPD surveillance. And national level costs amount only to 1.4% of the total immunization program costs and vaccines and syringes – 11%. Furthermore, aggregated costs were partitioned separately for a facility, district and national level and are presented in Table 17 and Table 17 below. Further partitioning of the national program costs in a cross tab inputs by activities are detailed in the matrixes provided in Annex 3.

Table 17: Financial cost and cost profile of the national immunization program

Item	Facility level		Facility+District level		Facility+District+National level	
	Total Cost $US	% of total cost	Total Cost $US	% of total cost	Total Cost $US	% of total cost
Recurrent cost	**8,137,856**	**92.0%**	**408,134**	**82.6%**	**112,674**	**85.0%**
Salaried Labour	6,454,459	73.0%	299,157	60.5%	21,449	16.2%
Per-Dime & Travel Allowances	10,189	0.1%	2,734	0.6%	1,372	1.0%
Vaccines	988,318	11.2%	0	0.0%	0	0.0%
Vaccine Injection & Safety Supplies	70,373	0.8%	0	0.0%	0	0.0%
Other Supplies	14,061	0.2%	3,663	0.7%	2,951	2.2%
Transportation/fuel	67,728	0.8%	16,179	3.3%	212	0.2%
Vehicle maintenance	7,998	0.1%	24,616	5.0%	1,894	1.4%
Cold Chain energy	29,478	0.3%	15,169	3.1%	3,270	2.5%
Printing	50,310	0.6%	2,484	0.5%	6,052	4.6%
Utilities and communications	416,333	4.7%	43,461	8.8%	16,892	12.7%
Other recurrent	28,609	0.3%	670	0.1%	58,582	44.2%
Capital cost	**705,100**	**8.0%**	**86,202**	**17.4%**	**19,815**	**15.0%**
Cold chain equipment	74,951	0.8%	16,356	3.3%	4,725	3.6%
Vehicles	55,437	0.6%	8,540	1.7%	2,298	1.7%
Other equipment	174,734	2.0%	19,360	3.9%	2,127	1.6%
Building	399,971	4.5%	41,954	8.5%	10,665	8.0%
TOTAL	**8,842,957**	**100.0%**	**494,335**	**100.0%**	**132,489**	**100.0%**

Table 18: Economic cost and cost profile of the national immunization program

Item	Facility level		Facility+District level		Facility+District+National level	
	Total Cost $US	% of total cost	Total Cost $US	% of total cost	Total Cost $US	% of total cost
Recurrent cost	**8,137,856**	**88.7%**	**408,134**	**76.1%**	**112,674**	**79.3%**
Salaried Labour	6,454,459	70.3%	299,157	55.8%	21,449	15.1%
Per-Dime & Travel Allowances	10,189	0.1%	2,734	0.5%	1,372	1.0%
Vaccines	988,318	10.8%	0	0.0%	0	0.0%
Vaccine Injection & Safety Supplies	70,373	0.8%	0	0.0%	0	0.0%
Other Supplies	14,061	0.2%	3,663	0.7%	2,951	2.1%
Transportation/fuel	67,728	0.7%	16,179	3.0%	212	0.1%
Vehicle maintenance	7,998	0.1%	24,616	4.6%	1,894	1.3%
Cold Chain energy	29,478	0.3%	15,169	2.8%	3,270	2.3%
Printing	50,310	0.5%	2,484	0.5%	6,052	4.3%
Utilities and communications	416,333	4.5%	43,461	8.1%	16,892	11.9%
Other recurrent	28,609	0.3%	670	0.1%	58,582	41.2%
Capital cost	**1,040,066**	**11.3%**	**128,270**	**23.9%**	**29,389**	**20.7%**
Cold chain equipment	91,483	1.0%	19,946	3.7%	5,792	4.1%
Vehicles	65,047	0.7%	14,598	2.7%	2,804	2.0%

Other equipment	191,377	2.1%	21,137	3.9%	2,336	1.6%
Building	692,158	7.5%	72,590	13.5%	18,457	13.0%
TOTAL	**9,177,922**	**100.0%**	**536,404**	**100.0%**	**142,063**	**100.0%**

Discussion

The study helped estimate average unit cost per dose delivered in 2011 which amounted to 18.3 $US and cost per FIC - 316.6 $US. Our study shows that the labour inputs are significant contributor to a unit cost and consequently to the overall immunization program cost. These findings are comparable with the evidence documented elsewhere - immunization program being labour intensive [30],[12][31].

We also found that total cost as well as unit cost of service provision differs by facility type, by facility scale and by urban-rural location, although in a latter case influence is only obvious when shared human resource costs are not accounted in a unit cost. From all of these factors facility scale have strongest influence on the total unit cost of service provision, which is similar with the available global evidence that scale of immunization services has strong and negative relationship with the unit cost of service provision [9],[32] which means that facilities with a greater scale are able to deliver service more efficiency, by using available inputs more effectively and therefore reducing costs per unit of output. Consequently, increasing scale of a facility (by merging smaller ones into bigger if at all possible) could help reduce the program costs.

Furthermore, unit cost of service provision varies between facility types and mainly due to observed differences in using capital and human resources. Smaller facilities are using capital less effectively compared to larger ones. And amount of staff time spent on delivering a dose of vaccine reveals strong correlation with the type of a facility. Namely in smaller/rural facilities staff tend to spend more time on delivering a dose of a vaccine than in bigger facilities, which is obviously indicative of a variable productivity of employed staff by a facility type. This could be determined by numerous factors, such as size and/or density of a population in a catchment area, staff quality (nurses vs. doctors), management capacity i.e. availability of immunization plans and supervisory visits [33] [34] etc. The recent study conducted by the WHO [35] in Moldova showed that staff in rural PHC facilities could be overstretched serving approximately 16.9 patients a day and spending on average 42.4 hours at work. Consequently, higher amount of time spend by the staff of small facilities on immunization is indicative that with new vaccine introduction it might become necessary to increase number of FTEs on a PHC level, unless staff productivity is increased with the help of different tools. As we observed, close to 33-34% of time spent by the staff on HO and FDO level are taken by HMIS and program management. Moldova currently is designing e-health system for primary health care, which could (or should) include the modules for the immunization. However, this module should be designed in a way that it reduces demand on staff time while collects all necessary data need for adequate management of immunization services on a facility level.

Our study also documented that not only costs are different by facility type but also facility performance, measured with the help of DPT3 rate, is different. Based on our analysis we can hypothesize that facility characteristics as well as facility's management performance may have influence on achieved DPT3 coverage rates. However, available literature also proves that immunization coverage rates are also related to socio-economic and education status of the population [36][37][38]proximity to health facility [39][40], etc. Therefore, the factors determined by our bi-variate analysis will not be sufficient to establish causal links with the facility productivity and costs unless other determinants related to the environmental context (e.g. population or geography characteristics) are as well evaluated in a multivariate model.

We have also seen that Moldova achieves high immunization coverage rates compared to other countries in the region [41]. However, differences exist when coverage rates are looked at by facility level. Namely, HOs, that are equipped only with nurses and located in rural areas, show the lowest performance – 90.2%. However, due to very small number of infants - 7 (95%CI: 6.7-7.9) in the catchment population of these facilities this low coverage translates into at most one child had missed its DPT3 dose, which could be due to numerous objective or subjective reasons. Therefore, trying to increase coverage in rural facilities most likely will be more costly and marginal impact on the overall program performance could be minimal due to low number of children covered by these facilities. Consequently in the Moldovan context it seems more appropriate to place more importance on FMCs, where DPT3 coverage is second lowest after HOs – 92.7%. Improving performance of these facilities seems more feasible due to their staffing patterns and resources available, it could be less costly due to lowest cost per dose delivered and per FIC and overall impact on the national program performance is expected to be greater. However, this strategy may raise equity concerns with regards to rural areas - HOs. To mitigate these concerns it seems possible to mostly focus efforts on significantly underperforming rural facilities, where DPT3 coverage rates are below 80% and provide supportive supervision or other assistance that will be necessary.

Finally the unit costs per dose (without shared labour costs) captured in our study were comparable only with findings from selected countries Columbia (2009) - 3.95$, Morocco (2009) – 7$. Also there were other studies that estimated significantly lower costs per dose delivered e.g. Gambia (1980-1981) – 1.09-1.75$, Peru (2001) 1.5-3.2$, Viet Nam (2005) - 0.7$, Ethiopia – 0.5$, etc. and others higher costs e.g. Mexico -15$. However, lack of details about the costs included in these estimates and for which vaccines makes such comparisons meaningless. Therefore, it would be more informative to compare our findings with those documented by other studies supported by the Bill and Melinda Gates Foundation, which used similar methodology and therefore offer greater potential for meaningful comparisons.

Comparison of Financial Flows with updated cMYP

Estimates of the immunization program costs were compared with the cMYP[8], which shows that in 2011 total immunization program cost was approximately $ US 1.6 million higher than projected in the cMYP. This difference was mainly due to underestimating shared costs, especially shared personnel costs, which drive this difference. Considering the fact that shared personnel costs may have imposed bias in the study we also compared estimated costs without shared personnel costs with those provided in the cMYP for 2011 and difference between study estimates and cMYP projections equalled to $ US 390,641 (see Table 19).

Table 19: The comparison of line items between cMYP and the costing study

Line items	cMYP	Costing study	Variance
Routine Recurrent Cost			
Vaccine costs	1,068,849	988,318	8%
Vaccine Injection & Safety Supplies[9]	158,670	72,333	119%
Salaries of full-time NIP health workers	273,784	320,606	-15%
Per-diems	14,676	14,295	3%
Transportation cost[10]	141,093	42,901	229%
Maintenance and overhead[11]	1,269,942	524,959	142%
Trainings	18,824	29,399	-36%
Social mobilization	23,531	3,981	491%
Disease surveillance	43,044	5,594	669%
Program management	42,355	125,400	-66%
Other cost		692	-100%
Subtotal	**3,054,767**	**2,128,478**	**44%**

[8] The cMYP for 2011-2015 was developed in 2010, therefore the cost of the immunization program for 2011 is not actual cost; it is a projection. Cost projection was made based on 2009 data.

[9] Vaccine injection and safety supplies includes also printing cost of vaccination cards

[10] Transportation cost includes both fuel cost and vehicle maintenance cost

[11] Building overhead cost includes cold chain energy and maintenance cost as well

Capital Cost			
Vehicles	6,478	66,275	-90%
Cold chain equipment cost	127,173	96,032	32%
Other capital equipment cost	19,760	196,221	-90%
Buildings	163,138	452,590	-64%
Subtotal	**316,549**	**811,118**	**-61%**
Shared Cost			
Shared personnel costs	4,433,533	6,454,459	-31%
Shared transportation cost	34,627	75,727	-54%
Subtotal	**4,468,180**	**6,530,186**	**-32%**
Total immunization program cost with shared health system costs	**7,839,496**	**9,469,781**	**-17%**
Total immunization program cost without shared personnel costs	**3,405,963**	**3,015,322**	**13%**

Personnel cost: In the cMYP facility level personnel costs includes only the salaries of nurses and doctors while salaries of other personnel such as managers of primary health care facilities, drivers and others are not considered. Our costing study revealed that PHC facility managers are in charge of organizing and managing immunization provision, they participate in planning meetings as well as attend immunization related trainings; drivers are involved in vaccine collection and distribution; therefore, we considered costs associated with these personnel in our costing study estimates.

Vaccine and injection supply: In the cMYP cost of vaccines and injection supplies for 2011 were calculated based on projected number of newborns, planned target for immunization coverage and planned wastage targets for each vaccine. We estimated cost of vaccines and injection supplies based on actual number of vaccines and injection supplies used in 2011.

Vehicles: Cost of vehicles for a facility level is not included in the cMYP estimates, although our study considers cost of vehicles for all three levels. If only district and national level vehicle costs were to be considered the difference between cMYP and our study estimates would be 4,340 USD.

Other equipment: Costs of other equipment (desktops, laptops, furniture and etc.) on a facility level are not included in the cMYP calculations, while our costing tools allowed capturing these costs as well.

Cold chain equipment cost: Based on the cMYP, procurement of additional cold room for the national level and 45 new refrigerators for district level was planned in 2011, although no additional cold chain equipment was actually purchased.

Comparison reveals some differences in assumptions used in the cMYP and our costing study: Following differences should be underlined:

Vehicle maintenance: In the cMYP 15% of fuel cost is used to estimate vehicle maintenance. This study estimates vehicle maintenance costs more directly. We estimated total vehicle maintenance costs per facility (per district) and multiplied by the share of km travelled for routine immunization related activities. According to our costing study, vehicle maintenance cost in 2011 was 12% of fuel cost.

Cold chain maintenance: The cMYP Guidelines estimates cold chain operation and maintenance as 5% of the capital cost of equipment. In the costing study the cold chain maintenance cost includes energy costs required to run the cold chain as well as the cost of repairs and spare parts. Our costing study revealed that cold chain maintenance cost in 2011 was only 0.4% of the cold chain costs.

Surveillance cost: a comprehensive analysis of surveillance costs were beyond the scope of this study. The study focused only on: a) estimating the value of activities related to case detection and outbreak response; b) estimating the proportion and value of time spent on a facility, district, and national levels on surveillance activities and c) estimating transportation/fuel costs for surveillance activities. Costs of laboratory services and the cost of capital equipment for surveillance were not estimated; therefore surveillance costs are underestimated in our study.

This comparison reveals weaknesses of the cMYP costing tool, which in some instances significantly underestimates costs and in the other overestimates. Consequently different approach/methodology might be warranted to address these weaknesses on a regional and global level if cMYPs will continue to be a planning tool for immunization services and for GAVI support.

Conclusions

The findings of our study are useful in informing policy discussions within Moldova that are focused on increasing immunization coverage and increasing efficiency of the immunization program performance.

Looking at the costs of immunization on a facility level we could conclude:

1. Due to the fact that facility performance is multidimensional phenomenon it becomes necessary to evaluate influence of different factors on a facility productivity and costs using more complex multivariate regression models and including not only facility specific characteristics and its inputs, but also factors characterizing demand side aspects and related to a population in a catchment area. Only such analysis will permit to better understand drivers of costs and productivity on a facility level and identify those key factors, which could be acted on by a facility and immunization program managers to improve immunization performance and/or to reduce service delivery costs. Furthermore, this knowledge could help inform global policies aimed at improved immunization program performance in other parts of the world.
2. Financial flow analysis and its comparison with the updated cMYP reveal significant discrepancies, underlying weaknesses and inadequacy of assumptions, used for multi-year financial planning for immunization services. Therefore, it becomes important to enrich current planning tools on a country, regional and global level, with more detailed costing data obtained from a country level and/or with better benchmarks, which could be used for the planning nationally, regionally or globally and which will help achieve better precision in financial estimates needed for scaling-up of immunization services.
3. The government of Moldova is focusing on increasing health system efficiency through various means, including infrastructure optimization. Our study findings confirm that immunization services are labour intensive and significant costs on a facility level arise due to cost of human resources. Reducing staff time spent on immunization could help increase efficiency of the program. This objective could be achieved either through task shifting[12] i.e. delegating certain immunization related tasks from doctors to nurses, or through reducing time spend on management and/or record-keeping functions. The latter could be achieved with the help of information technology, which is currently being developed for the HMIS. Adequate modules for immunization program planning and management along with the modules for record keeping offer potential for reducing staff time spent on these functions, conditioned that PHC modules of the HMIS are developed with this objective in mind.

[12]Task shifting is the name given to a process of delegation whereby tasks are moved, where appropriate, to less specialized health workers. By reorganizing the workforce in this way, task shifting presents a viable solution for improving health care coverage by making more efficient use of the human resources already available.

4. Further increasing DPT3 coverage in Moldova could be challenging task as the coverage levels are already high. But if government decides to further improve program performance, instead of focusing on HOs, the focus could be maintained on FMCs where current coverage rates are relatively lower – 92.7% and potential for increasing DPT3coverage is greater, which could be achieved at a lower cost.
5. Finally, after graduating from the GAVI Moldova is considering reforming its immunization program and decentralizing vaccine procurement responsibilities due to specificity of the national health care financing system and due to rules embedded in the national legislation. Our study shows that the cost of vaccines is critical element of the immunization program. Therefore centralized model for vaccine procurement seems to be more effective and decentralization of this function may drive vaccine prices up and could increase overall program cost.

Analysis of Financial Flows for the Routine Immunization

Background

In this section of the report we describe financial flows for the routine immunization, which looks at sources and uses of funds using health accounting approaches suggested by the OECD, Eurostat and WHO [42]. A *System of Health Accounts* (SHA) provides a framework for the systematic description of financial flows related to health care. The aim of our analysis was to describe the national immunization program from an expenditure perspective both for international and national purposes. Therefore our study looked at a funding flow for immunization services during 2011, which helped estimate amount of funds provided by the different national and external sources; amount of funds managed by the different financing agents within and outside of the country; funds spent on a provider level by a type of a provider, by function and by type of inputs. All amounts were estimated in a current 2011 $US using average annual exchange rates [43] to convert different currencies into $US.

Methods

For the financial flow analysis, the study looked at the overall health care financing system of the country [44] to understand funds flow and key players in the system, which helped understand and describe funding flow for immunization services.

Furthermore in our analysis we only looked from an expenditure perspective and separated funds flow in two broad categories: a) the funding flow, which could be directly attributed to the immunization services and explicitly traced through public finance system, e.g. vaccine and consumable purchase, direct financial support provided by external donors, etc. The information about these flows was sourced from various reports and through in-depth interviews with the key informants and b) a financial flow, which is not explicitly traceable through public finance management system, but is related to immunization services, e.g.: financing shared human resource costs, or paying for utility costs, or paying for cold chain maintenance, etc. These flows were estimated with the help of a facility survey. Using statistical weights, imputed in the survey dataset, the results from sampled facilities were scaled-up on a national level and consequently national level estimates were produced.

All individual expenditure estimates, generated by the study, were computerised in an Excel™ software and coded using internationally provided guidance [42] as well as using common principles developed by the study team. Consequently following classifications were used to code expenditure (for more details see Annex 6)

Classification of types of revenues of health financing schemes (FS) i.e. funding sources;

- Classification of financing schemes (HF);
- Classification of financing agents (FA);
- Classification of health care providers (HP);
- Classification of health care functions (HC);
- Classification of factors for health care provision (FP)

Using pivot table function in Excel™, two dimensional expenditure tables were generated, which are detailed later in this report.

Results

Funds Flow for Immunization Services

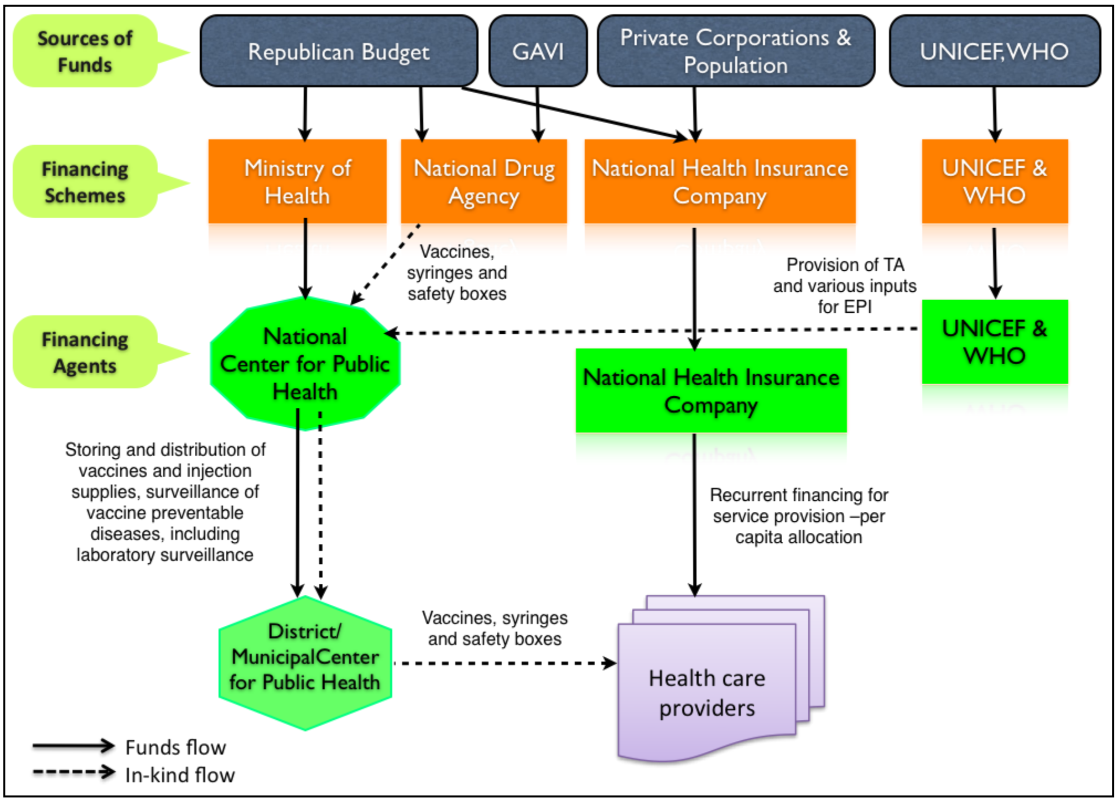
Overall funding for immunization services amounted to 8,814,053 $US during 2011, which is almost 1.15 million[13] more than originally planned (secure and probable funds) by the

[13] For financial flow analysis economic costs, estimated by the study, were excluded from total costs.

government in the *Comprehensive Multi-Year Plan* (cMYP) [2]. The largest share - 94.8% came from national sources (state budget -54% and mandatory health insurance contributions from corporations and households – 46%[14]). External sources collectively contributed only 5.2% and this was shared by GAVI 4.5%, by UNICEF - 0.2% and WHO - 0.5%. These estimates are comparable with projections for 2011 included in the cMYP where 92% of revenues were planned from national sources and 8% were budgeted for external sources.

