

# Evaluating the data quality, efficiency and operational cost of MyChild Solution in Uganda : The assessment report

June 2018

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# Executive Summary

This is an ineluctable fact that health systems and health policies cannot be navigated effectively without a good quality of data and efficient method to collect and process them. From planning to evaluation and quality improvement, data plays a pivotal role in the health systems, especially to expand the immunization coverage and mitigate the emergence of the preventable diseases, which is why it is vital to have high-quality data in an efficient way. Considering the shortages of health workers and workload in Uganda, the paper-based system is often burdensome, time-consuming and prone to errors, and thus, to address the issue Shifo Foundation introduced My Child Solution (MCS) in 2016 in the Mukono Municipality Council, in collaboration with The Ministry of Health Uganda and IKEA Foundation. In order to evaluate the contribution of the pilot intervention and its potentiality in national perspective, it was important to conduct the assessment, which was aimed to evaluate the solution from 3 different aspects of 1) Data quality, 2) Efficiency and 3) Operational Cost.

To evaluate the 3 components of this assessment, the data was obtained from the MCS, components of efficiency study and costs were identified and measured. In the study, the data quality assessment was guided by the WHO Data Quality Review Toolkit, a time-and-motion approach was incorporated to estimate the time-efficiency, and to compare the costs of MCS and current data collection tools within EPI HMIS system, an incremental cost analysis was employed. Even though, only the MyChild Card system was applied in Uganda, the potentiality of the MyChild Form system was also included in the cost analysis to assess its feasibility in the specific context.

According to the dimensions of WHO's Data Quality Review (DQR) Toolkit, the metrics, namely: Completeness, Timeliness, Internal consistency and External consistency, were within the recommended thresholds. Moreover, the ratio of data recording error was also low in the study ranging from 0.09% to 3.8%. Secondly, regarding the Time-efficiency, around 64% to 96% time could be reduced in different stages of data administration during and after the immunization sessions with MCS in contrast to current data collection tools used within Health Management Information System (HMIS).

However, the significance of time was also evident in the incremental cost analysis. When the value of time spent in data administration was considered, the current data collection tools subjected to the highest cost (0.63 USD per child) but in the contrary, excluding the value of time it exhibited the lowest cost (0.256 USD per child). Moreover, MyChild Form was the cheapest when the value of time was included (0.352 USD Per child) but excluding the value of time, the expenses in MyChild Form system was only 8.5% higher than the current data collection tools.

Overall, MCS was apparent to be both cost and time-efficient and where high quality of digital data on individual child/patient level can be generated. Although, the significance of the time-savings in pragmatic settings and resource allocation can be argued, if the saved time can be utilized to conduct awareness building activities like counselling and discussions, it can enhance awareness and facilitate community engagement to expand immunization coverage. Considering the quality of the data and findings of the efficiency study and cost analysis, this intervention can be scaled up to regional/sub-national level and evaluated for a national implementation with proper planning of time utilization.

# Acronyms

EPI – Expanded Program on Immunization

DQR – Data Quality Review

HMIS – Health Management Information System

MCS – MyChild Solution

WHO- World Health Organization

USD- United States Dollars

MOH – Ministry of Health

UGX – Ugandan Shilling

DPT- Diphtheria Pertussis Tetanus

# Background

Health system strengthening is becoming a top priority in national health agendas around the world as health system is getting more complex day by day. Systems approach rather than disease-specific approach has been gaining momentum since the advent of information and communication technology. World Health organization(WHO) identifies six building blocks i.e. health workforce; health services; health financing; governance and leadership; medical products, vaccines, and technologies; and health information as the core of a health system (1). Though all of building blocks are equally important, health information, aka quality and timely data stand out to be the foundation for any health system strengthening efforts (2). Absence of reliable and timely data may be paralyzing for the overall functioning of a health system as it delays decision making and allocation of resources if not worsen the situation (1).

Vaccination has a long history and considered to be one of the most successful public health intervention in the world which became a global effort when WHO adopted a policy to vaccinate all children against deadly infectious diseases in the form of expanded program on immunization(EPI) in 1974. Since then, all data related to immunization are collected and preserved in paper-based health management information system (HMIS) (3). For being an inefficient, time consuming and prone to human error countries like Sweden have already adopted information technology to tackle the inherent shortcomings of the paper-based system, which unfortunately is not the case yet for Uganda (3). Due to underdeveloped infrastructure, insufficient IT literacy, frequent power outages and network failures, and lack of funds for sustainability, it is very difficult and unsustainable to assimilate full-fledged IT solutions such as e-health solution in emerging economies (4).