Out of the total amount spent on immunization in 2011 the *National Health Insurance Company* (CNAM[15]) managed 80.3% of funds and primarily paid for recurrent expenses on a facility/provider level, 18.9% of funds were managed by the National Centre for Public Health and were primarily used for the NIP management, storage and distribution of direct inputs, e.g. vaccines, injection supplies and safety boxes. Portion of these funds also paid for surveillance of vaccine preventable disease and for trainings. The UNICEF and WHO managed only 0.2% and 0.5% of funds, respectively. These funds were primarily used for technical assistance and some other inputs for immunization services (see Figure 11 for schematic presentation of funds flow).

Figure 11 Funds flow for immunization services 2011



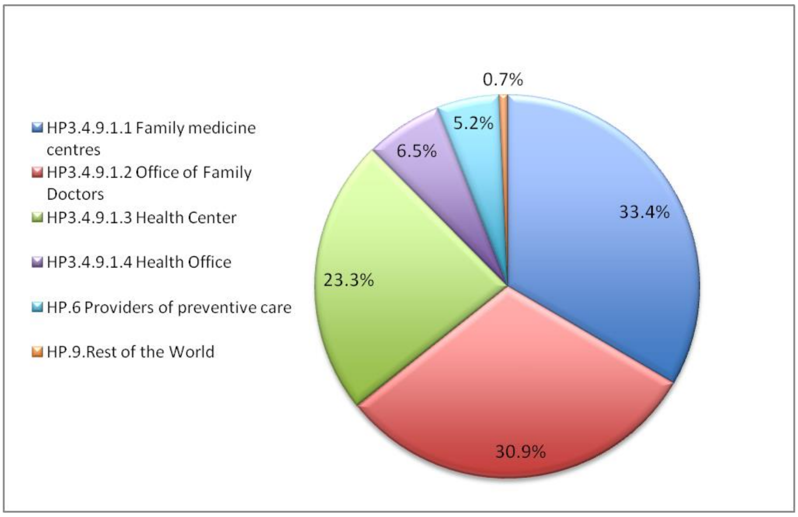
Funds flow on a provider level

Based on the funding flow analysis FMCs consumed the largest amount of funds – 33.4%, followed by offices of family doctors – 30.9% and health centres – 23.3%. The amount of funds spent on health offices was the lowest – 6.5%, because the volume of immunizations services (number of doses administered) offered by these facilities is the lowest. National and municipal/district public health centres spent only 5.2% of immunization funds and amounts administered by the WHO and UNICEF did not exceed 0.7%.

[14] Breakdown of revenues of the National Health Insurance Company received from the state budget and from private contributions were sourced from the National Health Accounts 2011 for Moldova. Similar breakdown was used to apportion revenues for immunization services from public and private sources.

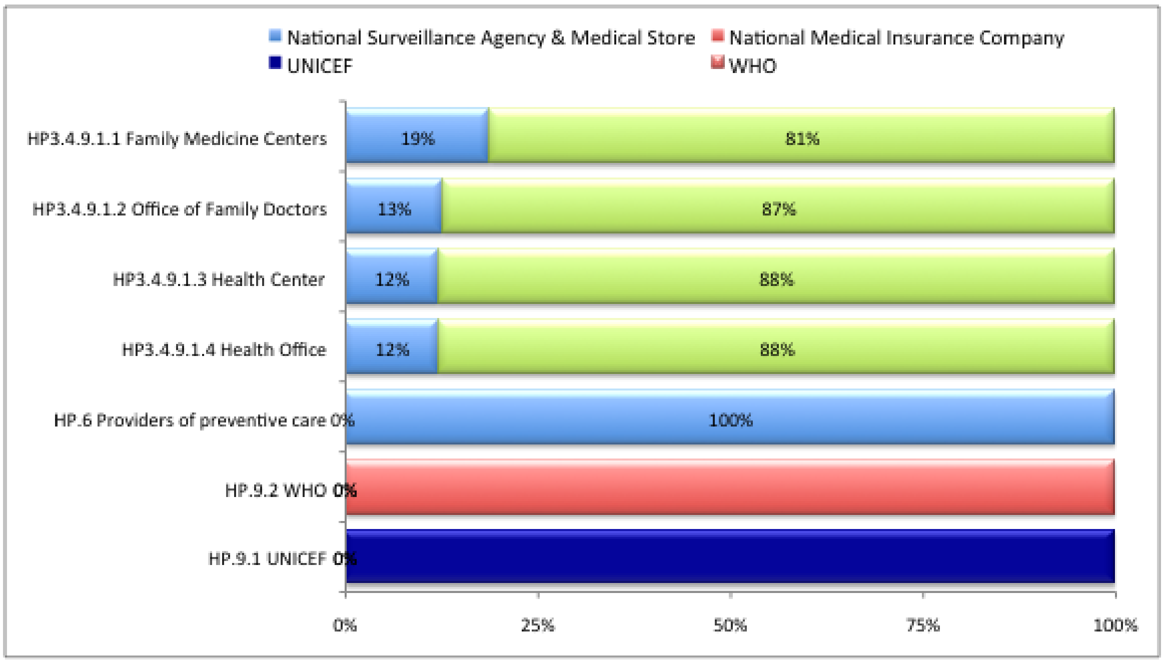
[15] Compania Nationala de Asigurari in Medicina

Figure 12 Funds flow on a provider level



Analysis also showed that major financier of a PHC care provider was CNAM, which provided 81-88% of the funds used for the immunization services. National and municipal/district public health centres solely depended on the funding from the state budget channelled through the MoH and the National Centre for Public Health. And the funds provided by the WHO and UNICEF were mainly used by their offices and did not reach a provider level (see Figure 13), with the exception of in-kind inputs.

Figure 13 Funds flow financing agents by providers



Financing of Immunization Functions

Analysis of funds flow by functions revealed that most funds are being spent on a facility-based immunization service delivery - 41%, followed by the program management – 18%. Record keeping & HMIS[16] and social mobilization have absorbed 14% and 12% respectively. The amount of funds spent on all other functions was 4% or below. For more details please see Table 20.

Table 20 Funding levels for different functions by a provider =100%

[16] HMIS denotes health management information system

Function / Provider	Social mobilization, advocacy	Facility-based routine immunization service delivery	Training	Vaccine collection, storage and distribution	Cold chain maintenance	Program Management	Supervision	Other routine immunization program activity	EPI Surveillance	Record-keeping and HMIS	Not disaggregated	Grand Total	Total $US
FMC	14%	42%	4%	1%	1%	20%	3%	0%	0%	15%	0%	**100%**	**2,948,758**
OFD	14%	47%	4%	4%	3%	17%	1%	0%	0%	11%	0%	**100%**	**2,719,876**
HC	12%	39%	4%	3%	2%	20%	3%	0%	0%	16%	0%	**100%**	**2,053,244**
HO	11%	51%	4%	5%	2%	14%	1%	0%	0%	11%	0%	**100%**	**571,368**
Providers of preventive care	1%	4%	5%	22%	9%	20%	11%	1%	12%	14%	0%	**100%**	**454,427**
UNICEF	22%	0%	0%	0%	0%	0%	0%	0%	0%	0%	78%	**100%**	**18,165**
WHO	0%	0%	3%	0%	0%	0%	0%	0%	9%	0%	88%	**100%**	**48,215**
Grand Total	**12%**	**41%**	**4%**	**4%**	**2%**	**18%**	**3%**	**0%**	**1%**	**14%**	**1%**	**100%**	**8,814,053**

These averages hide marked differences that emerge between types of medical providers. PHC providers spend comparable shares on similar functions and, as expected, providers of preventive care i.e. national and district/municipal centres of public health reveal different spending patterns by functions. Most resources at these facilities are spent on vaccine collection, storage and distribution 22% followed by program management -20% record keeping & HMIS -14% EPI surveillance-12%, supervision 11%, and cold chain maintenance – 9%. The amount of funds spent on all other functions was below 5%. For more details please see Table 20.

Funding inputs for immunization services

Funds spent on various inputs were analyzed in order to understand the level of resource consumption by the immunization services. The analysis revealed that the largest amount is being spent on wages and salaries that have consumed on average 77% of all funds dedicated for immunization or 6.78 million $US out of 8.81 million $US. Vaccines and syringes absorbed 14% of funds and the remaining 9% was spent on other inputs detailed in Table 21. Largest amount of vaccine & syringe inputs were spent on FMC level – 45%, followed by the offices of the family doctors – 28% and the health centres – 20%. Health offices being the smallest providers of immunization services consumed the least amount – 6% (see details in Table 22).

Furthermore, direct inputs related to the immunization program (i.e. vaccines & syringes, transport, maintenance, printing and other inputs) consumed only 25.9% of funds or 2.28 million $US while the rest – 74.1% were used to fund shared health system costs.

While the role of the external funding sources in funding immunization services is marginal – 5.2% (see earlier in this report), when external funding is related to only direct immunization inputs their share increases up to 20% and especially GAVI inputs amount to 17% of direct inputs necessary for the immunization program.

Table 21 Funding levels for different inputs by a provider = 100%

Provider \ Input/Factor	FP.1.1 Wages and salaries	FP.1.3.1 Per diem	FP.3.2 Vaccines & syringes	FP.3.3.1 Transport	FP.3.3.2 Maintenance	FP.3.3.3 Printing	FP.3.4.1 Utilities and communications	FP.3.4.2 Other	FP.9.9 Not disaggregated	Grand Total
HP3.4.9.1.1 Family Medicine Centers	76%	0%	19%	0%	0%	1%	3%	0%	0%	**100%**
HP3.4.9.1.2 Office of Family Doctors	79%	0%	13%	1%	0%	0%	7%	0%	0%	**100%**
HP3.4.9.1.3 Health Center	80%	0%	12%	1%	0%	1%	5%	0%	0%	**100%**
HP3.4.9.1.4 Health Office	74%	0%	12%	3%	0%	0%	10%	0%	0%	**100%**
HP.6 Providers of preventive care	71%	1%	1%	4%	6%	1%	17%	0%	0%	**100%**
HP.9.1 WHO	0%	0%	0%	0%	0%	22%	0%	0%	78%	**100%**
HP.9.2 UNICEF	0%	3%	5%	0%	0%	0%	0%	9%	83%	**100%**
Grand Total	**77%**	**0%**	**14%**	**1%**	**0%**	**1%**	**6%**	**0%**	**1%**	**100%**

Table 22 Funding levels for different inputs =100% by a provider

Provider \ Input/Factor	FP.1.1 Wages and salaries	FP.1.3.1 Per diem	FP.3.2 Vaccines & syringes	FP.3.3.1 Transport	FP.3.3.2 Maintenance	FP.3.3.3 Printing	FP.3.4.1 Utilities and communications	FP.3.4.2 Other	FP.9.9 Not disaggregated	Grand Total
HP3.4.9.1.1 Family Medicine Centers	33%	13%	45%	10%	3%	55%	19%	39%	0%	**33%**
HP3.4.9.1.2 Office of Family Doctors	32%	28%	28%	33%	9%	3%	34%	26%	0%	**31%**
HP3.4.9.1.3 Health Center	24%	18%	20%	17%	11%	28%	21%	16%	0%	**23%**
HP3.4.9.1.4 Health Office	6%	12%	6%	20%	0%	0%	11%	4%	0%	**6%**
HP.6 Providers of preventive care	5%	19%	0%	19%	77%	8%	15%	2%	0%	**5%**
HP.9.1 WHO	0%	0%	0%	0%	0%	7%	0%	0%	26%	**0%**
HP.9.2 UNICEF	0%	10%	0%	0%	0%	0%	0%	13%	74%	**1%**
Grand Total (%)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Grand Total $US	**6,775,065**	**14,295**	**1,234,755**	**84,119**	**34,508**	**58,846**	**524,603**	**33,697**	**54,164**	**8,814,053**

Conclusions

Presented analysis shows that funding estimates for the immunization program in Moldova obtained through this study were 8.81 $US million, which amounts to approximately 1.27% of the *Total National Health Expenditure* for 2011 or 2.4% of recurrent public financing for health[45]. This estimate is 15% higher than the secured and probable funds estimated in the cMYP for 2011. The largest difference arises from overestimating "Routine Recurrent Costs" in the cMYP and significant underestimation of the "Shared Health Systems Costs" primarily through undervaluation of human resource inputs on a provider level. With regards to the role of different funding sources in financing national immunization program the cMYP and the study estimates were comparable (see Table 23 for more details).

Table 23 Comparison of study estimates with cMYP projections for 2011[17]

Cost Category	cMYP Estimates for 2011	Study Estimates for 2011	Variance between cMYP and Study Findings
Routine Recurrent Costs	**US$**	**US$**	**US$**
Vaccines & Injection supplies	1,227,519	1,221,937	5,582
Personnel			
Salaries of NIP health workers (immunization specific)	273,784	320,606	(46,822)
Per-diems for supervision and monitoring	14,676	14,295	381
Transportation	141,093	42,901	98,192
Maintenance and overhead	1,269,942	524,959	744,983
Short-term training	18,824	29,399	(10,575)
IEC/social mobilization	23,531	3,981	19,549
Disease surveillance	43,044	5,594	37,450
Program management	42,355	119,504	(77,149)
Subtotal	**3,054,767**	**2,283,176**	**771,591**
Routine Capital Costs			
Vehicles	10,000	0	10,000
Cold chain equipment	65,943	0	65,943
Other capital equipment	57,000	0	17,000
Subtotal	**132,943**	**0**	**132,943**
Shared Health Systems Costs			0
Shared personnel costs	4,433,553	6,454,459	(2,020,906)
Shared transportation costs	34,627	75,727	(41,100)
Other	0	692	(692)
Subtotal Optional	**4,468,180**	**6,530,878**	**(2,062,698)**
GRAND TOTAL	**7,655,889**	**8,814,054**	**(1,158,164)**
Sources of Funds			
National sources	**90.8%**	**94.8%**	(4.0%)
External (secure and probable)	**9.2%**	**5.2%**	4.0%
From GAVI	7.8%	4.5%	3.3%
From WHO	1.3%	0.2%	1.1%
From UNICEF	0.1%	0.5%	(0.4%)

Cost of vaccines estimated through facility survey was 1,058,706 $US while financial flow analysis estimates these costs at 1,221,937 $US, which renders difference of 15.4%, maybe due to the fact that cost of a buffer stock was not captured by the facility level costing study.

Furthermore, while the role of the external sources in the overall funding for the national immunization program is marginal – 5.2%, when external funding is related to only direct immunization inputs their share increases up to 20% and especially for the GAVI inputs they reach 17%. This share is expected to grow significantly during 2012 and 2013 when new vaccines are introduced and are expected to significantly increase pressure on the national

[17] This comparison implies some methodological limitations because cMYP costing tool mixes inputs and functions in a spreadsheet, while SHA approach used in the study separately accounts for inputs and separately for functions. However on major line items the comparison renders valid estimates.

budget when Moldova graduates from GAVI in 2016. This pressure will be further aggravated by concurrent graduation from the Global Fund, which currently provides funding for most TB and HIV/AIDS inputs. Based on preliminary estimates provided in the *Medium Term Budgetary Framework for 2014-2016*, Moldova expects that graduation from the GAVI and the Global Fund will increase demand for national public health budget 2.45 times in 2016 compared to 2011 levels [46]. Due to limited fiscal space and weak economic growth prospects for the same period, this could pose significant challenges for the government during coming years and may put at risk adequate financing of the immunization, TB and HIV/AIDS programs.

In light of this it is thought that when the GAVI and Global Fund boards determine graduation policies, it should not be only linked to a country GNI, as this trigger sudden and simultaneous graduation from donor support and places challenges for fiscally constrained governments to pick up the price tag of donor funded programs. Such graduations run the risk of inadequate financing from national budgets since graduation, and entails risks of negatively affecting public health achievements realised with the help of GAVI and Global Fund. Consequently, it seems more appropriate for the GAVI and Global Fund to develop phasing out plans for each country in a more coordinated manner, considering different factors and not only GNIs, and while implementing these plans helping health and finance sectors of a country to gradually transition towards the national funding. Such approach seems to have better potential for obtaining durable public health impacts.

Cost Analysis of New Vaccine Introduction

Incremental Costs for NUVI on a Facility Level

The study also looked at *New Vaccine Introduction* (NUVI) costs, using the methodology described earlier. Incremental costs were estimated on a facility, district and national level. We looked at financial costs, cash flow, and economic costs with and without cold chain and staff salaries. Using the total cost of Rotavirus vaccine introduction we derived costs per unit of output, which are detailed in Table 25 below.

On average cash flow per unit of output was 7% higher than financial costs, economic costs that include the cost of additional shared labour were 20% higher when compared to financial cost and economic costs that also accounted for additional cold chain space were 26% higher.

Table 24 Total Incremental Rota virus vaccine introduction costs

Dimension	Financial cost ($US 2012)	Cash Flow ($US 2012)	Economic cost (without Cold Chain)	Economic cost (including Cold Chain)
Average facility cost without vaccines	3.1	4.8	43.6	56.1
Average Rota vaccine cost per facility	193.4	193.4	193.4	193.4
Shared staff salary costs per facility			38.9	38.9
Average Cold Chain Costs per Facility				12.6
Total number of facilities	1318	1318	1318	1318
Total facility level cost without vaccines	**4,080**	**6,269**	**108,707**	**141,810**
Total facility level cost with vaccines	**258,981**	**261,170**	**363,608**	**396,711**
Mean district cost without vaccines	43.6	66.4	108.1	232.0
Number of districts	37	37	37	37
Total district cost without vaccines	**1,613**	**2,458**	**3,998**	**8,584**
National level cost without vaccines	**118,219**	**142,660**	**87,550**	**72,385**
Total National Rota Introduction Cost	**378,813**	**406,288**	**455,156**	**477,680**

As stated earlier, introduction of Rotavirus vaccine in Moldova did not require purchase of additional cold chain, because the country had spare capacity and neither additional staff was added on a facility level to meet increased service delivery needs. Therefore, financial implication of the Rota virus vaccine introduction in Moldova was marginal and recurrent financial costs of the Rotavirus vaccination resulted only in additional 378.8 thousand $US on top of the routine immunization program costs. Due to investments required in staff training and other systems, start-up cash flow needs were some 27.5 thousand $US more than would be required for routine maintenance of Rotavirus vaccination.

However, had Moldova needed additional cold chain and/or staff to deploy new vaccines in the system, these costs would have increased by almost 26% to pay for additional staff salaries as well as for additional cold chain equipment. Out of total incremental financial cost of a rota virus vaccine introduction only 123, 912 $ was spent on immunization delivery costs and the rest was used for vaccine procurement.

Unit cost analysis showed that incremental financial cost of delivering Rotarix™ was 4.95$US per dose and 9.96$US per infant in the birth cohort. However, close to 65% of these financial costs were due to vaccines and only 35% were pure delivery costs (see Table 25 for details).

Economic costs per unit of output (with vaccine costs) were 52% higher over comparable financial costs, because they account for annualized costs of additional staff time at the facility and district levels and cold chain. Namely, cost of delivering a single dose of vaccine increases up to 7.48 $US and cost per infant up to 15.20 $US. Health system related vaccine delivery economic costs were found to be 4.29$ per dose and 8.76$ per infant (see Table 25).

Table 25: Incremental unit costs for a rotavirus vaccine introduction

National level unit costs	Financial cost $US Mean (95% CI)	Economic cost $US Mean (95% CI)
Unit costs without vaccines		
Cost per dose delivered	1.76 (1.70 : 1.82)	4.29 (3.71 : 4.87)
Cost per infant	3.52 (3.40 : 3.63)	8.76 (7.48 : 10.04)
Unit costs including vaccines		
Cost per dose delivered	4.95 (4.82 : 5.08)	7.48 (6.89 : 8.07)
Cost per infant	9.96 (9.81 : 10.10)	15.20 (13.90 : 16.50)

These findings are important, for going forward. It is well know that over past three decades number of diseases that have respective vaccines have increased 2.5 times, consequently vaccine doses delivered to a child faced almost three fold increase. Consequently vaccine volumes required to fully immunize child have grown four times and now they require significant additional volumes in cold chain as well as greater logistical complexity [47].Furthermore, investments currently being made in a new product development are expected to bring more vaccines to the Global market and countries may start introducing more vaccines in their routine immunization calendars. Consequently more and more cold chain capacity as well as staff time on a primary care level will become necessary to cope with increased vaccine volumes as well as with increased vaccination time demands on a facility level. Therefore, the structure of economic cost estimates arising from this study might be helpful in estimating potential costs of NUVI for the countries in future.

While for Moldova the cost of Rota virus vaccine introduction is marginal because it only amounts to estimated financial costs, if other additional vaccines will be introduced in future the country may face significant additional costs, resulting from additional cold chain capacity and possibly from additional staff to cope with increased workload. It has to be noted that even now in Moldova human resources are thinly stretched on a PHC level, which has been captured by the WHO[18] and recommended increasing staff to cope with the workload. Therefore, any further introduction of a new vaccine will further aggravate relative HR shortages on a PHC level and will obviously demand more staff time and costs. In such a case estimates in this report will become instrumental.

Estimated incremental costs on a national level were further disaggregated by inputs on a facility, district and national level and are presented in Table 26 and Table 27. Further disaggregation by input and activities are provided in Annex 4.

[18] WHO 2012. Evaluation of the structure and provision of primary care in the Republic of Moldova. Republic of Moldova Health Policy Paper Series No. 5, Chisnau, Moldova

Table 26: Incremental financial cost and cost profile at a facility, district and national levels for NUVI

Item	Facility level		District level		National level	
	Total Cost $US	% of total cost	Total Cost $US	% of total cost	Total Cost $US	% of total cost
Recurrent cost	**258,947**	**100.0%**	**260,560**	**100.0%**	**373,529**	**98.6%**
Salaried Labour	-		-		12,324	3.3%
Per-Dime & Travel Allowances	-		**117**	0.0%	1,525	0.4%
Vaccines	**254,867**	98.4%	**254,867**	97.8%	254,867	67.3%
Transportation/fuel	**4,080**	1.6%	**5,576**	2.1%	8,221	2.2%
Cold Chain energy	-		-		-	
Printing					14,011	3.7%
Building overhead	-		-		29,771	7.9%
Other recurrent	-		-		52,812	13.9%
Capital cost			-		**5,250**	**1.4%**
Other equipment					5,250	1.4%
TOTAL	**258,947**	**100.0%**	**260,560**	**100.0%**	**378,779**	**100.0%**

Table 27: Incremental economic cost (with cold chain) and cost profile at the facility, district and national levels for NUVI

Item	Facility level		District level		National level	
	Total Cost $US	% of total cost	Total Cost $US	% of total cost	Total Cost $US	% of total cost
Recurrent cost	**312,303**	**95.0%**	**316,301**	**93.7%**	**432,479**	**90.5%**
Salaried Labor	51,327	15.6%	52,966	15.7%	65,451	13.7%
Per Diem & Travel Allowances	-	0.0%	221	0.1%	2,126	0.4%
Vaccines	254,867	77.5%	254,867	75.5%	254,867	53.4%
Transport/ Fuel	6,109	1.9%	8,247	2.4%	10,893	2.3%
Printing	-	0.0%	-	0.0%	15,339	3.2%
Building overhead, Utilities, Communication	-	0.0%	-	0.0%	29,771	6.2%
Other Recurrent	-	0.0%	-	0.0%	54,033	11.3%
Capital costs	**16,548**	**5.0%**	**21,134**	**6.3%**	**45,165**	**9.5%**
Cold Chain Equipment	16,548	5.0%	21,134	6.3%	22,524	4.7%
Other Equipment	-	0.0%	-	0.0%	22,641	4.7%
TOTAL	**328,851**	**100.0%**	**337,435**	**100.0%**	**477,645**	**100.0%**

Finally, Table 28 presents results of sensitivity analysis showing that one-dollar increase in the vaccine price translates into 2.1% increase in the overall cost per infant and doubling the prices results in 24.1% increase.

Table 28: Price influence on financial costs per infant (sensitivity analysis)

Price Change	Price per dose of Rotarix	Cost per Infant (Rotarix)	Price per dose of PCV-13	Cost per Infant (PCV-13)	Incremental cost per Infant (Rotarix + PCV-13)	Percent Change relative to 2011 Prices per Infant
Baseline price	*2.5*	*9.9*	*7*	*32.6*	*42.5*	*13.4%*
1$ increase in price	3.5	12.5	8	36.5	49.0	15.5%
2$ increase in price	4.5	15.1	9	40.4	55.5	17.5%
3$ increase in price	5.5	17.7	10	44.3	62.1	19.6%
4$ increase in price	6.5	20.3	11	48.2	68.6	21.7%

5$ increase in price	7.5	22.9	12	52.2	75.1	23.7%
6$ increase in price	8.5	25.5	13	56.1	81.6	25.8%
Double of the baseline price	**4.9**	**16.3**	**14**	**60.0**	**76.2**	**24.1%**

Funding NUVI

We also used financial flow analysis to understand sources and uses of funds for the NUVI in Moldova. The methodology for financial flow analysis was similar to the one used for the routine immunization program. The analysis showed that 77% of funds, needed for the NUVI came from GAVI, 10.5% from UNICEF and WHO and the government was only responsible for providing 12.5% of the funds necessary for the Rotavirus vaccine introduction (see Table 29). If the role of CNAM in the routine immunization program was significant for the NUVI the role of the National Public Health Centre became more paramount as they administered 96.1% of all resources and CNAM only managed 1.6%.

Table 29 Financial Sources for NUVI

Source / Financing Agent	GAVI	State Budget	UNICEF	WHO	Total $US	Percent
CNAM		6,372			6,372	1.6%
District Public Health Center		2,221			2,221	0.5%
National Public Health Center	312,711	42,307	18,842	16,785	390,645	96.1%
UNICEF			1,760		1,760	0.4%
WHO				5,357	5,357	1.3%
Grand Total $US	**312,711**	**50,900**	**20,602**	**22,142**	**406,355**	**100.0%**
Percent	77.0%	12.5%	5.1%	5.4%	**100%**	

Similar to the routine immunization, most of resources for the NUVI are being spent on an FMC level, and the least amount on HOs determined by scale of these facilities. As expected CNAM financing for the NUVI is only used on a medical provider level to finance transportation costs related to trainings and program management and resources from the National Public Health Centre are being used by medical providers as well as by providers of a preventive care (see Table 30 for details).

Table 30 Funding flow on a provider level

Financing Agent / Providers	CNAM	District Public Health Center	National Public Health Center	UNICEF	WHO	Total $US	Percent
Family Medicine Center	1,301		128,553			**129,854**	31.96%
Health Center	1,036		49,555			**50,591**	12.45%
Office of Family Doctors	2,816		62,929			**65,745**	16.18%
Health Office	1,219		13,831			**15,049**	3.70%
Providers of preventive care		2,221	135,778			**137,999**	33.96%
WHO					5,357	**5,357**	1.32%
UNICEF				1,760		**1,760**	0.43%
Grand Total $US	**6,372**	**2,221**	**390,645**	**1,760**	**5,357**	**406,355**	**100%**
Percent	1.6%	0.5%	96.1%	0.4%	1.3%	**100%**	

Table 31 below describes use of funds for a different function on a provider level and shows that 92-99% of funds on a medical provider level are being used for facility based services provision and marginal amounts are being spent on trainings. Providers of preventive care i.e. district and national level centres of public health are the ones to assume responsibility for following key functions and spent following amounts out of 137,999$US they received: social mobilization - 14%, cold chain maintenance – 4%, program management 57% and supervision – 3% and surveillance -12%. Finally Table 32 below describes use of funds for various inputs and once again highlights that 92-99% of funds for the NUVI on a medical provider level are being spent on vaccines and little portion 2-7% are used to finance transportation costs to training sites.

Table 31 Use of funds for various functions on a provider level

Provider / Function	Social mobilization, advocacy	Facility-based routine immunization service delivery	Training	Vaccine collection, storage and distribution	Cold chain maintenance	Program Management	Supervision	EPI Surveillance	**Percent**	**Total $US**
Family Medicine Center	0%	99%	0%	0%	0%	1%	0%	0%	**100%**	**129,854**
Health Center	0%	98%	2%	0%	0%	0%	0%	0%	**100%**	**50,591**
Office of Family Doctors	0%	96%	4%	0%	0%	0%	0%	0%	**100%**	**65,745**
Health Office	0%	92%	7%	0%	0%	1%	0%	0%	**100%**	**15,049**
Providers of preventive care	14%	9%	1%	0%	4%	57%	3%	12%	**100%**	**137,999**
UNICEF	0%	0%	100%	0%	0%	0%	0%	0%	**100%**	**5,357**
WHO	0%	0%	100%	0%	0%	0%	0%	0%	**100%**	**1,760**
Total Percent	**5%**	**66%**	**3%**	**0%**	**1%**	**20%**	**1%**	**4%**	100%	**406,355**

Table 32 Use of funds for various inputs on a provider level

Provider / Inputs	Wages and salaries	Per diem	Vaccines	Transport	Printing	Utilities and communications	Other	Other equipment	**Percent**	**Total $US**
Family Medicine Center	0.0%	0.0%	99.0%	1.0%	0.0%	0.0%	0.0%	0.0%	**100%**	**129,854**
Health Center	0.0%	0.0%	98.0%	2.0%	0.0%	0.0%	0.0%	0.0%	**100%**	**50,591**
Office of Family Doctors	0.0%	0.0%	95.7%	4.3%	0.0%	0.0%	0.0%	0.0%	**100%**	**65,745**
Health Office	0.0%	0.0%	91.9%	8.1%	0.0%	0.0%	0.0%	0.0%	**100%**	**15,049**
Providers of preventive care	8.9%	0.6%	0.0%	3.5%	9.1%	21.6%	37.3%	19.0%	**100%**	**137,999**
UNICEF	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	**100%**	**5,357**
WHO	0.0%	25.3%	0.0%	0.0%	56.0%	0.0%	18.7%	0.0%	**100%**	**1,760**
Total Percent	**3%**	**1%**	**63%**	**3%**	**4%**	**7%**	**13%**	**6%**	**100%**	**406,355**

Discussion of Results

Our study documented that incremental financial costs of a rotavirus vaccine introduction (without vaccines) amounted to 123,912$, out of which 100,000 $US was provided through GAVI grant and the rest financed by UNICEF and WHO. These findings may point to the adequacy of GAVI's vaccine introduction grant relative to the financial need of the country in a Moldovan case. However, incremental financial cost per infant (without vaccine) was estimated at 3.52$ which is 4.4 times higher than 80 cents established per infant under GAVI vaccine introduction grant policies [48].Consequently, adequacy of the introduction grant from GAVI for Moldova was only determined by small size of the birth cohort. Furthermore, as noted earlier costs in Moldova were low because the country had spare cold chain capacity on the national and district level and was able to meet increased vaccine volume needs without additional investments. It is well known that most countries face cold chain capacity constraints when they introduce new or underutilized vaccines [49]. Therefore it is expected that difference between GAVI established amount per infant – 80c under vaccine introduction grants and actual financial costs of delivering new vaccine per infant could be even greater in the countries that have bigger birth cohorts.

Our study estimated financial cost per infant to be 9.96$, when vaccine costs are considered. This translates into 3.1% increase over the cost per infant under the national immunization schedule, which was estimated at 316.6 $ in 2011. Our estimates for a rotavirus vaccine introduction were based on 2.5$ per dose of Rotarix™, currently being purchased through UNICEF with GAVI co-financing. In 2013 Moldova plans introducing pneumococcal (PCV-13) mono dose vaccine with GAVI assistance, although graduation is expected in 2016. Based on sensitivity analysis, this may result in cost increase per infant by another 10.3%[19]. Therefore, 13.4% gradual increase in the total cost of delivering immunization services, which is expected to occur over 2013-2016, seems affordable in the current fiscal context where immunization program accounts to only 2.4% of the recurrent public financing for health and is comparable to the levels found elsewhere [50]; [51].However, after GAVI graduation vaccine prices are expected to increase because of the national public procurement rules, which mandate local tendering[20] and as a consequence for all non-UNICEF supplied vaccines Moldova pays almost twice the UNICEF price [6]. Also it is estimated that every dollar increase in vaccine price may result in 2.1% increase of immunization costs and doubling the vaccine price will demand almost 24.1% more from the national budget. Consequently financial sustainability of the immunization program will significantly depend on future vaccine prices, which does not make Moldova much different from many other countries, where cost of new vaccines has been found to drive up to 60% of vaccine introduction costs [52].

Finally, introducing new vaccines and even in case of doubling vaccine prices the share of public health spending that will be required in Moldova will be close to 3% of public financing for health and will be comparable to the levels documented elsewhere [50]. Therefore affordability and financial sustainability of immunization services may look promising. However, looking at financial sustainability of immunization programs in a silo and not taking broader country fiscal context into consideration, may lead to misleading conclusions. Namely, in 2016 Moldova is expected to graduate from GAVI and, due to recently introduced policies, will also receive significantly reduced financing from the Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria (GFATM) [53]. Currently both donors contribute significant share of financing for public health programs. Concurrent reduction/graduation of the assistance from the GFATM and GAVI is expected to significantly increase pressure on the national budget. This has been confirmed by the estimates in the Medium Term Budgetary Framework for 2014-2016 [54] which yet does not account for PCV introduction and is being discussed with the ministry of finance. In its budget planning the Ministry of Health expects that graduation from the GAVI and reductions in financing from the GFATM will increase demand on the national budget for public health programs 2.45 times in 2016 compared to 2012 levels. Due to limited fiscal space and weak economic growth prospects for the same period [55] this could pose

[19] Estimates are based on three dose schedule proposed by Moldova in its GAVI application and Weighted Average Price (WAP) - 7$US per dose published by UNICEF for 2012. The estimates do not take into account additional investments in the cold chain, because existing cold chain capacity in Moldova is sufficient to accommodate PVC vaccines.

[20] Due to small market size of Moldova with 3.5 million population and small birth cohort, big vaccine manufacturers are not much interested to bid on local tenders.

significant challenges for the government and may put at risk adequate financing of the immunization, TB and HIV/AIDS programs in this country.

Comparison with NUVI introduction plan

We also compared cash flow estimates derived from our study with the *New Vaccine Introduction Plan* [56] that was developed by the government of Moldova in 2011.

Before describing findings we have to note significant limitations, which this comparison poses. The new vaccine introduction plan uses cost elements from the cMYP, where some inputs and functions are mixed in a same budget line. In order to derive more meaningful comparison we have made following adjustments for example per-diems that were given to personnel for attending trainings were accounted under the "training" cost category in the study findings, while per-diems given to personnel for supervisory visits were included in the line for "human resources". Transportation costs regardless of function (social mobilization, program management and training) were accounted under the "vehicles and transportation" cost category, etc. Nonetheless, comparison on a total cost level shows that total financial requirements for the Rotavirus vaccine introduction in Moldova were estimated at US $227,000, but actual expenditure was less by US $ 75,512 or by 33%. Detailed comparison by cost categories is presented in Table 33 below, although it is not informative due to limitations noted above. Therefore, bottom line comparison is more important and it further confirms that for going forward cMYP approach needs further improvements to help better estimate NUVI costs and help secure financial support from GAVI or other donors.

Table 33: Comparison of full needs and expenses for the new vaccine introduction

Cost Category	Plan	Costing Study	Variance
	Full needs for new vaccine introduction (US$)	Expenses for the New vaccine introduction (US$)	
Training	25,000	7,117	17,883
Social Mobilization, IEC and Advocacy	30,000	18,842	11,158
Cold Chain Equipment & Maintenance	22,000	5,840	16,160
Vehicles and Transportation	45,000	11,240	33,760
Programme Management	20,000	22,475	(2,475)
Surveillance and Monitoring	25,000	16,785	8,215
Human Resources	30,000	13,170	16,830
Technical assistance	30,000		30,000
Overhead		29,771	(29,771)
Office equipment		26,248	(26,248)
Total	**227,000**	**151,488**	**75,512**

Table 34 below presents comparison of new vaccine introduction grant with our costing study.

Table 34: Comparison of new vaccine introduction grant with costing study

Cost Category	NUVI Plan	GAVI Grant	Costing Study
	Full needs for new vaccine introduction (US$)	Funded with new vaccine introduction grant (US$)	Expenses for the New vaccine introduction (US$)
Training	25,000	15,000	7,117
Social Mobilization, IEC and Advocacy	30,000	15,000	18,842

Cold Chain Equipment & Maintenance	22,000	15,000	5,840
Vehicles and Transportation	45,000		11,240
Programme Management	20,000	20,000	22,475
Surveillance and Monitoring	25,000	25,000	16,785
Human Resources	30,000	10,000	13,170
Technical assistance	30,000		
Overhead			29,771
Office equipment			26,248
Total	**227,000**	**100,000**	**151,488**

Conclusions

Our study shows that cMYP in its current form and as the critical toll for financial planning for NUVI may not be appropriate unless further improvements are introduced or alternative approaches to financial planning are developed. The variation, resulting from cMYP are significant and if on a country level (especially for Moldova) they are negligible, on a regional and Global level such weaknesses could result in a significant bias and waste of resources.

This is the first costing study conducted in Moldova and consequently the estimated incremental financial and economic costs for the new vaccine introduction provide useful inputs for the national planning and policymaking.

While introducing PCV vaccine and graduating from the GAVI support the government may want to use the remaining time till the end of 2016 and identify the best vaccine procurement mechanisms[21], which would allow purchasing vaccines from UNICEF or at a comparable price. This will help minimize vaccine price, materialize savings and reduce the financial pressure on the national budget after GAVI graduation.

Our estimates for the incremental financial costs that are necessary to introduce a new vaccine in the immunization program proved to be 4.4 times higher compared to 80c currently paid by GAVI. These findings highlighted possible weaknesses in the GAVI policies and call for thorough re-evaluation in light of emerging new evidence.

We have documented that incremental financial costs are not high, when only a rotavirus vaccine introduction is evaluated. However, with expected PCV introduction, with possible vaccine price increases after GAVI graduation and with concurrent reduction in the funding from the GFATM, financial sustainability of immunization and other health programs may be put at risk and Moldova may lose the health gains achieved thus far. These challenges do not look unique to Moldova and many countries that are graduating from GAVI assistance and expecting funding reductions from the GFATM could be at similar risk. Consequently, careful evaluation and elaboration of graduation and/or co-financing policies across donors seems to be warranted to assure that achieved health gains are sustained and enhanced after countries graduate from donor assistance. When evaluating these policies not only national fiscal context has to be considered but also expected graduation from other donors' support needs to be as well taken into account.

[21]Allowing for purchases from UNICEF or for pulled procurement under national legislation, etc.

Immunization Cost Determinants and Productivity

Introduction

Cost-effectiveness of immunization programs are well documented worldwide within developed and developing country settings. Consequently, investing public financial resources on activities aimed at enhancing vaccination activities reveal to be a priority [10][57] [58][59][60][61].

Although strong steps have been taken globally to expand immunization coverage rates, the progress is not sufficient in many countries and several issues are still pending on the international agenda, namely: how to identify and to reach out to non-served population? Which new vaccines need to be considered in an improved vaccination calendar? What are the costs of including them (both non-served population and new vaccines) in the current immunization plans? etc.

As in many other health care services, strategies of immunization programs and their cost structures cannot be replicated from one country to another. Population density, their location and accessibility along a territory, geographic particularities and distribution of health care services and population characteristics (health habits, education) among others, have strong influence on costs of delivering vaccination services [14] [16].

Beyond that, vaccine procurement mechanisms, status of cold chains and managerial issues on a facility and on an immunization program level also has significant influence on success of vaccination initiatives. Global evidence on what actually determines cost of immunization and how much is necessary for developing countries to deliver these services is still inconclusive. Our study aims at contributing additional evidence around the topic of immunization costs and productivity determinants, by using the facility level costing data from Moldova.

Particular studies on cost determinants for immunization programs provide rich insights about relevance of particular factors under specific scenarios. Bishai et al. [**Error! Bookmark not defined.**] analyzes average costs and DTP3 coverage, by using a fifty-country panel from 2000 to 2003 arising from WHO and GAVI sources. They prove the presence of strong economies of scale in the provision of immunization coverage, leaving room for increasing coverage and closing the immunization gap. Also using facility data, Robertson et al [62] calculated average costs per FIC in Gambia which further contributed to the argument of decreasing costs with scale. In the same direction, Kahn et al. [31] based on immunization centers in Dhaka, Bangladesh, calculated average cost of FIC during the year 1999. Results prove decreasing costs with population scale, and identified the relevance of community support in reaching higher coverage.