Shifo Foundation, a Stockholm based non-profit organization, came up with a solution called MyChild Solution (MCS), based on Smart Paper Technology, which amalgamates existing paper-based system with information technology and thus, claims to address the weaknesses of sustaining e-health solutions. The solution allows health worker to capture data on a paper-based form and transfer the data into the system by scanning and then system automatically generates necessary data for the EPI program using Smart paper Technology, which is a part of the solution. In the process, the solution reduces the hassles of filling up multiple forms which may improve efficiency of the health worker as well as enable them to become user of the data not only producer of data (5).

MCS solution can be implemented in two ways: MyChild Card and MyChild Form. MyChild card is based on a home record and first to use Smart Paper Technology developed by Shifo. In the MCS card system, all the information about the child and his/her vaccination are recorded in MCS card hence removes the need of multiple forms such as child registers, tally sheets etc. This card is kept by families at home and taken to health centers during vaccination.

Another one is MCS Form, which is designed in such a way that it can be kept in the health facility and children are registered with unique ID against which all the data are captured. An MCS form can capture data as much as 50 children in one form while MCS Card can capture only one in one card, so the printing cost for MCS Form is significantly less than MCS Card system.

In the existing Health Management Information System (HMIS), the vaccinator needs to fill out 5 different forms prior to vaccination, namely: the register of child immunization, child

registration book, child registration card, daily vaccine administration and utilization sheet, and vaccination card. Then, they aggregate the collected data on daily basis, use it to produce the monthly reports and proceed them to the provincial health directorate to incorporate into national database (6). Moreover, the parents are required to bring the child vaccination card every time, as without the card, it is almost impossible to find out the name of the child during the sessions from the register containing around 200 pages and 3000 entries of children (6).

Being a Sub-Saharan country where there is 4% of global health workforce but 25% of disease burden, Uganda is facing acute shortage of health workforce, for example 1 nurse for 3000 population (7). Given the scenario and work processes are not integrated across the department, it is very common for a mother in Uganda to have a lengthy waiting time before the child get vaccinated and it is one the most important causes for drop out during vaccination period (8).

To address the issue, Shifo commenced its operation in Uganda in 2015 with Mukono District aiming to reduce workload of the vaccinators while ensuring quality and timely data at an individual level. This independent evaluation was conducted to assess how far the intervention could reflect to its aim in the setting of Uganda. Motivation of the study was to assess quality of immunization data produced by MCS and efficiency of the system, in contrast to operational costs. Data quality was intended to be measured according to WHO Data Quality Review (DQR) toolkit where operational costs and efficiency parameters were compared with current version of HMIS system. Results of this evaluation might help to determine scaling up the intervention at a national level and further strategic development in a sustainable way. The study was divided into three sections:

- Assessment of data quality
- Evaluation of efficiency
- Analysis of incremental cost

# An overview of current version of HMIS system and MyChild solution in Uganda

## Current version of HMIS system

Different types of paper-based registers and forms are in immunization center to collect all the data related to immunization in current version of HMIS system. Monitoring and evaluation are also done by using these forms. The forms and registers are as follows:

1. Child Health Cards are the home-based records in which all services received by a child at a health facility are recorded.
2. Child register (HMIS form 073a) and deworming registers (HMIS 075a) are used to register children and record vaccine and deworming they received. These registers are used to identify immunization defaulters and replace Child health cards when they are lost.
3. Child tally sheets (HMIS form 073a) are used to record the doses as they are given during each immunization session. These sheets are used to accumulate the number of doses of each dose of vaccine administered at the end of the day and month when preparing the daily and monthly attendance summary.
4. Monthly HMIS 105 report form is used to aggregate data at the health facility. The form is later sent to the district office for verification and entry into the HMIS system.
5. Vaccine and Other supplies (dry stock) ledgers are used to manage vaccines, diluents, and other stocks.
6. The Combined Requisition and Issue note is a book that is used to requisite for vaccines and other supplies from the relevant level (regional or national).

## MyChild Card and MyChild Form solution

MyChild Card is a uniquely designed child health card and the first to apply of MyChild Solution using Smart Paper Technology. MyChild Card allows health workers to quickly record registration information of children (including name, birth date, address, phone number, etc.) along with all vaccinations that have been administered. The card also contains general information for parents on vaccination schedules, importance of vaccination and date of the next visit. MyChild Solution incorporates the wider processes of digitisation, automatic registration, stock ordering, and data collection. MyChild Solution is claimed to be comprehensive and meant to constitute a new preventive healthcare system for children in Uganda.