Creese et al [63] looked at costs per fully immunized child (FIC) in Indonesia, Philippines and Thailand, analyzing 1978/79 facility level data. Bi-variate analysis across institutions and countries found significant rural-urban differences in input prices as well as in population accessibility to the services. Walker et al. [9] looked at disaggregated immunization costs per budgetary line in three Peruvian districts and calculated average expenses per FIC. Findings show significant differences across urban and rural locations, as well among type of facilities, particularly between urban and rural health centers, suggesting the presence of geographical access barriers in reaching immunization. All of these findings from other parts of the world resonate well with the findings of our study presented in earlier sections.

Particular goal of this chapter is to identify productivity indicators by human and capital factors in the Moldavian immunization program, analyzing production and costs determinants. Ordinary least square (OLS) method was applied to a traditional cost function structure, recognizing a multivariate influence different factors on immunization costs, where production variables as well as population and health system characteristics participate in the definition of average costs.

Estimations were performed on a facility level as well as on a district and the national level. And in all three cases, cost determinants were studied including and excluding costs related to wages for shared staff, which is covered by the national purchaser - CNAM.

Results confirm the presence of economies of scale in the production of immunized population. The share of time spent by staff at health centers is a driving component in explaining immunization coverage, followed by infrastructure indicators, although the former is more important with 3:1 ratio. In addition to production factors, socio-economic variables are relevant in defining average immunization costs, showing the interaction between demand characteristics with supply structure in the design of a vaccination program.

Methodology and Major Research Questions

Out of 1,318 health care facilities in charge of delivering immunization services in Moldova across 37 districts, the research team sampled 50 institutions, combining districts with urban and rural locations, as well as capturing diversity of health service providers (see Table 67 in the Annex 5 for sampling criteria).

The survey allowed capturing facility performance indicators (fully immunized child and number of total doses administered), human resource characteristics and their participation in the immunization activity (hours worked on immunization activities, presence of doctor in the health center), as well as a facility specific scale factors (total square meters per facility, cold chain capital index, etc.).

Beyond this information, the facility-based dataset was enriched with information about input prices, socio-economic characteristics of a population sourced from the national statistical office, such as number of infants in a catchment area, average household income, education level of families living in a given area, etc. These variables were evaluated with the help of bi-variate correlations, and appropriate ones also tested in the regression model (described later) to see their influence on productivity as well as on the cost of delivering immunization services in Moldova.

Table 35 below and Table 68 in the Annex 5; summarize descriptive statistics for un-weighted and weighted sample of facilities, respectively. These variables were used in the econometric analysis described later in the report.

The estimation strategy used in the study considers a sequence of two steps. The first step analyzes determinants of main production indicators/outputs: i.e. what explains the number of *Fully Immunized Child* (FIC) and the total number of doses administered on a facility level? In order to answer these questions, we looked at variables related to inputs i.e. human resources and facility capacity/specification. Production determinants are also corrected by scale variables (number of infants in catchment area), as well as by wastage rates, which could be seen as a proxy for a facility management practices. Applying a linear production function, immunization outputs take the form:

$$Q\_i = A\_i + α\_1 \, L\_i + α\_2 \, K\_i - α\_3 W\_i \qquad (1)$$

Where Q is the output indicator (FIC or number of doses administered) for facility "i", L and K are multiplicative vectors of production factors, with participation α1 and α2 respectively and A is the scale of infants present in the catchment area. The production function also depends on the wastage rate (W), which weighted the productivity of each factor.

Originally, a Cobb-Douglas functional form was considered as a potential specification for the production function, given its relative straightforward reading of coefficients within a log linear equation. However, it assumes constant elasticity of substitution, which imposes a constraint to the estimation. In addition, histograms of both dependent variables used in the econometric implementation (Fully immunized children and total number of doses administered) suggest the presence of a semi-log specification. Therefore, applying natural logarithms on the right side of the equation (1) facilitates the use of ordinary least square estimations techniques and allows identification of semi-elasticities in production with respect to a relevant input indicator(s)(see equation 2):

$$Q\_i = \ln A\_i + \alpha\_1 \ln L\_i + \alpha\_2 \ln K\_i + \alpha\_3 \ln W\_i \qquad (2)$$

The second estimation step proposes to answer the question: what determines the cost of immunization services? For this purposes we use the Total Economic Cost at a facility level as well as at district and national levels as a dependant variable.

The costs model implemented follows the structure of a hybrid model where prices, demand side and quality-driver characteristics interact [64]; [65]. This type of specification allows combining pure structural cost function characteristics with potentially relevant ad-hoc variables. In this case, the scale factor is defined by the output indicator measured in the first step (FIC). The cost function may also need to consider the influence of the demand side (population characteristics) on immunization. Therefore, the cost equation will take the form:

$$\text{Ln}\ CQ\_i = \ln FIC\_i + \alpha\_1 \ln w\_i + \alpha\_2 \ln r\_i - \alpha\_3 \ln W\_i + \alpha\_4 \ln P\_i \qquad (3)$$

Where CQ is the vector of cost specification for facility i, FIC is the scale factor, w and r are input prices for vectors related to labor-related and infrastructure-related characteristics and P represents demand-side and quality shifter variables

Table 35: Summary statistics, unweighted sample

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Fully Immunized Child (FIC)	50	60,88	135,16	1	714
Total number of doses administered	50	895,20	1844,43	33	9060
Total Economic Cost, Facility Level	50	11942	21743	565	112548
Total Economic Cost, Facility + District Level	50	12502,23	22404,94	627,75	115062
Total Economic Cost, Facility + District + National Level	50	12663,11	22723,92	641,27	116657
Share of staff time spent in the facility for immunization in % (FTE)	50	1,32	2,01	0,2	10,20
Total working hours	50	51,22	12,12	8	71
Total facility square meters	50	577,76	1173,18	20	5820
Cold chain capital index (cold chain economic cost at facility level)	50	72,86	22,20	7,79	136,14
Hourly wage, mid career nurse (USD)	50	1,82	0,16	1,45	2,28
Refrigerator unit price (USD)	50	0,76	0,36	0,01	2,13
Total number of infants in the facility catchment area	50	66,06	149,98	1	810
Share of population with university education in %	50	6,46	5,38	2,90	24,40
Dummy Facility Type (=1 if FMC)	50	0,10	0	0	1
Dummy Doctor at the facility (=1 Yes)	50	0,88	0,33	0	1
Dummy Facility Location (=1 if Urban)	50	0,06	0,24	0	1
Distance from the facility to the vaccine collection point	50	19,60	13,14	0	50

Overall Wastage Rate in % (from total number of doses administered)	50	17,01	8,89	4,90	36,90

Results

Productivity

The issue about productivity and how it can be measured and compared across alternative definitions of output can be addressed with the help of two Tables presented below. They help understand observed differences in performance between types of facility. First, Table 36 looks at FIC related outputs by using FIC to human resource ratios (i.e. FIC per immunization working hour and total working hours per FIC), and FIC to infrastructure ratios (i.e. FIC per thousand outpatient visits and facility's square meters per FIC). Each indicator is presented by a facility type (FMC, OFD, HC and HO), and for the total average. The last three columns on the right hand-side present T-tests of comparing OFDs with other facilities. Table 37 repeats the same exercise using same indicators but related to total doses administered instead of FIC.

Table 36: FIC: Performance Indicators by Facility Type; Weighted sample.

	Facility Type					T-test		
Annual Indicators	FMC	OFD	HC	HO	Mean	OFD vs. FMC	OFD vs. HC	OFD vs. HO
FIC/Immunization working hours	2.488	1.194	1.362	1.500	1.636	-1.294***	-0.168***	-0.306***
FIC/Total working hours	0.127	0.006	0.017	0.003	0.039	-0.121***	-0.011***	0.003***
FIC/Outpatient visits	0.001	0.005	0.004	0.008	0.005	0.003***	0.001***	-0.003***
FIC/Facility Sq. Meters	0.113	0.135	0.100	0.119	0.116	0,022	0.038***	0.016**

Notes: Significance levels: *** p<0.01, ** p<0.05,* p<0.1.

Table 36 shows that an additional working hour spent on immunization is associated with about 1.6 fully immunized child in Moldova, with a minimum at OFDs - 1.194 FIC per hour and a maximum at FMCs with 2.5 additional fully immunized child. Contrary increasing ***total working hours*** clearly has lower correlation with immunization outputs across types of facilities.

On the other hand, infrastructure has no strong linkages with immunization performance. One thousand outpatient visits relates to one to eight more children fully immunized, while increasing facility physical space in the same proportion is associated in average with 116 new FIC. All observed differences across facilities are statistically significant, with the exception of one.

Table 37 reproduces the same indicators using the total number of administered doses as the output variable and shows that FMCs delivers 37.4 doses per immunization hour and 1.86 doses per working hour as opposed to OFDs with the lowest number of doses-20.5 per immunization hour.

In terms of variables used as proxy of capital measures, Table 37 shows that, on average, Moldavian health facilities present a mean value of 1.8 new doses administered per square meter. Such indicator has its lowest value in FMCs with 1.161 dose administered per each square meter, while the highest productivity is reached at OFD with 2.3 FICs.

Nevertheless, this bi-variate analysis still hides valuable information having potential to explain immunization performance. Each type of facility is associated to certain geographical environment (rural, urban, with different levels of population density), as well as medical and support personnel structure and capacity, among other issues. Deeper look with the help of multivariate estimations may allow understanding production and costs determinants much better. Therefore, we now move onto multivariate analysis.

Table 37: Total Dose Adm.: Performance Indicators by Facility Type; Weighted sample

	Facility Type					T-test		
Annual Indicators	FMC	OFD	HC	HO	Mean	OFD vs. FMC	OFD vs. HC	OFD vs. HO
Total Dose Adm./Immunization working hours	37.419	20.478	21.471	22.810	25.545	-16.940***	-0,992	-2.332***
Total Dose Adm./ Total working hours	1.8553	0.107	0.275	0.058	0.574	-1.749***	-0.169***	0.049***
Total Dose Adm./ Outpatient visits	0.024	0.086	0.065	0.119	0.074	0.061***	0.021***	-0.032***
Total Dose Adm./ Facility Sq. Meters	1.161	2.308	1.526	1.760	1.801	0.697***	0.782***	0.548***

Notes: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

First Step: Production Determinants

The Moldova uses only fixed strategy for immunization delivery, therefore we regressed two production indicators following the specification in equation (2): "*Number of Fully Immunized Children*" and "*Total Number of Doses Administered*" per facility, against explanatory variables from Table 36. Although both dependant variable relate to the service production capacity of a facility, the "*Total Number of Doses Administered*" could be seen as a facility-specific scale factor and the "*Number of Fully Immunized Children*" also involves quality dimension of the services rendered, because in order to achieve higher number of FICs several things have to occur: children that need vaccination have to be identified, they need to be followed by the staff and vaccination schedule has to be completed on time.

Explanatory variables used in the regression were facility level inputs (human resources and infrastructure), proxy explaining logistics required for vaccine distribution i.e. distance to vaccine collection site, size of population in a facility catchment area and facility type, and ability of a population to reach immunization site (by urban or rural location). In addition, the variable "*wastage rate*" was included in the regression as a proxy for managerial effectiveness of a service provider.

The analysis of the histograms on the dependent variable (Figure 15 and Figure 16 in the Annex 5) suggested using semi-log functions in the econometric implementation for production analysis. In addition, and following Manning and Mullahy [66], the final set of estimation techniques includes the use of robust standard errors given the presence of heteroscedasticity under basic OLS specifications[22].

Results of regression bring particular learning for our analysis. Firstly, the impact of human resources on facility outputs is positive and significant at 99% in all specifications. Coefficients can be read as productivity indicators, and show that increasing working hours devoted to immunization by one per cent (measured as total working hours per 10,000 populations) would result on three additional child being fully immunized (see Table 38). Devoting more staff time towards immunization has comparable impact on total number of

[22] One of the main assumptions for OLS regression is that the variance of the error term is constant (there is not heteroscedasticity). Otherwise, OLS does not provide estimates with the smallest variances. The Breusch-Pagan / Cook-Weisberg test is designed to detect any linear form of heteroscedasticity. One way to deal with the problem of heteroscedasticity is the use of robust standard errors. The use of robust standard errors does not change coefficient estimates, but (because the standard errors are changed) the test statistics give reasonably accurate p-values.

doses administered, not only in terms of magnitude of impact but also in statistical significance[23].

Furthermore, two alternative measures of capital were included in the analysis: facility square meters and the cold chain capital index[24], intending both to capture productivity issues related to infrastructure. In the case of total number of doses administered coefficients of both variables (square meters and cold chain) show to be significant at 95% level, although their effects on productivity are significantly smaller than those of human resources. On the other hand the cold chain capital index does not affect FIC but has positive and statistically significant influence on the total doses delivered by a facility, and its influence is greater that of square meters.

The difference between centers and –particularly- number of infants in a catchment population, show to have positive relationship in explaining higher immunization outputs, but the magnitude of their impact is lower when their coefficients are compared with those which relates to human resources.

Table 38: Determinants of Production

	Ln FIC			Ln Total Dose Adm.		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Total working hours	0.0311**	0.0330***	0.0315***	0.0249***	0.0269***	0.0254***
	(0.0121)	(0.0114)	(0.0114)	(0.00870)	(0.00740)	(0.00728)
Total facility square meters	0.000507**		0.000461**	0.000523**		0.000459**
	(0.000219)		(0.000218)	(0.000210)		(0.000204)
Cold chain capital index		0.0109	0.00955		0.0147**	0.0133**
		(0.00717)	(0.00705)		(0.00575)	(0.00555)
Total number of infants in the facility catchment area	0.00636***	0.00577**	0.00547**	0.00538***	0.00444*	0.00413**
	(0.00213)	(0.00273)	(0.00219)	(0.00173)	(0.00230)	(0.00172)
Dummy Facility Type (=1 if FMC)	-1.708	-0.0152	-1.620	-1.529	0.192	-1.407
	(1.123)	(1.040)	(1.152)	(0.944)	(0.884)	(0.968)
Dummy Doctor at the facility (=1 Yes)	0.585***	0.676***	0.627**	0.702***	0.809***	0.760***
	(0.209)	(0.239)	(0.235)	(0.213)	(0.219)	(0.220)
Distance from the facility to the vaccine collection point	0.00360	0.00553	0.00583	-0.000313	0.00250	0.00280
	(0.00882)	(0.00947)	(0.00926)	(0.00655)	(0.00710)	(0.00669)
Overall Wastage Rate	-0.0387***	-0.0399***	-0.0402***	-0.0460***	-0.0478***	-0.0481***
	(0.0105)	(0.0101)	(0.00963)	(0.0101)	(0.00969)	(0.00899)
Constant	0.703	-0.119	0.0121	3.982***	2.888***	3.018***
	(0.823)	(1.147)	(1.135)	(0.663)	(0.796)	(0.779)

[23] Nevertheless, the analysis may involve potential issues related to endogeneity. Claiming that the share of staff at the health center spent on immunization affects the number of fully immunized children does not reveal that it is possible that health care personnel are responding to demand requirements.

[24] One possible measure of capital in immunization activities is the cold chain available capacity at the health care center level. As cold chain devices varies in capacity across facility types, one potential way of capturing the scale of this factor is to know the share of total costs at the facility level, under the assumption that higher capacity is linked with higher economic costs. The cold chain capital index captures this proportion.

R-squared	0.721	0.714	0.735	0.779	0.787	0.811

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

If uni-variate analysis showed that distance from a health care facility and type of medical facility were closely associated with the facility outputs, the multivariate analysis indicates that these two factors do not have statistically significant influence on productivity in a multivariate model. On the other hand, the econometric analysis proves that presence of doctors in the facility has strongest influence on the number of doses delivered and number of FICs produced. All specifications show this influence to be statistically significant at 99% level.

Finally, wastage rate, which had statistically significant influence in a bi-variate analysis, retains its significance and negative coefficients on both output indicators, although with slightly stronger implications for the total number of doses administered[25].

Second Step: Cost Determinants

For evaluating determinants of costs we used Equation (3) described earlier and we used two alternative approaches.

The first approach for explaining total cost on a facility level used facility-specific scale variable and prices of inputs in the production function -see specifications (1) through (4) in Table 39. In the second approach in addition to price variables we used a hybrid specification where other variables were considered, as wastage rate and share of the population with university education –see specifications (5) to (8) in Table 39.

In both cases, the scale factor is the total number of FIC and/or FIC estimated[26] with the help of Table 38. Based on the available evidence, the expectation is that higher scale will require more resources to deliver immunization services and therefore the total facility costs will be higher. However due to economies of scale, we also expect cost per FIC to decline as the scale increases.

When we evaluated input prices they do not show strong differences across facilities. Probably centralized purchase of equipments (i.e. cold boxes, freezers, ice packs, thermometers, refrigerators), as well as uniform national regulation of labor inputs affecting salaries and incentives for personnel, explain limited variability in inputs costs across facilities. Table 70, Table 71 and Table 72 in Annex 5 were developed to present information about units and their prices on a facility level. Table 70 describes hours spent on immunization by different staff categories showing clearly that nurses the most involved with vaccination, followed by doctors and managers/directors. Within nurses Table 71 presents minimum, maximum and their average remuneration per hour, as well as the rates of variations with each group, which is relatively low due to uniform national regulations for wages. Consequently, in the regression analysis we used mid-career nurse hourly wage as a proxy for prices of human resources.

[25] Table 9 shows the results of applying the same model under a log-log specification. In general, findings are similar to the ones introduced under the log normal setup: labor factor has stronger and significant effects on production than capital inputs; infants in the catchment area are also significant, although facility type, and distance from the distribution point are not. Wastage rates are negative and significant, and the dummy variable capturing the relevance of doctors supplying services at the health center level in this case is not statistically relevant.

[26] Due to the fact that FIC strongly correlated with the demand and supply side variables used in the regression and to avoid multi-collinearity we used FIC estimated as well. The variable is built based on the estimation of FIC arisen from step one of the model. Replacing coefficients obtained in specification (3) of FIC into the original database leads to a new variable, FIC estimated, allowing to link production decisions with the cost structure.

For prices of capital Table 72 describes differences observed across capital items. As in the case of human resources, the table summarizes minimum, maximum and average prices for an array of five different devices used in the immunization program. Three of them show low coefficients of variation, while two others (cold boxes and refrigerators) the variation is more prominent. Therefore in the econometric analysis unit prices of cold boxes and refrigerators were used as a proxy for capital.

To account for supply and demand side characteristics in the regression model we used two variables, which could provide information about impact of various inputs on immunization costs.

The first one relates to a facility management practices associated to efficiency in the use of resources (wastage rates). The second variable accounted for demand-side factors-characteristics of households (i.e. income, educational level) which may affect demand for health services [67] [68]. As these variables were strongly cross-correlated we only retained the share of population with university education in the model.

Results of both approaches are presented in Table 39. The first four columns of the table (specifications (1) through (4)) show the dependent variable *"Total Facility Specific Economic Costs"* explained by the scale and price specification, but using alternatively FIC and estimated FIC from Table 38. In all cases, coefficients of FIC and estimated FIC show to be positive and significant at 99% level. Using natural logarithms on both sides of the equation allow identifying the decreasing effect of scale on a unit cost of immunization. Increasing the number of FIC by one percent results in total cost increase by 0.74% or less-than-one proportion. Consequently, the coefficients presented in Table 39 show that average cost per FIC declines with increasing number of FICs per facility. Replacing the original variable for FIC for its estimated specification (see column (2) and (4)) does not change either the significance or the weight of the variable influence on the total cost, which assures robustness of our findings.

Prices of human resources and capital do not show conclusive and strong influence on the total cost of immunization. Only labor prices reveal statistically significant influence when FIC estimated is used in the regression. Similarly price of refrigerators reveals statistically significant influence only with FIC estimated specification. On the other hand, ice pack unit prices are not significant under any specification of the model. One potential explanation is that the estimated FIC is showing a stylized behavior of the scale variable, which provides room for additional effects to arise, probably associated to particular characteristics at the health center level. These effects may compensate the clear centralized patterns of procurement and payment at the national level.

Specifications (5) to (8) in Table 39 introduce supply and demand characteristics in addition to input prices[27]. Coefficients related to production factor variables show positive and significant influence on explaining immunization costs on a facility level. However, the relevance of each input is different. Human resources show a higher coefficient in explaining costs, five times higher than infrastructure indicators, supporting the argument of vaccination is a labor-intensive intervention. At the same time infrastructure related supply-side variables do not present statistical significance in the model.

The regression analysis shows low efficiency gaps across facilities: the variable distance from the distribution point to the vaccine collection site is not significant in explaining costs, which could refer to lack of logistic challenges across the immunization system in Moldavia. In addition, the dummy variable capturing rural/urban differences in immunization costs is

[27] The approach combines supply and demand characteristics into a single reduced-form regression. Nevertheless, additional information, not available at this stage, may allow estimating a system of equations, in order to capture separately both vectors of determinants.

not statistically significant ,which may refer to a low equity gap in access to immunization services between urban-rural facilities.

Table 39: Total Economic Cost, Facility Level

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep. Var.: Ln Total Economic Cost, Facility Level							
Ln Fully Immunized Children (FIC)	0.743***		0.743***		0.615***		0.616***	
	(0.0598)		(0.0548)		(0.0749)		(0.164)	
Ln FIC Est.		0.815***		0.813***		0.694***		1.720***
		(0.107)		(0.109)		(0.150)		(0.218)
Ln FIC2							-0.000218	
							(0.0297)	
Ln FIC2 Est.								-0.139***
								(0.027)
Ln Hourly wage, mid career nurse	1.122	1.442**	0.991	1.409**	1.050	1.395**	1.050	1.628*
	(0.981)	(0.532)	(1.024)	(0.569)	(0.986)	(0.593)	(0.999)	(0.619)
Ln Refrigerator unit price	0.0502	0.183***	-0.0745	0.152	-0.0651	0.132	-0.0651	0.132
	(0.0823)	(0.0361)	(0.165)	(0.133)	(0.137)	(0.133)	(0.139)	(0.112)
Ln Ice pack unit price			-1.033	-0.261	-1.468	-0.667	-1.469	-0.934
			(1.127)	(1.086)	(0.947)	(1.111)	(1.007)	(0.904)
Ln Share of population with university education					0.618***	0.447*	0.619**	0.692***
					(0.186)	(0.229)	(0.264)	(0.174)
Ln Overall Wastage Rate					-0.00933	-0.0188	-0.00945	0.210
					(0.175)	(0.200)	(0.181)	(0.156)
Constant	5.526***	5.303***	2.649	4.581	0.842	3.130	0.837	-0.283
	(0.661)	(0.512)	(3.309)	(2.993)	(2.924)	(3.279)	(3.187)	-2,839
R-squared	0.815	0.795	0.821	0.795	0.859	0.811	0.859	0.891

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Demand side variables show their explanatory power (positive and significant at 99% of confidence) over immunization costs on a facility level under any specification: higher education levels allow demanding for more immunization, triggering vaccination costs. Wastage rate proved not to be significant influence over costs in any specification.

Finally, specifications (7) and (8) introduce the variable FIC2 and FIC2-est, which are the second power of the scale variables used in our cost estimations. The goal of these variables is to explicitly check the hypothesis of decreasing costs with scale, as shown in the literature. Although with FIC the new variable does not have significant power, it shows 99% of significance with FIC estimated. Its sign is negative, supporting the argument of lower costs once quantities produced are higher.

Table 73 in the Annex 5, shows exactly the same specifications provided in Table 39, but using un-weighted sample, in order to check the explanatory power of the sample selection. One-to-one comparisons across different alternative econometric specifications confirm robustness of our findings.

Immunization program in Moldavia is strongly centralized. Central Government assumes responsibility for cold chain, vaccine and syringe procurement and distribution, payment to providers is managed through the single purchaser - CNAM, etc. All of this leaves limited responsibility over cost management to a lower level, which mainly is responsible for organizing and managing immunization program at a facility level only. Therefore, cost determinants are expected to be mainly dependent on health care provider characteristics, where decentralized responsibilities and social factors interact.

Table 40: Total Economic Cost, Facility + District, and Facility + District + National Level

	Dep. Var.: Ln Total Economic Cost							
	Facility + District Level				Facility + District + National Level			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln Fully Immunized Children (FIC)	0.749***		0.609***		0.750***		0.608***	
	(0.0525)		(0.160)		(0.0522)		(0.159)	
Ln FIC Est.		0.818***		1.719***		0.819***		1.717***
		(0.106)		(0.204)		(0.105)		(0.202)
Ln FIC2			0.00274				0.00329	
			(0.0286)				(0.0284)	
Ln FIC2 Est.				-0.138***				-0.137***
				(0.0255)				(0.0252)
Ln Hourly wage, mid career nurse	0.919	1.339**	0.979	1.561**	0.91	1.331**	0.971	1.553**
	(0.989)	(0.553)	(0.964)	(0.610)	(0.981)	(0.551)	(0.956)	(0.608)
Ln Refrigerator unit price	-0.0612	0.167	-0.0490	0.151	-0.0597	0.169	-0.0471	0.153
	(0.155)	(0.127)	(0.132)	(0.106)	(0.154)	(0.127)	(0.131)	(0.105)
Ln Ice pack unit price	-0.973	-0.197	-1.355	-0.817	-0.967	-0.19	-1.342	-0.804
	(1.075)	(1.049)	(0.958)	(0.870)	(1.067)	(1.045)	(0.951)	(0.866)
Ln Share of pop.n with university education			0.579**	0.661***			0.574**	0.658***
			(0.256)	(0.168)			(0.254)	(0.167)
Ln Overall Wastage Rate			-0.0205	0.195			-0.0216	0.193

			(0.182)	(0.150)			(0.182)	(0.149)
Constant	2.914	4.859	1.350	0.234	2.944	4.893*	1.413	0.302
	(3.151)	(2.886)	(3.048)	(2.723)	(3.127)	(2.873)	(3.025)	(2.707)
R-squared	0.835	0.806	0.869	0.899	0.838	0.808	0.871	0.900

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

To evaluate this assumption, costs arising on a district and national level were allocated to the facility level costs and regressed in the model described earlier. Findings of this analysis are presented in Table 40, which presents similar results to those described in Table 39 specifications (3) and (4). Columns (1) to (4) in Table 40 include district level costs along with costs on a facility level. The last four columns also add national level expenditures to those presented for a district level. The results are consistent with findings presented for a facility level in Table 39. Coefficients and significance levels vary only marginally, supporting the hypothesis that average costs per fully immunized child is mainly affected by performance at a local facility level factors.

Finally, because salaries constitute a main source of expenditures paid at the national level, it was decided to conduct similar econometric analysis but excluding the wages from the dependent variable. These results are presented in Table 74 (at the facility level) and Table 75 (at District and National levels) in the Annex 5.

Results confirm prior findings about economies of scale affecting cost of immunization service provision. In addition relative explanatory power of human resources related variable is obviously reduced, giving more room for infrastructure characteristics. As a result, the variable related to wages of health staff loses statistically significance and its coefficients are smaller.

Conclusions and Discussions

As we have seen in this section traditional bi-variate productivity indicators, such as FIC per hour devoted to vaccination, or total number of doses administrated per unit of capital used for immunization allows overall comparisons across facility types. However, they do not help in defining the significance and impact of each potential driver over production outputs and costs.

By using a representative sample of health care facilities and the econometric model, elaborated in this section, our analyses of **production determinants** show particular importance of human resources in producing higher outputs (measured as FIC or as total doses administered). In comparison to facility infrastructure, such as cold chain equipment or square meters of a facility, regression estimations reveal strong labor-intensive character of immunization programs. If in univariate analysis facility size (measured in square meters) had strong influence in producing more FICs or delivering more doses, in the multivariate model it retains statistical significance, but the power of its influence is 48 to 68 times less that of working hours devoted to immunization by the staff.

While labor inputs (hours spent on immunization) are critical for increasing the outputs, the quality of such labor inputs seems to be more important in achieving higher production levels. Our model showed that having a doctor in the facility has more significant influence on the volume of outputs (FICs and doses administered) than having just nurses. In all cases, labor related inputs bring positive and significant coefficients at 99% of significance, while relevance of proxies for capital have less revealing results, particularly when FIC is used as an output measure.

Production estimations also point to the importance of the population size in the catchment area, increasing of which allows for cost savings at the same level of production. The distance of health centers from a vaccine distribution point does not affect production levels significantly. Particularly, dummy variables for facility type, which seemed to have significant influence in a bi-variate analysis, does not reveal significant effects on production, showing higher importance of other production drivers beyond the general characteristics of health care facilities. Finally facilities with lower wastage rates, when all other factors are kept constant, are more able to produce higher outputs.

Our econometric analysis of ***total economic cost determinants*** on a facility level strongly supports the presence of economies of scale in immunization programs. These findings once again re-confirm similar arguments, provided by others [**Error! Bookmark not defined.**].

Moreover, the econometric model for evaluating immunization costs contributes to the discussion about centralized health systems that subject providers to uniform rules and its influence on immunization costs. Namely, we found that input prices for labor and capital reveal non-conclusive influence on the immunization costs. Considering that in Moldova central government regulates wages, as well as centrally procures and delivers immunization inputs: vaccines, cold boxes, syringes and safety boxes etc. such inconclusive influence of the prices is not surprising. Furthermore, the analysis showed that costs arising on a district and national level are not that important and mostly facility level costs determine overall variability seen among facilities. Therefore, factors operating on a facility level seem to have most influence on the cost of immunization. It will be most interesting to compare our results with those obtained from decentralized systems, where decision making for labour remuneration and/or purchase of inputs are decentralized to sub-national entities and/or facilities. It is expected that predictability of immunization costs would be higher in the centralized models compared to decentralized ones, although this assumption has not been yet validated. Although the set of similar studies supported by the Gates Foundation offer opportunity for such comparisons. All of this attracts the interest as after graduation from GAVI Moldova may introduce greater decentralization in its immunization programs. In some quarters[28] there are discussions to allow facilities to purchase immunization inputs on their own while CNAM will only reimburse for the volume of services delivered. In light of our findings such decisions, if implemented, could pose risks of resulting in greater variability in input prices. Therefore, before acting on such decisions thorough evaluation of their impact on the national immunization costs is warranted.

The next important finding of the econometric model is importance of the staff time devoted to immunization in determining costs. The specification (4) in Table 39 proves that increasing average nurse wage by one unit would cause total immunization cost increase by 1.4, which re-confirms labour intensity of immunization services and therefore price changes in labour inputs would have significant impact on the overall cost of the program. Consequently, when making decisions and trying to expand coverage and/or add new vaccines, which may require additional staff, the discussions should center on seniority and diversity of health care personnel involved in immunization and how this may affect labour costs. In the earlier section we argued for increasing DPT3 coverage by focusing on FMCs, which at a relatively lower costs offer greater potential for increasing national DPT3 rates. This argument is strongly supported by outcomes of the econometric model, which show that FMC that have higher number of population in their catchment area, have greater capacity and better-qualified staff and are more capable of managing their wastage rates, therefore they have greater ability to increase coverage at a lower cost.

These arguments are further supported by regression analysis that shows that the distance between the immunization center and the distribution point (as a proxy for vaccine logistics), urban-rural dummy and size of the facility are not statistically significant factors in explaining immunization costs.

Furthermore, differences between urban/rural locations are not relevant variables in explaining immunization costs on a facility level. Therefore, the econometric analysis did not identify strong equity issues across providers in Moldova, which is expected as the resource flow from center to urban and rural facilities are comparable in Moldova, which probably explains their ability in delivering comparable services to the population. Therefore, focus on FMCs is not expected to have negative equity outcomes.

[28] Based on interviews conducted by authors with national stakeholders

Finally, demand side variables show their explanatory power (positive and significant at 99% of confidence) over immunization costs on a facility level under any specification: higher education levels allow demanding for more immunization, triggering vaccination costs..

In conclusion, presented analysis of production and costs determinants allows separating the effect of four different factors on immunization outputs: operative capacity at the facility level largely related to human resources, managerial efficiency for vaccine and program management, population scale in the catchment and educational level are seem to have the most explanatory power on the productivity and immunization costs.

Annex 1: Sampling frame of rural and urban facilities by districts

Table 41: Sampling frame of rural facilities by districts, selected and visited facilities

Facility ID	No	District Name	Facility	Facility Type	sampled/ replacement	Actually visited
1	1	Briceni	OFD Criva	OFD	Replacement	
2	2	Briceni	Drepcauti	OFD		
3	3	Briceni	Sireuti	OFD		
4	4	Briceni	Hlina	OFD		
5	5	Briceni	Colicauti	OFD	Sampled	visited
6	6	Briceni	Tabani	OFD	Replacement	
7	7	Briceni	Halahora de Sus	OFD		
8	8	Briceni	Trebisauti	OFD		
9	9	Briceni	Bulboaca	OFD	Sampled	visited
10	10	Briceni	Medicalpoint Caracusenii Noi	HO	Replacement	
11	11	Briceni	Larga	HC		
12	12	Briceni	Cotelea	OFD		
13	13	Briceni	Medjeva	OFD	Sampled	visited
14	14	Briceni	Corjeuti	HC	Replacement	
15	15	Briceni	Balasinesti	OFD		
16	16	Briceni	Pererita	OFD		
17	17	Briceni	Sl. Sireuti	OFD	Sampled	visited
18	18	Briceni	Beleavinet	OFD	Replacement	
19	19	Briceni	Berlinet	OFD		
20	20	Briceni	Tetcani	OFD		
21	21	Briceni	Bezeda	OFD		
22	22	Briceni	Bogdanesti	OFD	Sampled	visited
23	23	Briceni	Grimesti	OFD	Replacement	
24	24	Briceni	Marcauti	OFD		
25	25	Briceni	Balcauti	OFD		
26	26	Briceni	Mihaileni	OFD	Sampled	visited
27	27	Briceni	Medical point Groznita	HO	Replacement	
28	28	Briceni	Grimancauti	OFD		
29	29	Briceni	Cotiujeni	OFD		
30	30	Briceni	Caracusenii Vechi	OFD	Sampled	visited
31	31	Briceni	Medical point Trestieni	HO	Replacement	
32	32	Călăraşi	Raciula	OFD		
33	33	Călăraşi	Niscani	OFD		
34	34	Călăraşi	Paulesti	OFD		
35	35	Călăraşi	Frumoasa	OFD	Sampled	visited
36	36	Călăraşi	Parcani	OFD	Replacement	
37	37	Călăraşi	Temeleuti	OFD		
38	38	Călăraşi	Peticeni	OFD		
39	39	Călăraşi	Novaci	OFD	Sampled	visited
40	40	Călăraşi	Tuzara-Seliste	OFD	Replacement	
41	41	Călăraşi	Pitusca	OFD		
42	42	Călăraşi	Varzarestii Noi	OFD		
43	43	Călăraşi	Radeni	OFD	Sampled	visited
44	44	Călăraşi	Dereneu	OFD	Replacement	
45	45	Călăraşi	Tiberica	OFD		
46	46	Călăraşi	Meleseni	OFD		
47	47	Călăraşi	Hirjauca	OFD		
48	48	Călăraşi	Leordoaia	HO	Sampled	visited

Facility ID	No	District Name	Facility	Facility Type	sampled/ replacement	Actually visited
49	49	Călărași	Palanca	HO	Replacement	
50	50	Călărași	Mindra	HO		
51	51	Călărași	Sadova	OFD		
52	52	Călărași	Oniscani	HC	Sampled	visited
53	53	Călărași	Hirbovat	OFD	Replacement	
54	54	Călărași	Hirbova	OFD		
55	55	Călărași	Hoginesti	OFD		
56	56	Călărași	Bravicea	HC	Sampled	visited
57	57	Călărași	Saseni	OFD	Replacement	
58	58	Călărași	Bahu	OFD		
59	59	Călărași	Pirjolteni	HC		
60	60	Călărași	Horodiste	OFD	Sampled	visited
61	61	Călărași	Buda	OFD	Replacement	
62	62	Călărași	Cabaiesti	OFD		
63	63	Călărași	Valcinet	HC		
64	64	Călărași	Sipoteni	HC		
65	65	Călărași	Bahmut	OFD	Sampled	visited
66	66	Călărași	Gara Bahmut	OFD	Replacement	
67	67	Chișinău	Bacioi	HC		
68	68	Chișinău	Truseni	HC		
69	69	Chișinău	Ghidighici	HC	Sampled	visited
70	70	Chișinău	Ciorescu	HC	Replacement	
71	71	Chișinău	Bubuieci	HC		
72	72	Chișinău	Budesti	HC		
73	73	Chișinău	Colonita	HC	Sampled	visited
74	74	Chișinău	Stauceni	HC	Replacement	
75	75	Chișinău	Gratiesti	HC		
76	76	Leova	Sirma	OFD		
77	77	Leova	Hanasenii Noi	OFD		
78	78	Leova	Sarata Noua	HC	Sampled	visited
79	79	Leova	Cupcui	OFD	Replacement	
80	80	Leova	Cazangic	OFD		
81	81	Leova	Seliste	HO		
82	82	Leova	Frumusica	HO	Sampled	visited
83	83	Leova	Tomai	HC	Replacement	
84	84	Leova	Tochile-Raducani	OFD		
85	85	Leova	Sarata- Razesi	OFD		
86	86	Leova	Filipeni	HC	Sampled	visited
87	87	Leova	Romanovca	HO	Replacement	
88	88	Leova	Borogani	HC		
89	89	Leova	Sarateni	HC		
90	90	Leova	Cneazevca	OFD		
91	91	Leova	Victoria	HO	Sampled	replaced
92	92	Leova	Vozneseni	OFD	Replacement	visited
93	93	Leova	Saratica Veche	HO		
94	94	Leova	Cazlar	HO		
95	95	Leova	Bestemac	OFD	Sampled	visited
96	96	Leova	Tomaiul Nou	HO	Replacement	
97	97	Leova	Troita	HO		
98	98	Leova	Troian	HO		
99	99	Leova	Covurlui	OFD	Sampled	visited
100	100	Leova	Saratica Noua	HO	Replacement	
101	101	Leova	Cimpul drept	HO		
102	102	Leova	Colibabovca	OFD		

Facility ID	No	District Name	Facility	Facility Type	sampled/ replacement	Actually visited
103	103	Leova	Ceadar	OFD	Sampled	visited
104	104	Leova	Orac	OFD	Replacement	
105	105	Leova	Tigheci	OFD		
106	106	Leova	Cuporani	HO		
107	107	Leova	Baius	OFD		
108	108	Ungheni	Nicolaevca Noua	HO	Sampled	replaced
109	109	Ungheni	Costuleni	OFD	Replacement	visited
110	110	Ungheni	Zagarancea	OFD		
111	111	Ungheni	Manoioesti	OFD		
112	112	Ungheni	Rezina	OFD	Sampled	visited
113	113	Ungheni	Vulpesti	HO	Replacement	
114	114	Ungheni	Romanovca	HO		
115	115	Ungheni	Poiana	HO		
116	116	Ungheni	Cornesti	OFD	sampled	visited
117	117	Ungheni	Bumbata	OFD	replacement	
118	118	Ungheni	Boghenii Noi	OFD		
119	119	Ungheni	Izvoreni	HO		
120	120	Ungheni	Boghenii Vechi	HO		
121	121	Ungheni	Micresti	HO	sampled	visited
122	122	Ungheni	Magurele	OFD	replacement	
123	123	Ungheni	Drujba	OFD		
124	124	Ungheni	Hirnesti	HO		
125	125	Ungheni	Minzatesti	HO	sampled	visited
126	126	Ungheni	Veverita	HO	replacement	
127	127	Ungheni	Sinestii Noi	OFD		
128	128	Ungheni	Leordoaia	HO		
129	129	Ungheni	Sculeni	HC		
130	130	Ungheni	Blindesti	HO	sampled	visited
131	131	Ungheni	Floreni	HO	replacement	
132	132	Ungheni	Gherman	OFD		
133	133	Ungheni	Petresti	HC		
134	134	Ungheni	Medeleni	HO	sampled	visited
135	135	Ungheni	Semeni	OFD	replacement	
136	136	Ungheni	Cioropcanii Vechi	HC		
137	137	Ungheni	Stolniceni	OFD		
138	138	Ungheni	Bulhac	HO	sampled	visited
139	139	Ungheni	Floresti	OFD	replacement	
140	140	Ungheni	Buciumeni	HO		
141	141	Ungheni	Pirlita	HC		
142	142	Ungheni	Nicolaevca Veche	HO		
143	143	Ungheni	Todiresti	OFD	sampled	visited
144	144	Ungheni	Graseni	HO	replacement	
145	145	Ungheni	Tescureni	OFD		
146	146	Ungheni	Hristoforovca	HO		
147	147	Ungheni	Agromonovca	OFD	sampled	visited
148	148	Ungheni	Zazulenii Vechi	HO	replacement	
149	149	Ungheni	Cetireni	HC		
150	150	Ungheni	Untesti	OFD		
151	151	Ungheni	Floritoaia Veche	OFD	sampled	visited
152	152	Ungheni	Floritoaia Noua	HO	replacement	
153	153	Ungheni	Grozasca	HO		
154	154	Ungheni	Napadeni	HO		
155	155	Ungheni	Cornova	OFD	sampled	visited
156	156	Ungheni	Condratesti	OFD	replacement	