# Assessment of Data Quality

## Aim and objective

The aim of this section of the study was to assess the quality of the data collected by MCS according to the DQR guideline by WHO. The aim was executed in a set of five dimensions and the incorporated research questions:

- *Dimension 1 - Completeness and timeliness:* What is the level of data completeness and timeliness of immunization session captured in electronic reports? What is the level of completeness and timeliness of facility reporting as well as completeness of indicator data and session data?
- *Dimension 2 - Internal consistency:* What is the level of consistency between immunization indicators and between scanned smart paper forms and electronic data?
- *Dimension 3 - External consistency:* What is the level of consistency between data generated through MyChild Solution and external data sources?
- *Dimension 4, External comparisons of population data:* What is the level of consistency of denominator between MyChild data and official government population statistics?
- *Assessment of Data Recording Error:* What is the incidence of data recording errors in immunization data collected with MyChild Solution? Even though, the dimension was not mentioned in the WHO toolkit, it was included in the study to measure the incidence of data recording error, which could also be used as an indicator for data accuracy.

## Methods:

To address the specific research questions regarding data quality, the methodology has been developed according to the toolkit for DQR by the World Health Organization (WHO).

The overall time frame of the study was January 2017 to December 2017 except data completeness & timeliness where the time frame was December 2017 to February 2018. Analysis of the data was done by statistical software STATA 13 and Microsoft Excel.

### Dimension 1. Completeness and timeliness of data

(Evaluation of reporting)

Data completeness

The extent, to which data reporting was done, was measured in this dimension. Data completeness is a reliable indicator to assess the ability of the system to collect the data in a continuous and efficient manner. Completeness means proportion between the number of monthly reports sent by the administrative units to the next higher level within a specified period of time and expected number of reports by those units within that period. Completeness of facility reporting in Uganda was calculated by comparing the number of

reports sent by the facilities to the Mukono district headquarters at the end of month against the number of reports expected to be reported by those facilities. In addition to this, session data completeness was calculated by comparing number of reported sessions with the scheduled number of immunization sessions both at static and outreach sites captured by MyChild Solution. The completeness of the data was assessed from the EPI performance reports from the 21 facilities of Mukono District in Uganda where the time frame was of three months, from December '17 to February '18. From the dashboard, Scheduled sessions were evaluated in contrast to the held sessions in the different facilities, namely: Static, Outreach and Maternity. The sessions which were missed or annulled with proper explanations were counted as completed. A formula was generated to calculate the complete data:

$$\text{Incomplete reports} = (\text{Scheduled sessions} + \text{Unexpected sessions}) - (\text{Held sessions} + \text{Missed sessions with explanation})$$

Subsequently, a completeness rate of 100% indicates that all units were reported and WHO recommended threshold level for data completeness is 75%.

In the study, only the sessions covering the core indicators of immunization by WHO DQR (DPT1, DPT2 and DPT3) were taken into consideration. The completeness of the data quality was assessed according to facility reporting and indicator data. Apart from them, the consistency of reporting completeness over time was not included in the study, as in order to measure that, at least three years of data would be needed, where Shifo has implemented MyChild Solution in Mukono District, Uganda just two years back. Therefore, it was not included in the study.

- Data timeliness

Timeliness of facility reporting was calculated by comparing the reports received from health facilities by subnational administrative units by the deadline for reporting. Evaluation of timeliness of data was based on HMIS reports generated and sent from MyChild Solution.

## **Dimension 2. Internal consistency of reported data**

(Coherence within the collected data)

Coherence of the reporting based on the history of reporting of program indicators was measured in this dimension. Assessment of the reported indicators was done to find out if there was any unreasonable relation to other values. Within this dimension, the results of programme indicators were compared to other indicators with which they have a predictable relationship to determine whether the expected relationship exists between the two indicators.

In WHO toolkit, there are four metrics to determine internal consistency. Out of this four metrics, outliers and consistency over time were not included in the evaluation because timeframe of data was not enough to make calculations (three year data is required to check consistency over time). To check outliers, it is a requirement to have one year data of all facilities and MyChild solution was being implemented in Mukono District progressively over the year, hence the outliers were not included in the study.

The remaining two metrics for this dimension were considered to be relevant for this assessment: Consistency between indicators and consistency between reported data and original records.

- Consistency between indicators is measured by looking at indicators with a predictable relationship, e.g. DPT1 is always higher than DPT2 and DPT2 is always higher than DPT3, to determine if the anticipated relationship held true. Moreover, the consistency of reported data and original records were evaluated to determine the accuracy of reported indicators by comparing them to source documents from facilities. Consistency between indicators was checked by examining the relationship among DPT1, DPT2 and DPT3 coverage to ascertain if the expected relationship is true among the doses of DPTs. If the highest number of administered cases were in DPT1 and lowest in DPT3, then data was considered to be consistent according to WHO DQR toolkit.
- Consistency between reported data and original records was measured by comparing information in the original scanned documents to the information in the electronic records. Original document image filled in by health workers containing child immunisation data that had been scanned and imported by the solution's recognition software were compared to the digitised data available in the electronic record. Only records of services administered during the visit were considered for this study.