Facility ID	No	District Name	Facility	Facility Type	sampled/ replacement	Actually visited
157	157	Ungheni	Curtoaia	HO		
158	158	Ungheni	Radenii Vechi	HC		
159	159	Ungheni	Alexeevca	OFD		
160	160	Ungheni	Saghieni	HO	sampled	replaced
161	161	Ungheni	Busila	HO	replacement	visited
162	162	Ungheni	Lidovca	HO		
163	163	Ungheni	Negurenii Vechi	OFD		
164	164	Ungheni	Zazulenii Noi	HO	sampled	visited
165	165	Ungheni	Tighira	OFD	replacement	
166	166	Ungheni	Coseni	HO		
167	167	Ungheni	Valea Mare	HC		
168	168	Ungheni	Buzduganii de Sus	HO	sampled	visited
169	169	Ungheni	Buzduganii de Jos	HO	replacement	
170	170	Ungheni	Morenii Noi	OFD		
171	171	Ungheni	Sicovet	HO		
172	172	Ungheni	Danuteni	HC		
173	173	Ungheni	Negurenii NOI	HO	sampled	replaced
174	174	Ungheni	Chirileni	OFD	replacement	visited
175	175	Ungheni	Frasinesti	OFD		
176	176	Ungheni	Elizavetovca	HO		
177	177	Ungheni	Costuleni-Macaresti	HC	sampled	visited
178	178	Vulcanesti (Găgăuzia)	Cismicioi	HC	replacement	
179	179	Vulcanesti (Găgăuzia)	Etulia	HC		
180	180	Vulcanesti (Găgăuzia)	Vulcanesti	OFD		
181	181	Vulcanesti (Găgăuzia)	Carbolia	OFD	sampled	visited

Table 42: Sampling frame of urban/peri-urban facilities by districts, selected and visited facilities

No	Facility ID	District name	Facility	Facility type	selected/ replacement	Actually visited
1	182	Briceni	Lipcani	HC	selected	Visited
2	183	Briceni	Briceni	HC	replacement	
3	184	Călărași	Calarasi	HO	selected	Visited
4	185	Chișinău	CFD-1	CFD	replacement	
5	186	Chișinău	CFD-2	CFD		
6	187	Chișinău	CFD-3	CFD	selected	Visited
7	188	Chișinău	Sîngera	HC	replacement	
8	189	Chișinău	Medical Centre of civil aviation	MC		
9	190	Chișinău	Medical Center	MC		
10	191	Chișinău	Buiucani	DCC	replacement	
11	192	Chișinău	CFD-4	CFD		
12	193	Chișinău	CFD-5	CFD		
13	194	Chișinău	CFD-6	CFD		
14	195	Chișinău	HC Durlesti	HC	selected	Visited
15	196	Chișinău	HC Vatra	HC	replacement	
16	197	Chișinău	Centru	DCC		
17	198	Chișinău	CFD-7	CFD		
18	199	Chișinău	University Clinic	UC		
19	200	Chișinău	Cricova	HC		
20	201	Chișinău	Vadu-lui-Voda	HC		
21	202	Chișinău	Ciocana	DCC		
22	203	Chișinău	CFD-8	CFD	selected	Visited
23	204	Chișinău	CFD-9	CFD	replacement	
24	205	Chișinău	Riscani	DCC		
25	206	Chișinău	CFD-10	CFD		
26	207	Chișinău	CFD-11	CFD		
27	208	Chișinău	CFD-12	CFD		
28	209	Chișinău	Galaxia			
29	210	Chișinău	Sancos			
30	211	Leova	Leova	CFD	replacement	
31	212	Leova	Iargara	HC	selected	Visited
32	213	Ungheni	Ungheni CFD	CFD	selected	Visited
33	214	Ungheni	Corbesti	HC	replacement	
34	215	Vulcanesti (Găgăuzia)	Vulcanesti	HC	selected	Visited

Annex 2: Unit Costs Analysis for Immunization Services

Figure 14Total cost of immunization by facility type

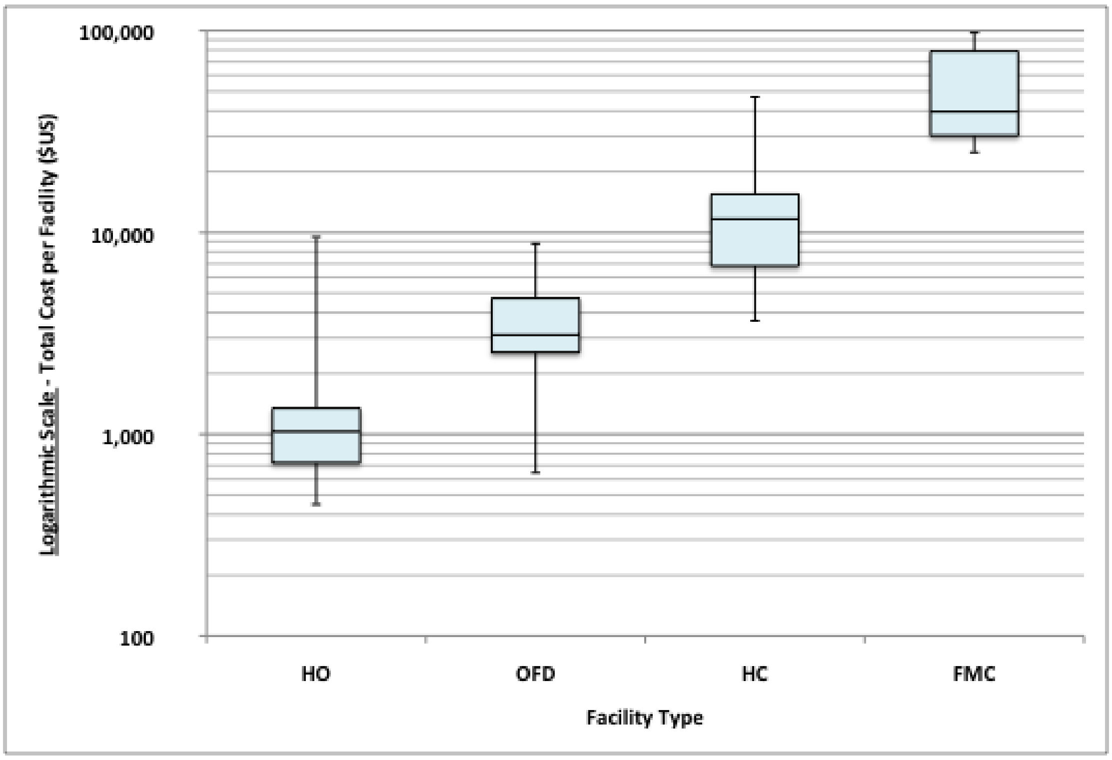


Table 43: Facility specific mean cost per dose, cost per FIC and cost per infant by location

By location		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose	Rural	17.4	17.6	1238	0.596
	Semi-urban	17.0	14.1	54	
	Urban	12.7	12.7	26	
	Total	**17.1**	**17.4**	**1318**	
Economic cost per dose	Rural	18.4	18.6	1238	0.561
	Semi-urban	17.5	14.5	54	
	Urban	13.1	13.1	26	
	Total	**18.0**	**18.3**	**1318**	
Financial cost per FIC	Rural	316.4	321.6	1238	0.309
	Semi-urban	257.5	215.9	54	
	Urban	173.4	173.4	26	
	Total	**301.9**	**314.3**	**1318**	
Economic cost per FIC	Rural	334.5	340.3	1238	0.290
	Semi-urban	264.5	222.1	54	
	Urban	180.1	180.1	26	
	Total	**318.2**	**332.3**	**1318**	
Financial cost per Infant	Rural	300.5	306.7	1238	0.294
	Semi-urban	239.6	201.2	54	
	Urban	158.6	158.6	26	
	Total	**285.9**	**299.5**	**1318**	
Economic cost per Infant	Rural	317.6	324.6	1238	0.279
	Semi-urban	246.2	207.0	54	
	Urban	164.8	164.8	26	
	Total	**301.3**	**316.6**	**1318**	

Table 44: Facility specific mean cost per dose, cost per FIC and cost per infant without wages by location

By location		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose without wages	Rural	5.5	5.6	1238	0.253
	Semi-urban	4.1	3.6	54	
	Urban	3.2	3.2	26	
	Total	**5.2**	**5.5**	**1318**	
Economic cost per dose without wages	Rural	6.4	6.6	1238	0.226
	Semi-urban	4.6	4.0	54	
	Urban	3.7	3.7	26	
	Total	**6.1**	**6.4**	**1318**	
Financial cost per FIC without wages	Rural	100.4	103.0	1238	0.210
	Semi-urban	61.8	54.0	54	
	Urban	44.3	44.3	26	
	Total	**93.2**	**99.8**	**1318**	
Economic cost per FIC without wages	Rural	118.4	121.7	1238	0.216
	Semi-urban	68.8	60.1	54	
	Urban	51.0	51.0	26	
	Total	**109.4**	**117.8**	**1318**	
Financial cost per Infant without wages	Rural	95.6	98.3	1238	0.224
	Semi-urban	57.6	50.3	54	
	Urban	40.5	40.5	26	
	Total	**88.5**	**95.2**	**1318**	
Economic cost per Infant without wages	Rural	112.7	116.2	1238	0.232
	Semi-urban	64.1	56.1	54	
	Urban	46.7	46.7	26	
	Total	**103.9**	**112.3**	**1318**	

Table 45: Facility specific mean cost per dose cost per FIC and cost per infant by type of facility

By facility type		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose	FMC	11.3	10.1	55	0.346
	HC	18.7	18.8	190	
	OFD	17.6	17.7	708	
	HO	17.2	17.3	365	
	Total	**17.1**	**17.4**	**1318**	
Economic cost per dose	FMC	11.7	10.4	55	0.338
	HC	19.3	19.4	190	
	OFD	18.5	18.5	708	
	HO	18.6	18.7	365	
	Total	**18.0**	**18.3**	**1318**	
Financial cost per FIC	FMC	167.2	149.9	55	0.288
	HC	302.4	318.1	190	
	OFD	329.9	330.4	708	
	HO	304.0	306.2	365	
	Total	**301.9**	**314.3**	**1318**	
Economic cost per FIC	FMC	172.9	155.1	55	0.285
	HC	311.6	328.8	190	
	OFD	346.6	347.2	708	
	HO	329.6	332.2	365	
	Total	**318.2**	**332.3**	**1318**	
Financial cost per infant	FMC	154.9	139.1	55	0.233
	HC	287.8	312.3	190	
	OFD	321.7	322.2	708	
	HO	270.1	272.9	365	
	Total	**285.9**	**299.5**	**1318**	
Economic cost per infant	FMC	160.1	143.9	55	0.249
	HC	296.7	322.9	190	
	OFD	338.2	338.7	708	
	HO	293.4	296.5	365	
	Total	**301.3**	**316.6**	**1318**	

Table 46: Facility specific mean cost per dose, cost per FIC and cost per infant without wages by type of facility

By facility type		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose without wages	FMC	2.9	2.7	55	0.014
	HC	4.5	4.6	190	
	OFD	5.0	5.0	708	
	HO	7.1	7.1	365	
	Total	**5.2**	**5.5**	**1318**	
Economic cost per dose without wages	FMC	3.3	3.1	55	0.009
	HC	5.0	5.2	190	
	OFD	5.9	5.9	708	
	HO	8.5	8.5	365	
	Total	**6.1**	**6.4**	**1318**	
Financial cost per FIC without wages	FMC	43.4	40.7	55	0.091
	HC	73.1	79.2	190	
	OFD	96.0	96.2	708	
	HO	125.2	126.4	365	
	Total	**93.2**	**99.8**	**1318**	
Economic cost per FIC without wages	FMC	49.0	45.9	55	0.083
	HC	82.3	89.9	190	
	OFD	112.7	113.0	708	
	HO	150.9	152.4	365	
	Total	**109.4**	**117.8**	**1318**	
Financial cost per infant without wages	FMC	40.2	37.8	55	0.162
	HC	69.8	77.9	190	
	OFD	93.9	94.1	708	
	HO	113.7	115.1	365	
	Total	**88.5**	**95.2**	**1318**	
Economic cost per infant without wages	FMC	45.4	42.6	55	0.152
	HC	78.7	88.5	190	
	OFD	110.4	110.6	708	
	HO	136.9	138.7	365	
	Total	**103.9**	**112.3**	**1318**	

Table 47: Facility specific mean cost per dose, cost per FIC and cost per infant by facility scale

By facility scale		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose	Low	18.8	19.0	489	0.311
	Medium	17.7	17.6	556	
	High	14.7	14.1	273	
	Total	**17.1**	**17.4**	**1318**	
Economic cost per dose	Low	20.4	20.5	489	0.190
	Medium	18.4	18.3	556	
	High	15.2	14.5	273	
	Total	**18.0**	**18.3**	**1318**	
Financial cost per FIC	Low	324.9	328.2	489	0.096
	Medium	347.2	346.0	556	
	High	228.0	224.8	273	
	Total	**301.9**	**314.3**	**1318**	
Economic cost per FIC	Low	353.8	357.5	489	0.078
	Medium	360.9	359.7	556	
	High	234.4	231.2	273	
	Total	**318.2**	**332.3**	**1318**	
Financial cost per infant	Low	300.0	303.9	489	0.064
	Medium	340.5	339.3	556	
	High	210.2	210.0	273	
	Total	**285.9**	**299.5**	**1318**	
Economic cost per infant	Low	327.2	331.5	489	0.059
	Medium	354.0	352.8	556	
	High	216.2	216.1	273	
	Total	**301.3**	**316.6**	**1318**	

Table 48: Facility specific mean cost per dose, cost per FIC and cost per infant without wages by facility scale

By facility scale		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Financial cost per dose without wages	Low	7.5	7.6	489	p<0.01
	Medium	4.6	4.5	556	
	High	3.6	3.5	273	
	Total	**5.2**	**5.5**	**1318**	
Economic cost per dose without wages	Low	9.1	9.1	489	p<0.01
	Medium	5.2	5.2	556	
	High	4.0	3.9	273	
	Total	**6.1**	**6.4**	**1318**	
Financial cost per FIC without wages	Low	136.7	138.0	489	p<0.01
	Medium	88.2	88.1	556	
	High	55.2	55.1	273	
	Total	**93.2**	**99.8**	**1318**	
Economic cost per FIC without wages	Low	165.7	167.3	489	p<0.01
	Medium	101.9	101.7	556	
	High	61.6	61.6	273	
	Total	**109.4**	**117.8**	**1318**	
Financial cost per infant without wages	Low	128.3	129.7	489	p<0.01
	Medium	86.5	86.3	556	
	High	50.9	51.4	273	
	Total	**88.5**	**95.2**	**1318**	
Economic cost per infant without wages	Low	155.5	157.3	489	p<0.01
	Medium	99.9	99.8	556	
	High	56.8	57.4	273	
	Total	**103.9**	**112.3**	**1318**	

Table 49: Breakdown of the weighted facility specific mean economic cost per dose by location

Item	Rural		Semi-Urban		Urban		Total	
	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost
Recurrent cost	**15.53**	**83.4**	**13.22**	**91.0**	**11.81**	**89.9**	**15.36**	**83.71**
Salaried Labour	12.06	64.71	10.56	73.61	9.43	72.31	11.94	65.07
Per-Dime & Travel Allowances	0.04	0.00	0.03	0.00	0.00	0.00	0.04	0.22
Vaccines	1.49	8.02	1.39	9.72	1.54	12.31	1.49	8.12
Vaccine Injection & Safety Supplies	0.11	0.53	0.09	0.69	0.12	0.77	0.11	0.60
Other Supplies	0.04	0.00	0.01	0.00	0.03	0.00	0.04	0.22
Transportation/fuel	0.33	1.60	0.09	0.69	0.01	0.00	0.31	1.69
Vehicle maintenance	0.02	0.00	0.01	0.00	0.01	0.00	0.02	0.11
Cold Chain energy	0.16	1.07	0.02	0.00	0.00	0.00	0.15	0.82
Printing	0.02	0.00	0.13	0.69	0.22	1.54	0.03	0.16
Building overhead	1.21	6.42	0.83	5.56	0.41	3.08	1.18	6.43
Other recurrent	0.05	0.53	0.06	0.69	0.04	0.00	0.05	0.27
Capital cost	**3.10**	**16.6**	**1.31**	**9.00**	**1.33**	**10.1**	**2.99**	**16.29**
Cold chain equipment	0.52	2.67	0.05	0.00	0.02	0.00	0.49	2.67
Vehicles	0.15	1.07	0.14	0.69	0.01	0.00	0.15	0.82
Other equipment	0.46	2.67	0.33	2.08	0.19	1.54	0.45	2.45
Building	1.97	10.70	0.79	5.56	1.11	8.46	1.90	10.35
TOTAL	**18.63**	**100.00**	**14.53**	**100.00**	**13.14**	**100.00**	**18.35**	**100.00**

Table 50: Breakdown of the weighted facility specific mean economic cost per dose by facility type

Item	FMC		HC		OFD		HO		Total	
	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost
Recurrent cost	**9.33**	**89.7**	**17.21**	**88.7**	**15.83**	**85.4**	**14.41**	**77.2**	**15.36**	**83.71**
Salaried Labour	7.33	70.48	14.21	73.25	12.62	68.11	10.16	54.42	11.94	65.07
Per-Dime & Travel Allowances	0.01	0.10	0.02	0.10	0.02	0.11	0.10	0.54	0.04	0.22
Vaccines	1.40	13.46	1.49	7.68	1.52	8.20	1.44	7.71	1.49	8.12
Vaccine Injection & Safety supplies	0.10	0.96	0.09	0.46	0.11	0.59	0.11	0.59	0.11	0.60
Other Supplies	0.01	0.10	0.03	0.15	0.04	0.22	0.04	0.21	0.04	0.22
Transportation/fuel	0.03	0.29	0.19	0.98	0.24	1.30	0.57	3.05	0.31	1.69
Vehicle maintenance	0.00	0.00	0.03	0.15	0.03	0.16	0.00	0.00	0.02	0.11
Cold Chain energy	0.01	0.10	0.09	0.46	0.09	0.49	0.33	1.77	0.15	0.82
Printing	0.11	1.06	0.09	0.46	0.02	0.11	0.00	0.00	0.03	0.16
Building overhead	0.28	2.69	0.94	4.85	1.10	5.94	1.58	8.46	1.18	6.43
Other recurrent	0.05	0.48	0.03	0.15	0.04	0.22	0.08	0.43	0.05	0.27
Capital cost	**1.07**	**10.3**	**2.19**	**11.3**	**2.70**	**14.6**	**4.26**	**22.8**	**2.99**	**16.29**
Cold chain equipment	0.02	0.19	0.15	0.77	0.42	2.27	0.86	4.61	0.49	2.67
Vehicles	0.03	0.29	0.41	2.11	0.16	0.86	0.01	0.05	0.15	0.82
Other equipment	0.28	2.69	0.51	2.63	0.41	2.21	0.53	2.84	0.45	2.45
Building	0.74	7.12	1.12	5.77	1.71	9.23	2.86	15.32	1.90	10.35
TOTAL	**10.40**	**100.00**	**19.4**	**100.00**	**18.53**	**100.00**	**18.67**	**100.00**	**18.35**	**100.00**

Table 51: Breakdown of the weighted facility specific mean economic cost per dose by facility scale

Item	Low		Medium		High		Total	
	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost	Cost per dose $US	% of total cost
Recurrent cost	**15.77**	**76.9**	**16.09**	**87.7**	**13.14**	**90.70**	**15.36**	**83.71**
Salaried Labour	11.38	55.46	13.09	71.37	10.61	73.27	11.94	65.07
Per-Dime & Travel Allowances	0.08	0.39	0.03	0.16	0.02	0.14	0.04	0.22
Vaccines	1.53	7.46	1.48	8.07	1.44	9.94	1.49	8.12
Vaccine Injection & Safety Supplies	0.12	0.58	0.09	0.49	0.10	0.69	0.11	0.60
Other Supplies	0.07	0.34	0.02	0.11	0.02	0.14	0.04	0.22
Transportation/fuel	0.50	2.44	0.27	1.47	0.07	0.48	0.31	1.69
Vehicle maintenance	0.03	0.15	0.01	0.05	0.02	0.14	0.02	0.11
Cold Chain energy	0.29	1.41	0.09	0.49	0.03	0.21	0.15	0.82
Printing	0.01	0.05	0.02	0.11	0.06	0.41	0.03	0.16
Building overhead	1.70	8.28	0.94	5.13	0.73	5.04	1.18	6.43
Other recurrent	0.06	0.29	0.05	0.27	0.04	0.28	0.05	0.27
Capital cost	**4.75**	**23.1**	**2.25**	**12.3**	**1.34**	**9.30**	**2.99**	**16.29**
Cold chain equipment	0.93	4.53	0.30	1.64	0.08	0.55	0.49	2.67
Vehicles	0.13	0.63	0.16	0.87	0.17	1.17	0.15	0.82
Other equipment	0.58	2.83	0.42	2.29	0.27	1.86	0.45	2.45
Building	3.11	15.16	1.37	7.47	0.82	5.66	1.90	10.35
TOTAL	**20.52**	**100.00**	**18.34**	**100.00**	**14.48**	**100.00**	**18.35**	**100.00**

Table 52: Breakdown of the weighted facility specific mean economic cost per infant by location

Item	Rural		Semi-Urban		Urban		Total	
	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost
Recurrent cost	**269.59**	**83.06**	**187.94**	**90.80**	**148.14**	**89.87**	**263.83**	**83.34**
Salaried Labour	208.38	64.20	150.89	72.90	118.13	71.67	204.24	64.52
Per-Dime & Travel Allowances	0.56	0.17	0.37	0.18	0.00	0.00	0.54	0.17
Vaccines	26.18	8.07	20.46	9.89	19.31	11.72	25.81	8.15
Vaccine Injection & Safety Supplies	1.83	0.56	1.26	0.61	1.47	0.89	1.80	0.57
Other Supplies	0.80	0.25	0.16	0.08	0.44	0.27	0.76	0.24
Transportation/fuel	5.17	1.59	1.29	0.62	0.12	0.07	4.91	1.55
Vehicle maintenance	0.27	0.08	0.12	0.06	0.07	0.04	0.26	0.08
Cold Chain energy	2.88	0.89	0.28	0.14	0.06	0.04	2.72	0.86
Printing	0.26	0.08	1.69	0.82	2.83	1.72	0.37	0.12
Building overhead	22.55	6.95	10.53	5.09	5.15	3.12	21.71	6.86
Other recurrent	0.71	0.22	0.89	0.43	0.56	0.34	0.71	0.22
Capital cost	**54.98**	**16.94**	**19.04**	**9.20**	**16.69**	**10.13**	**52.74**	**16.66**
Cold chain equipment	8.98	2.77	0.72	0.35	0.25	0.15	8.47	2.68
Vehicles	2.41	0.74	1.93	0.93	0.12	0.07	2.34	0.74
Other equipment	7.66	2.36	4.70	2.27	2.32	1.41	7.43	2.35
Building	35.93	11.07	11.69	5.65	14.00	8.49	34.50	10.90
TOTAL	**324.57**	**100.00**	**206.98**	**100.00**	**164.83**	**100.00**	**316.57**	**100.00**

Table 53: Breakdown of the weighted facility specific mean economic cost per infant by facility type

Item	FMC		HC		OFD		HO		Total	
	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost
Recurrent cost	**129.07**	**89.70**	**284.58**	**88.14**	**284.14**	**84.86**	**226.6**	**76.42**	**263.83**	**83.34**
Salaried Labour	101.30	70.40	234.38	72.59	228.14	68.13	157.86	53.24	204.24	64.52
Per-Dime & Travel Allowances	0.17	0.12	0.39	0.12	0.34	0.10	1.08	0.36	0.54	0.17
Vaccines	19.46	13.52	25.15	7.79	27.39	8.18	24.05	8.11	25.81	8.15
Vaccine Injection & Safety supplies	1.38	0.96	1.59	0.49	1.92	0.57	1.76	0.59	1.80	0.57
Other Supplies	0.13	0.09	0.46	0.14	0.87	0.26	0.81	0.27	0.76	0.24
Transportation/fuel	0.43	0.30	3.25	1.01	0.43	0.13	7.57	2.55	4.91	1.55
Vehicle maintenance	0.06	0.04	0.55	0.17	0.34	0.10	0.00	0.00	0.26	0.08
Cold Chain energy	0.18	0.13	1.47	0.46	1.74	0.52	5.65	1.91	2.72	0.86
Printing	1.56	1.08	1.30	0.40	0.21	0.06	0.00	0.00	0.37	0.12
Building overhead	3.75	2.61	15.59	4.83	22.08	6.59	26.90	9.07	21.71	6.86
Other recurrent	0.65	0.45	0.45	0.14	0.68	0.20	0.92	0.31	0.71	0.22
Capital cost	**14.82**	**10.30**	**38.31**	**11.86**	**50.71**	**15.14**	**69.93**	**23.58**	**52.74**	**16.66**
Cold chain equipment	0.33	0.23	2.76	0.85	7.74	2.31	14.07	4.74	8.47	2.68
Vehicles	0.38	0.26	7.35	2.28	2.22	0.66	0.27	0.09	2.34	0.74
Other equipment	3.94	2.74	8.44	2.61	7.21	2.15	7.87	2.65	7.43	2.35
Building	10.17	7.07	19.76	6.12	33.54	10.02	47.72	16.09	34.50	10.90
TOTAL	**143.89**	**100.00**	**322.89**	**100.00**	**334.85**	**100.00**	**296.53**	**100.00**	**316.57**	**100.00**

Table 54: Breakdown of the weighted facility specific mean economic cost per infant by facility scale

Item	Low		Medium		High		Total	
	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost	Cost per infant $US	% of total cost
Recurrent cost	**249.43**	**75.24**	**309.83**	**87.83**	**195.91**	**90.67**	**263.83**	**83.34**
Salaried Labour	174.19	52.54	253.01	71.72	158.64	73.42	204.24	64.52
Per-Dime & Travel Allowances	0.81	0.24	0.46	0.13	0.25	0.12	0.54	0.17
Vaccines	26.27	7.92	27.65	7.84	21.24	9.83	25.81	8.15
Vaccine Injection & Safety Supplies	2.05	0.62	1.76	0.50	1.46	0.68	1.80	0.57
Other Supplies	1.47	0.44	0.37	0.10	0.30	0.14	0.76	0.24
Transportation/fuel	6.77	2.04	5.15	1.46	1.10	0.51	4.91	1.55
Vehicle maintenance	0.31	0.09	0.15	0.04	0.40	0.19	0.26	0.08
Cold Chain energy	5.02	1.51	1.79	0.51	0.49	0.23	2.72	0.86
Printing	0.13	0.04	0.34	0.10	0.85	0.39	0.37	0.12
Building overhead	31.72	9.57	18.35	5.20	10.62	4.92	21.71	6.86
Other recurrent	0.69	0.21	0.80	0.23	0.56	0.26	0.71	0.22
Capital cost	**82.08**	**24.76**	**42.94**	**12.17**	**20.16**	**9.33**	**52.74**	**16.66**
Cold chain equipment	15.56	4.69	5.79	1.64	1.20	0.56	8.47	2.68
Vehicles	1.41	0.43	2.91	0.82	2.88	1.33	2.34	0.74
Other equipment	9.05	2.73	7.66	2.17	4.08	1.89	7.43	2.35
Building	56.06	16.91	26.58	7.53	12.00	5.55	34.50	10.90
TOTAL	**331.51**	**100.00**	**352.77**	**100.00**	**216.07**	**100.00**	**316.57**	**100.00**

Table 55: Breakdown of the weighted facility specific mean economic cost per FIC by location

Item	Rural		Semi-Urban		Urban		Total	
	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost
Recurrent cost	**282.48**	**83.00**	**201.71**	**90.83**	**161.9**	**89.88**	**276.79**	**83.29**
Salaried Labour	218.64	64.25	161.93	72.92	129.10	71.67	214.55	64.56
Per-Dime & Travel Allowances	0.71	0.21	0.40	0.18	0.00	0.00	0.68	0.20
Vaccines	27.30	8.02	21.87	9.85	21.13	11.73	26.96	8.11
Vaccine Injection & Safety Supplies	1.93	0.57	1.34	0.60	1.61	0.89	1.90	0.57
Other Supplies	0.81	0.24	0.18	0.08	0.47	0.26	0.78	0.23
Transportation/fuel	5.37	1.58	1.40	0.63	0.14	0.08	5.11	1.54
Vehicle maintenance	0.28	0.08	0.13	0.06	0.07	0.04	0.27	0.08
Cold Chain energy	3.07	0.90	0.30	0.14	0.06	0.03	2.89	0.87
Printing	0.26	0.08	1.81	0.82	3.06	1.70	0.38	0.11
Building overhead	23.33	6.86	11.39	5.13	5.65	3.14	22.49	6.77
Other recurrent	0.78	0.23	0.96	0.43	0.61	0.34	0.78	0.23
Capital cost	**57.84**	**17.00**	**20.36**	**9.17**	**18.22**	**10.12**	**55.52**	**16.71**
Cold chain equipment	9.68	2.84	0.77	0.35	0.27	0.15	9.13	2.75
Vehicles	2.48	0.73	2.08	0.94	0.13	0.07	2.42	0.73
Other equipment	8.14	2.39	5.00	2.25	2.55	1.42	7.90	2.38
Building	37.54	11.03	12.51	5.63	15.27	8.48	36.07	10.85
TOTAL	**340.32**	**100.00**	**222.07**	**100.00**	**180.12**	**100.00**	**332.31**	**100.00**

Table 56: Breakdown of the weighted facility specific mean economic cost per FIC by facility type

Item	FMC		HC		OFD		HO		Total	
	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost
Recurrent cost	**139.11**	**89.73**	**290.04**	**88.21**	**295.6**	**85.14**	**254.34**	**76.57**	**276.79**	**83.29**
Salaried Labour	109.19	70.43	238.87	72.65	234.22	67.46	179.77	54.12	214.55	64.56
Per-Dime & Travel Allowances	0.17	0.11	0.40	0.12	0.36	0.10	1.54	0.46	0.68	0.20
Vaccines	20.97	13.53	25.62	7.79	28.11	8.10	26.32	7.92	26.96	8.11
Vaccine Injection & Safety supplies	1.49	0.96	1.62	0.49	1.96	0.56	1.99	0.60	1.90	0.57
Other Supplies	0.14	0.09	0.48	0.15	0.87	0.25	0.85	0.26	0.78	0.23
Transportation/fuel	0.46	0.30	3.29	1.00	4.43	1.28	8.07	2.43	5.11	1.54
Vehicle maintenance	0.06	0.04	0.55	0.17	0.35	0.10	0.00	0.00	0.27	0.08
Cold Chain energy	0.20	0.13	1.47	0.45	1.76	0.51	6.24	1.88	2.89	0.87
Printing	1.67	1.08	1.33	0.40	0.21	0.06	0.00	0.00	0.38	0.11
Building overhead	4.06	2.62	15.93	4.85	22.62	6.52	28.46	8.57	22.49	6.77
Other recurrent	0.70	0.45	0.48	0.15	0.71	0.20	1.10	0.33	0.78	0.23
Capital cost	**15.93**	**10.27**	**38.75**	**11.79**	**51.59**	**14.86**	**77.82**	**23.43**	**55.52**	**16.71**
Cold chain equipment	0.35	0.23	2.78	0.85	7.84	2.26	16.24	4.89	9.13	2.75
Vehicles	0.40	0.26	7.40	2.25	2.35	0.68	0.27	0.08	2.42	0.73
Other equipment	4.20	2.71	8.52	2.59	7.35	2.12	9.20	2.77	7.90	2.38
Building	10.98	7.08	20.05	6.10	34.05	9.81	52.11	15.69	36.07	10.85
TOTAL	**155.04**	**100.00**	**328.79**	**100.00**	**347.19**	**100.00**	**332.16**	**100.00**	**332.31**	**100.00**

Table 57: Breakdown of the weighted facility specific mean economic cost per FIC by facility scale

Item	Low		Medium		High		Total	
	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost	Cost per FIC $US	% of total cost
Recurrent cost	**269.66**	**75.42**	**315.98**	**87.85**	**209.61**	**90.65**	**276.79**	**83.29**
Salaried Labour	190.23	53.21	257.94	71.72	169.65	73.37	214.55	64.56
Per-Dime & Travel Allowances	1.15	0.32	0.47	0.13	0.27	0.12	0.68	0.20
Vaccines	27.90	7.80	28.17	7.83	22.78	9.85	26.96	8.11
Vaccine Injection & Safety Supplies	2.22	0.62	1.79	0.50	1.55	0.67	1.90	0.57
Other Supplies	1.50	0.42	0.37	0.10	0.31	0.13	0.78	0.23
Transportation/fuel	7.12	1.99	5.27	1.47	1.17	0.51	5.11	1.54
Vehicle maintenance	0.31	0.09	0.15	0.04	0.44	0.19	0.27	0.08
Cold Chain energy	5.45	1.52	1.81	0.50	0.51	0.22	2.89	0.87
Printing	0.13	0.04	0.34	0.09	0.89	0.38	0.38	0.11
Building overhead	32.83	9.18	18.85	5.24	11.39	4.93	22.49	6.77
Other recurrent	0.82	0.23	0.82	0.23	0.65	0.28	0.78	0.23
Capital cost	**87.87**	**24.58**	**43.69**	**12.15**	**21.63**	**9.35**	**55.52**	**16.71**
Cold chain equipment	17.17	4.80	5.90	1.64	1.29	0.56	9.13	2.75
Vehicles	1.41	0.39	2.91	0.81	3.25	1.41	2.42	0.73
Other equipment	10.02	2.80	7.81	2.17	4.27	1.85	7.90	2.38
Building	59.27	16.58	27.07	7.53	12.82	5.54	36.07	10.85
TOTAL	**357.53**	**100.00**	**359.67**	**100.00**	**231.24**	**100.00**	**332.31**	**100.00**

Table 58: Total facility specific Financial and Economic mean cost with and without wages by location

By location		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Total Financial cost	Rural	4,398	4,053	1238	0.000
	Semi-urban	28,924	31,173	54	
	Urban	82,394	82,394	26	
	Total	**11,530**	**6,710**	**1318**	
Total Financial Cost without wages	Rural	1,168	1,098	1238	0.000
	Semi-urban	7,575	8,829	54	
	Urban	21,226	21,226	26	
	Total	**3,013**	**1,812**	**1318**	
Total Economic Cost	Rural	4,563	4,215	1238	0.000
	Semi-urban	29,781	32,160	54	
	Urban	85,524	85,524	26	
	Total	**11,943**	**6,964**	**1318**	
Total Economic Cost without wages	Rural	1,334	1,260	1238	0.000
	Semi-urban	8,433	9,816	54	
	Urban	24,356	24,356	26	
	Total	**3,425**	**2,066**	**1318**	

Table 59: Total facility specific Financial and Economic mean cost with and without wages by facility type

By facility type		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Total Financial cost	FMC	60,744	55,877	55	0.000
	HC	15,610	11,494	708	
	OFD	4,147	4,135	190	
	HO	1,777	1,765	365	
	Total	**11,530**	**6,710**	**1318**	
Total Financial cost without wages	FMC	16,136	15,456	55	0.000
	HC	3,721	2,796	708	
	OFD	1,103	1,101	190	
	HO	615	612	365	
	Total	**3,013**	**1,812**	**1318**	
Total Economic cost	FMC	62,902	57,869	55	0.000
	HC	16,079	11,849	708	
	OFD	4,310	4,298	190	
	HO	1,893	1,881	365	
	Total	**11,943**	**6,964**	**1318**	
Total Economic cost Without wages	FMC	18,294	17,448	55	0.000
	HC	4,189	3,151	708	
	OFD	1,266	1,264	190	
	HO	731	728	365	
	Total	**3,425**	**2,066**	**1318**	

Table 60: Total facility specific Financial and Economic mean cost with and without wages by facility scale

By facility scale		Unweighted Mean $US	Weighted Mean $US	N	Unweighted P Value
Total Financial cost	Low	1,337	1,343	489	0.000
	Medium	4,316	4,303	556	
	High	29,840	21,247	273	
	Total	**11,530**	**6,710**	**1318**	
Total Financial cost Without wages	Low	542	543	489	0.000
	Medium	1,103	1,102	556	
	High	7,631	5,538	273	
	Total	**3,013**	**1,812**	**1318**	
Total Economic cost	Low	1,451	1,457	489	0.000
	Medium	4,477	4,465	556	
	High	30,833	21,942	273	
	Total	**11,943**	**6,964**	**1318**	
Total Economic cost Without wages	Low	656	658	489	0.000
	Medium	1,264	1,263	556	
	High	8,624	6,232	273	
	Total	**3,425**	**2,066**	**1318**	

Annex 3: Cost Matrix of Routine Immunization

Table 61: Matrix of facility level economic costs of routine immunization (USD)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour	1,924,379	1,102,743	182,308	286,448	1,079,058	4,188	146,817	186,047	1,519,124	23,349	**6,454,459**
Per Diem & Travel Allowances				10,189							**10,189**
Vaccines	988,318										**988,318**
Vaccine Injection & Safety Supplies	70,373										**70,373**
Other Supplies	5,896	3,039		860		13			4,253		**14,061**
Transport/ Fuel	3,791		472	7,815		299		42,697	12,654		**67,728**
Vehicle Maintenance			387	476		140		5,717	1,278		**7,998**
Cold Chain Energy Costs	29,478										**29,478**
Printing		50,310									**50,310**
Building overhead, Utilities, Communication	416,069					263					**416,333**
Other Recurrent				27,561			356			692	**28,609**
Cold Chain Equipment	83,937							7,546			**91,483**
Vehicles			1,941	748		351		48,287	13,720		**65,047**
Other Equipment	158,735	32,550				92					**191,377**
Buildings	691,608					550					**692,158**
TOTAL	**4,372,584**	**1,188,642**	**185,108**	**334,097**	**1,079,058**	**5,633**	**147,173**	**290,294**	**1,551,292**	**24,041**	**9,177,922**

Table 62: Matrix of district level economic costs of routine immunization (USD)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour	1,924,379	1,160,210	222,526	297,452	1,082,491	45,592	183,197	262,349	1,545,696	29,724	**6,753,616**
Per Diem & Travel Allowances				12,426				443	53		**12,923**
Vaccines	988,318										**988,318**
Vaccine Injection & Safety Supplies	70,373										**70,373**
Other Supplies	5,896	4,793		1,110		1,037			4,887		**17,724**
Transport/ Fuel	3,791		3,402	10,356	65	435		51,141	14,718		**83,907**
Vehicle Maintenance			4,483	3,700		150		19,455	4,825		**32,614**
Cold Chain Energy Costs	44,647										**44,647**
Printing		52,739			55						**52,794**
Building overhead, Utilities, Communication	416,069					4,932			38,793		**459,794**
Other Recurrent				28,231			356			692	**29,279**
Cold Chain Equipment	101,224							10,205			**111,429**
Vehicles			6,229	1,168		355		56,030	15,863		**79,645**
Other Equipment	158,735	36,602				3,009			14,168		**212,514**
Buildings	691,608					9,355			63,785		**764,748**
TOTAL	**4,405,040**	**1,254,344**	**236,640**	**354,444**	**1,082,611**	**64,865**	**183,553**	**399,623**	**1,702,788**	**30,417**	**9,714,325**

Table 63: Matrix of national level economic costs of routine immunization (USD)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour	1,924,379	1,163,618	224,258	299,131	1,083,283	49,637	186,701	264,420	1,549,686	29,952	**6,775,065**
Per Diem & Travel Allowances				13,798				443	53		**14,295**
Vaccines	988,318										**988,318**
Vaccine Injection & Safety Supplies	70,373										**70,373**
Other Supplies	5,896	4,910		1,168		1,176			5,024	2,500	**20,675**
Transport/ Fuel	3,791		3,586	10,356	65	435		51,169	14,718		**84,119**
Vehicle Maintenance			6,130	3,700		150		19,702	4,825		**34,508**
Cold Chain Energy Costs	47,917										**47,917**
Printing	1,960	52,905			3,981						**52,846**
Building overhead, Utilities, Communication	416,070					8,118			52,499		**476,687**
Other Recurrent				28,231		4,418	356			54,856	**87,861**
Cold Chain Equipment	106,692								10,529		**117,221**
Vehicles			8,668	1,168		355		56,396	15,863		**82,449**
Other Equipment	158,735	36,973				3,450			15,692		**214,850**
Buildings	691,608					12,836			78,760		**783,205**
TOTAL	**4,415,738**	**1,258,407**	**242,643**	**357,552**	**1,087,329**	**80,575**	**187,057**	**402,658**	**1,737,121**	**87,309**	**9,856,389**

Annex 4: Cost Matrix for Incremental NUVI costs

Table 64: Matrix of a facility level incremental Economic Costs for NUVI (US $)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour				32,335	18,992						**51,327**
Per Diem & Travel Allowances											
Vaccines	254,867										**254,867**
Transport/ Fuel				4,321					1,788		**6,109**
Cold Chain Equipment	14,978							1,570			**16,548**
TOTAL	**269,845**			**36,656**	**18,992**			**1,570**	**1,788**		**28,851**