With MyChild Solution, visit forms are scanned in batches and are assigned unique session IDs. Each visit form inside the batch is also assigned a unique document ID, which is a combination of batch ID and a document number. To estimate the level of consistency between original document image of the smart paper forms and electronic data, 266 smart paper forms from Uganda were assessed and compared with the electronic data. Percentage of the mismatch was calculated to validate the consistency between them. Sample size was calculated with 5% margin of error and 90% confidence interval using online sample size calculator<sup>1</sup>.

Original images of scanned visit forms were checked against health data captured in digitized documents. Tracking the id of children in each form and the id of children whose health data was not recognised correctly was done. The discrepancies that lead to incorrect recognition of the child can either have false ticks (piece of dart or a crossed out tick) that were identified as ticks and not rectified during verification or real ticks but too faint to be detected by the system.

### **Dimension 3. External consistency**

(A comparison between program data and other source of data such as surveys.)

This dimension was designed to evaluate the level of consistency between two sources of data measuring the same health indicator. Two most frequently used data sources are the HMIS data and the periodic surveys such as yearly Demographic Health Survey (DHS).

The level of consistency between the data generated through MyChild Solution and DHS report was evaluated by comparing MCS data on DPT coverage with municipal data of Mukono from DHS report 2016 in Uganda. The time frame set for the segment was between 2017-11-22 and 2018-02-19, the latest three months where all the district was covered by

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<sup>1</sup> <http://www.raosoft.com/samplesize.html>

MCS. According to the WHO toolkit, if the difference does not exceed 33% it should be classified as externally consistent.

#### **Dimension 4. External comparisons of population data**

(Denominator data used to measure performance indicators)

To compare results within or across geographical areas, over time, and between population subgroups it is required to compare with population census. This dimension could not be evaluated since the system was gradually implemented in the district and some facilities only used the system for few months, hence the whole population of the district was not yet registered in the system. Moreover, official government statistics usually have data on specific regions not facility based. However, it was difficult for facilities to have exact number of population in a specific period of time because the recipient families sometimes migrate between the facilities catchment area. It would be relevant to measure this indicator when the project is scaled to sub-national or national level.

#### **Assessment of data recording error**

Although data recording error was not included in the WHO data quality review toolkit, it was included in the study to identify whether the solution was easy or sophisticated for end users aka health workers. Through detection of data recording errors it would be possible to draw conclusion about the ability of the system to capture real world data and its degree of efficiency. The incidence of data recording errors was defined as the proportion of data that was incorrectly entered on the visit forms in term of:

##### **i. Two different doses of the same vaccine marked as administered during the same visit**

To evaluate this data entry error, following cases were assessed:

- if the same child was marked as administered with DPT1 and DPT2 at the same visit
- if the same child was marked as administered with DPT1 and DPT3 at the same visit
- if the same child was marked as administered with DPT2 and DPT3 at the same visit

All children who received DPT doses between 1st January to 31st December 2017 were collected from MCS database, and vaccine information from all the visits during this time period was analysed to identify children who had been marked as having received different doses of the DPT marked as administered during the same visit.

##### **ii. Same dose of the same vaccine marked as administered during two different visits**

Facts behind this error can be technical (a health worker administers a vaccine that was already administered before), or it can be due to an error of data entry, where the vaccine is marked on the form but not administered. The incidences of single-dose Bacillus Calmette-Guérin (BCG) vaccine being marked as administered twice for the same child were investigated. As the vaccine leaves a visible scar on the arm, reducing the likelihood of it being administered twice. All children who received BCG between 1<sup>st</sup> January to 31<sup>st</sup> December 2017 were collected from MCS database, and vaccine information from all the visits during this time period was analysed to identify children who had been marked as having received BCG twice.

## Result

### **Dimension 1. Completeness and timeliness of data**

#### *Data completeness and timeliness of facility reporting*

Results of the assessment indicate that all monthly reports from the health centers using MyChild Solution were sent to the district headquarters at the end of month. Hence, completeness of health facility reporting was 100%.

Timeliness of the reports from the December 2017 to December 2018 was 100%. Last date of sending monthly reports to district headquarters in Mukono, Uganda is 7th of the next month. It was found from the dashboard notifications developed by the MCS system that all three reports for corresponding three months were sent within deadline, hence making timeliness of data 100%.