Table 65: Matrix of a district level incremental Economic Costs for NUVI (US $)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour				33,100	18,992				875		**52,966**
Per Diem & Travel Allowances				221							**221**
Vaccines	254,867										**254,867**
Transport/ Fuel				5,688	129			641	1,788		**8,247**
Vehicle Maintenance											
Cold Chain Equipment	18,957							2,177			**21,134**
TOTAL	**273,824**			**39,008**	**19,121**			**2,819**	**2,663**		**337,435**

Table 66: Matrix of a National level incremental Economic Costs for NUVI (US $)

Line Item/ Activity	Routine Facility-based Service Delivery	Record-Keeping & HMIS	Super-vision	Training	Social Mobilization & Advocacy	Surveillance	Cold Chain Maintenance	Vaccine Collection, Distribution Storage	Program Management	Other	TOTAL
Salaried Labour			2,465	33,230	18,992				10,764		**65,451**
Per Diem & Travel Allowances			846	1,279							**2,126**
Vaccines	254,867										**254,867**
Transport/ Fuel			2,624	5,692	129			660	1,788		**10,893**
Printing	12,511			2,828							**15,339**
Building overhead, Utilities, Communication									29,771		**29,771**
Other Recurrent				2,602	18,842	16,785	5,840		9,964		**54,033**
Cold Chain Equipment	20,269							2,255			**22,524**
Other Equipment									22,641		**22,641**
TOTAL	**287,647**		**5,935**	**45,631**	**37,964**	**16,785**	**5,840**	**2,915**	**74,928**		**477,645**

Annex 5:

Table 67: Sample definition

Center Characteristics A	B	No. of Facilities C	Sample D	Ratio E=C:D
Low Doses Administered	Rural	257	8	32.5
	Semi-Urban	15	2	7.5
Medium Doses Administered	Rural	464	15	30.9
	Semi-Urban	17	2	8.5
High Doses Administered	Rural	508	17	29.9
	Semi-Urban	22	1	22
Capital City	Rural	9	2	4.5
	Semi-Urban	26	3	8.7

Table 68: Summary statistics; weighted sample

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Fully Immunized Children (FIC)	50	33,82	88,77	1	714
Total number of doses administered	50	516,61	1245,69	33	9060
Total Economic Cost, Facility Level	50	6963	13682	565	112548
Total Economic Cost, Facility + District Level	50	7341,4	14207,3	627,7	115062
Total Economic Cost, Facility + District + National Level	50	7434,6	14419,6	641,2	116657
Share of staff time spent in the facility for immunization in % (FTE)	50	0,82	1,28	0,2	10,20
Total working hours	50	50,43	12,67	8	71
Total facility square meters	50	349,22	898,37	20	5820
Cold chain capital index (% of the cold chain cost from the total cost)	50	69,45	19,64	7,79	136,14
Hourly wage, mid career nurse (USD)	50	1,82	0,16	1,45	2,28
Refrigerator unit price (USD)	50	0,74	0,34	0,01	2,13
Total number of infants in the facility catchment area	50	36,07	97,66	1	810
Share of population with university education in %	50	4,96	3,40	2,90	24,40
Dummy Facility Type (=1 if FMC)	50	0,04	0,20	0	1
Dummy Doctor at the facility (=1 Yes)	50	0,86	0,35	0	1
Dummy Facility Location (=1 if Urban)	50	0,02	0,14	0	1
Distance from the facility to the vaccine collection point	50	20,64	13,35	0	50
Overall Wastage Rate in % (from total number of doses administered)	50	17,45	9,41	4,90	36,90

Note: each observation represents 1317.97 facilities.

Table 69: Production Determinants - in natural logarithms

	Ln FIC		Ln Total Dose Adm.	
VARIABLES	(1)	(2)	(3)	(4)
Ln Total working hours	0.265***	0.265**	0.296**	0.296**
	(0.0520)	(0.110)	(0.133)	(0.124)
Ln Total facility square meters	0.0564**	0.0564**	0.211***	0.211***
	(0.0273)	(0.0251)	(0.0700)	(0.0568)
Ln Total number of infants in the facility catchment area	0.909***	0.909***	0.619***	0.619***
	(0.0280)	(0.0319)	(0.0718)	(0.0596)
Dummy Facility Type (=1 if FMC)	-0.0514	-0.0514	0.206	0.206
	(0.129)	(0.0800)	(0.330)	(0.265)
Dummy Doctor at the facility (=1 Yes)	0.0681	0.0681	0.269*	0.269
	(0.0542)	(0.0785)	(0.139)	(0.194)
Ln Distance from the facility to the vaccine collection point	-0.0351	-0.0351*	-0.0663	-0.0663
	(0.0250)	(0.0185)	(0.0642)	(0.0507)
Ln Overal Wastage Rate	-0.117***	-0.117**	-0.383***	-0.383***
	(0.0373)	(0.0481)	(0.0958)	(0.118)
Constant	-0.767***	-0.767**	2.563***	2.563***
	(0.242)	(0.352)	(0.620)	(0.767)
R-squared	0.992	0.992	0.939	0.939

Notes: (1) Standard errors in parentheses. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. Ho: Constant variance. Chi2(1) = 2.24, Prob > chi2 = 0.1347. (2) Robust standard errors in parentheses. (3) Standard errors in parentheses. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. Ho: Constant variance. Chi2(1) = 6.93, Prob > chi2 = 0.0085. (4) Robust standard errors in parentheses.

Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Figure 15: Histogram of FIC

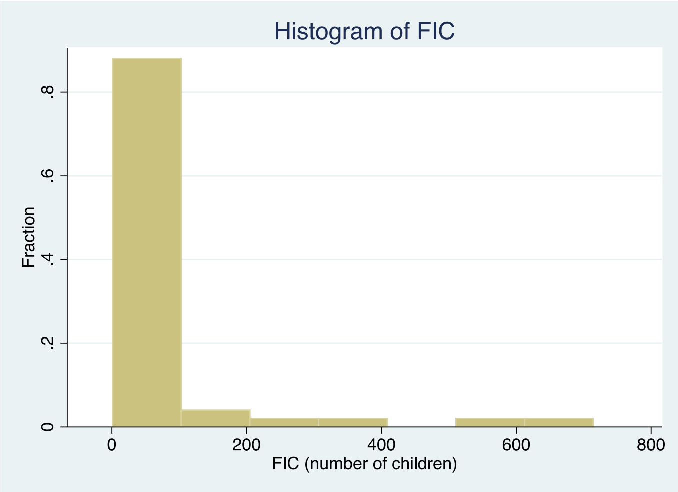


Figure 16: Histogram of total doses administered

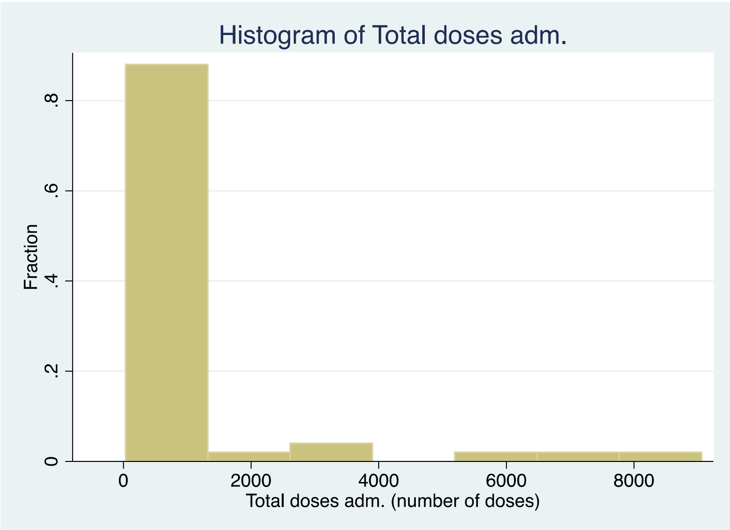


Table 70: Immunization working hours per week, by type of Human Resources

Position	Obs.	Mean
Director	13	6,18
Family doctor	144	6,94
Chief Nurse	18	10,22
Nurse vaccination	20	24,62
General Nurse	214	8,44

Table 71: Input Prices: Labour; Positions and hourly wage (USD); Summary statistics and coefficient of variation (CV).

Position	Obs.	Mean	SD	Min.	Max.	CV
Chief Nurse	18	2,48	0,43	1,63	3,19	0,17
Nurse vaccination	20	1,94	0,35	1,39	2,64	0,18
Nurse	214	1,91	0,49	0,54	4,72	0,26
Young	22	1,08	0,2	0,54	1,31	0,19

Mid-career	153	1,85	0,22	1,4	2,29	0,12
Experienced	39	2,63	0,42	2,31	4,72	0,16

Table 72: Input Prices: Capital; Type of equipment in the facility and unit prices corrected by volume; Summary statistics and coefficient of variation (CV).

Type	Obs.	Mean	SD	Min.	Max.	CV
Freeze Indicators	22	2,9	0,02	2,8	2,95	0,01
Ice Packs	50	0,06	0,01	0,05	0,1	0,17
Thermometers	48	3,04	0,53	2,9	5,5	0,17
Cold box	58	0,7	0,33	0,21	1,12	0,47
Refrigerator	52	0,68	0,41	0,01	2,12	0,60

Table 73: Total Economic Cost, Facility Level (Unweighted Sample)

	Dep. Var.: Ln Total Economic Cost, Facility Level			
VARIABLES	(1)	(2)	(3)	(4)
Ln Fully Immunized Children (FIC)	0.810***		0.625***	
	(0.0449)		(0.0664)	
Ln FIC Est.		0.806***		0.525***
		(0.103)		(0.124)
Ln Hourly wage, mid career nurse	0.685	1.252*	0.706	1.178*
	(1.028)	(0.733)	(0.980)	(0.671)
Ln Refrigerator unit price	-0.0993	0.126	-0.0857	0.0961
	(0.166)	(0.195)	(0.125)	(0.165)
Ln Ice pack unit price	-1.268	-0.800	-1.633*	-1.275
	(1.185)	(1.536)	(0.893)	(1.380)
Ln Share of population with university education			0.572***	0.800***
			(0.144)	(0.197)
Ln Overal Wastage Rate			-0.0221	-0.173
			(0.158)	(0.212)
Constant	2.026	3.269	0.646	1.881
	(3.420)	(4.234)	(2.667)	(3.996)
R-squared	0.890	0.813	0.918	0.863

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 74: Total Economic Cost without Wages, Facility Level

	Dep. Var.: Ln Total Economic Cost Without Wages, Facility Level					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Ln Fully Immunized Children (FIC)	0.629***		0.629***		0.480***	
	(0.0594)		(0.0586)		(0.0578)	
Ln FIC Est.		0.703***		0.705***		0.564***
		(0.0631)		(0.0650)		(0.0805)
Ln Hourly wage, mid career nurse	0.165	0.441	0.136	0.497	0.219	0.489
	(0.827)	(0.462)	(0.858)	(0.487)	(0.763)	(0.441)
Ln Refrigerator unit price	0.0423	0.154***	0.0145	0.207**	0.0366	0.189**
	(0.0560)	(0.0226)	(0.111)	(0.0904)	(0.0742)	(0.0880)
Ln Ice pack unit price			-0.230	0.439	-0.634	0.0116
			(0.932)	(0.769)	(0.633)	(0.700)
Ln Share of pop. with university education					0.692***	0.515***
					(0.124)	(0.153)
Ln Overal Wastage Rate					-0.0557	-0.0450
					(0.103)	(0.113)
Constant	5.339***	5.113***	4.698*	6.329***	3.043	4.841**
	(0.549)	(0.347)	(2.600)	(2.064)	(1.824)	(2.049)
R-squared	0.847	0.855	0.847	0.857	0.912	0.885

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 75: Total Economic Cost without Wages, Facility + District + National Level

	Dep. Var.: Ln Total Economic Cost Without Wages			
	Facility + District Level		Facility + District + National Level	
VARIABLES	(1)	(2)	(3)	(4)
Ln Fully Immunized Children (FIC)	0.658***	0.518***	0.665***	0.526***
	(0.0560)	(0.0605)	(0.0559)	(0.0610)
Ln Hourly wage, mid career nurse	0.0641	0.154	0.0682	0.159
	(0.797)	(0.725)	(0.786)	(0.715)
Ln Refrigerator unit price	0.0338	0.0645	0.0339	0.0653
	(0.0997)	(0.0694)	(0.0990)	(0.0694)
Ln Ice pack unit price	-0.189	-0.473	-0.198	-0.473
	(0.875)	(0.622)	(0.872)	(0.624)
Ln Share of population with university education		0.622***		0.617***
		(0.123)		(0.123)

Ln Overal Wastage Rate		-0.0925		-0.0956
		(0.113)		(0.114)
Constant	4.956**	3.814**	4.940**	3.840**
	(2.418)	(1.808)	(2.407)	(1.814)
R-squared	0.876	0.924	0.880	0.926

Notes: Robust standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 76: Correlation Matrix I

Correlation Matrix I

	lnFic	lnTotDosesAdm	workinghours	sqmeter	costo_ch	infants	Dfacilitytype	Ddoctor	distance	wastage
lnFic	1									
lnTotDosesAdm	0,97	1								
workinghours	0,51	0,49	1							
sqmeter	0,72	0,74	0,31	1						
costo_ch	0,62	0,65	0,24	0,62	1					
infants	0,76	0,76	0,32	0,76	0,72	1				
Dfacilitytype	0,67	0,68	0,27	0,87	0,63	0,81	1			
Ddoctor	0,31	0,34	0,15	0,16	0,08	0,15	0,12	1		
distance	-0,35	-0,39	-0,28	-0,41	-0,35	-0,32	-0,39	-0,23	1	
wastage	-0,32	-0,38	-0,03	-0,1	-0,02	-0,1	-0,12	-0,01	0,09	1

Table 77: Correlation Matrix II

Correlation Matrix II

	lnb1totalcost	lnb2totalcost	lnb3totalcost	lnFic	lnFicHat	lnWageHour	lnPriceRefrig	lnPriceIcePack	lnFte	lnSqMetx10k	lnUnivEduc	DFacilityType	LnDistance	lnWastage	Ddoctor	Durban
lnb1totalcost	1															
lnb2totalcost	1	1														
lnb3totalcost	1	1	1													
lnFic	0,94	0,94	0,94	1												
lnFicHat	0,89	0,89	0,89	0,9	1											
lnWageHour	0,11	0,1	0,1	0,06	-0,01	1										
lnPriceRefrig	0,3	0,31	0,31	0,26	0,11	0,21	1									
lnPriceIcePack	-0,25	-0,25	-0,25	-0,19	-0,1	-0,24	-0,86	1								
lnFte	0,98	0,98	0,98	0,89	0,83	0,13	0,36	-0,33	1							
lnSqMetx10k	-0,29	-0,29	-0,29	-0,43	-0,35	0,06	0,22	-0,2	-0,22	1						
lnUnivEduc	0,8	0,8	0,8	0,74	0,76	0	0,04	0,03	0,77	-0,11	1					
DFacilityType	0,69	0,69	0,69	0,69	0,76	-0,02	0,18	-0,1	0,65	-0,04	0,66	1				
LnDistance	-0,37	-0,38	-0,38	-0,38	-0,37	-0,12	-0,37	0,25	-0,32	-0,12	-0,19	-0,53	1			
lnWastage	-0,11	-0,12	-0,12	-0,19	-0,17	0,1	-0,03	0,11	-0,15	0,38	0,1	-0,07	-0,08	1		
Ddoctor	0,43	0,42	0,42	0,29	0,29	0,18	0,08	-0,13	0,46	-0,11	0,18	0,13	-0,22	0,19	1	
Durban	0,67	0,66	0,66	0,62	0,72	0,02	0,07	-0,09	0,63	-0,19	0,72	0,53	-0,17	0,1	0,11	1

Glossary

Variable	Description
Fully Immunized Children (FIC)	Number of children < 1 received DTP3 dose.
Total number of doses administered	Total number of doses administered for all vaccines in the facility in 2011.
Total Economic Cost, Facility Level	Total facility specific-related-to-immunization economic cost.
Total Economic Cost, Facility + District Level	Immunization economic cost, which includes facility specific expenditures and districts expenditures on public health centers.
Total Economic Cost, Facility + District + National Level	Immunization economic cost, which includes facility specific expenditures, plus national and districts expenditures for immunization services
Share of staff time spent in the facility for immunization in % (FTE)	Total staff time spent in the facility for immunization per week divided by the number of working hours per week, expressed in percentages.
Total working hours	Total working hours per week.
Total facility square meters	Total facility Square Meters.
Cold chain capital index	Cold chain economic cost in the facility, expressed in USD. Formula: (Share of the cold chain cost from the total cost (%)*Total Economic Cost, Facility Level)/100.
Hourly wage, mid career nurse (USD)	Hourly wage of midcareer nurse, expressed in USD.
Refrigerator unit price corrected by volume (USD)	Refrigerator unit price corrected by volume, expressed in USD. Formula: Total refrigerator economic cost/(Refrigerator quantity*Net volume).
Infants in the facility catchment area	Total number of infants in the facility catchment area.
Share of population with university education in %	Share of population with University education among 15-49 year old, expressed in percentages.
Dummy Facility Type (=1 if FMC)	Dummy =1 if FMC, 0= if Other.
Dummy Doctor at the facility (=1 Yes)	Dummy =1 if Yes, 0= if No.
Dummy Facility Location (=1 if Urban)	Dummy =1 if Urban, 0= if Other.
Distance from the facility to the vaccine collection point	Distance from the facility to the vaccine collection point.
Overal Wastage Rate in %	Overal vaccine wastage rate, expressed in percentages: (Total number of doses provided in 2011 - total number of doses administered in 2011)*100/total number of doses provided in 2011)

Annex 6: Data Coding for Financial Flow Analysis

Codes used for financial flow analysis:

Classification of types of revenues of health financing schemes (FS)

Code	Description
FS.1	Transfers from government domestic revenue
FS.1.1	Internal transfers and grants
FS.1.1.1	Internal transfers within central government
FS.2	Transfers distributed by government from foreign origin
FS.2.2	Commodity transfers
FS.2.2.3	GAVI
FS.7	Direct foreign transfers
FS.7.2	Direct foreign aid in-kind
FS.7.2.2	Direct foreign aid in kind: services (including TA)
FS.7.2.2.2	Direct multilateral foreign aid in kind
FS.7.2.2.2.1	UNICEF
FS.7.2.2.2.2	WHO

Classification of financing schemes (HF)

Code	Description
HF.1	Government schemes and compulsory contributory health care financing schemes
HF.1.1	Government schemes
HF.1.1.1	Central government schemes
HF.1.2	Compulsory contributory health insurance schemes
HF.4	The Rest of the World
HF.4.1	UNICEF
HF.4.2	WHO

Classification of financing agents (FA)

Code	Description
FA.1	**General Government**
FA.1.1	Central Government Agencies
FA.1.1.1	Central Ministry of Health:
FA.1.1.1.3/5	National Surveillance Agency & Medical Store[29]
FA.1.1.4	National Medical Insurance Company
FA.6	**Rest of the World**
FA.6.1	International Organisations (Multilaterals)
FA.6.1.1	UNICEF
FA.6.1.2	WHO

Classification of health care providers (HP)

Code	Description
HP.3	**Providers of ambulatory health care**
HP.3.4	Ambulatory health care centres
HP.3.4.9	All other ambulatory centres
HP3.4.9.1	*Government facilities*

[29] In Moldova both functions are performed by the same institution, therefore in these codes were used interchangeable to denote role of the Centre for Public Health.

Code	Description
HP3.4.9.1.1	Center of Family Doctors
HP3.4.9.1.2	Office of Family Doctors
HP3.4.9.1.3	Health Center
HP3.4.9.1.4	Health Office
HP.6	**Providers of preventive care**
HP.9	**Rest of the world**
HP.9.1	UNICEF
HP.9.2	WHO

Classification of health care functions (HC)

Code	Description
HC.6	**Preventive care**
HC.6.1	Information, education and counselling programmes
HC.6.1.1	Social mobilization, advocacy
HC.6.2	Immunization programmes
HC.6.2.1	Facility-based routine immunization service delivery
HC.6.2.3	Training
HC.6.2.4	Vaccine collection, storage and distribution
HC.6.2.5	Cold chain maintenance
HC.6.2.6	Supervision/Program management
HC.6.2.7	Other routine immunization program activity
HC.6.5	Surveillance
HC.6.5.1	EPI Surveillance
HC.6.5.2	Record-keeping and HMIS
HC.99	**Not disaggregated**

Classification of factors for health care provision (FP)

Code	Description
FP.1	**Compensation of employees**
FP.1.1	Wages and salaries
FP.1.3	All other costs relating to employees
FP.1.3.1	Per diem
FP.3	**Materials and services used**
FP.3.2	Vaccines & syringes
FP.3.3	Non-health care services
FP.3.3.1	Transport
FP.3.3.2	Maintenance
FP.3.3.3	Printing
FP.3.3.4	Utilities and communications
FP.3.4	Non-health care goods
FP.3.4.2	Other
FP.9.9	**Not disaggregated**

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