#### *Data completeness report of MCS in Uganda*

There were no incomplete reports in all of the three months denoting 100% completeness of data. There were respectively 120, 137 and 120 sessions scheduled in the following months of December, January and February where number of missed or cancelled sessions were 37, 27 and 14. Explanations of all the cancelled sessions were reasonable and thus, accepted. Details of the reports are illustrated in the Table 1.

#### *Data completeness of Indicator data*

DPT1, DPT2 and DPT3 were considered as indicators in this dimension. MCS Solution automatically generates data related to these indicators. Indicator data was checked and found to be 100% completed.

Table 1 Completeness of reports

DECEMBER '17					
FACILITIES	SCHEDULES	TOTAL GIVEN	MISSED	MISSED OR CANCELLED WITH PROPER EXPLANATION	UNEXPECTED
STATIC	101	80	24	24	3
OUTREACH	18	5	13	13	0
MATERNITY	1	1	0	0	0
TOTAL	120	86	37	37	3
JANUARY '18					
STATIC	111	97	14	14	0
OUTREACH	22	10	13	13	1
MATERNITY	4	4	0	0	0
TOTAL	137	111	27	27	1
FEBRUARY '18					
STATIC	101	94	7	7	0
OUTREACH	19	12	7	7	0
MATERNITY	0	0	0	0	0
	120	106	14	14	0

## Dimension 2: Internal consistency

Consistency between indicators

According to WHO DQR toolkit, data was found to be consistent within the DPT vaccines whereas DPT1 was administered the most followed by DPT2 and DPT3 respectively. During the time period of 2017.01.01 till 2017.12.31 the percentage of DPT1, DPT2 and DPT3 are shown in the table 2. The result is consistent with WHO DQR toolkit requirements.

*Table 2 Assessment of Internal consistency*

Vaccines	Number of administrations	Percentage (%)
DPT1	8307	18.24
DPT2	7830	17.19
DPT3	6940	15.24

*Consistency between source documents from facilities and electronic data*

The visit information from immunisation sessions available in the electronic record was compared to the original document image containing details of 265 visits. No inconsistency between electronic record and checked original document image from MyChild Card was found. This resulted in data consistency rate of 100%.

**Dimension 3 : External consistency between data sources**

Consistency between data sources was examined by comparing DPT1 and DPT3 coverage reported by MyChild Solution to coverages reported in the most recent Demographic and Health Survey conducted in Uganda in 2016. Out of all children eligible for vaccination during the study period, DPT3 coverage was 49% in Mukono. The most recent national population-based data from DHS showed that DPT3 coverage was 62% when considering information based on vaccination card. DPT3 coverage measured with MyChild Solution was 13% lower compared to DHS 2016 report, which is below the 33% threshold defined in the Data Quality Review toolkit, suggesting good external consistency.

**Incidence of data recording error**

- *Data recording error I (Proportion of children with the same dose of the same vaccine marked as administered during two different visits)*  
Among the 13605 observations, there were 526 cases where BCG was reported to be administered twice to the same children, which is 3.8% of total number of children immunized with BCG. This indicates 3.8% data recording error.
- *Data recording error II (Reported cases of children with different doses of the same vaccine administered during the same visit)*  
There were 276 cases where it was reported to be administered with both DPT1 and DPT2 among the 15840 observations amounting to 1.7% of recording error. Moreover, there were 130 cases where DPT3 and DPT1 were reported to be administered together, and 209 cases for DPT1 and DPT3 resulting in 0.9% and 1.4% of data recording error respectively.

# Evaluating the Efficiency at facility level

## Specific Objective

1. What is the time required to perform the data administration with MCS and HMIS system at the facility level?

## Method

In order to address the specific objectives, the study compared time spent on data administration at facility level between the current HMIS system and the MyChild Solution (with MyChild Card) to estimate the time efficiency. The time consumption was assessed from a pre/post intervention evaluation by the research team, comprising of the members from Ministry of Health Uganda, Mukono Municipal Council, Dokolo District and Shifo Foundation. The study was conducted in the districts of Dokolo and Mukono in September 2016 and October-November 2015 respectively. All the administrative tasks were observed during and after the service delivery to capture the time spent per vaccination and care delivery session. Each of the activities such as data administration during vaccination, time spent after the session, time to develop monthly report, counselling time etc were timed and recorded. All the times were measured using a stopwatch to quantify the sequences of tasks and distribute time by the professionals. The study employed a direct on-site observation using manual timing techniques, and was performed until reaching a “point of saturation”.

Secondly, the cost-efficiency was calculated comparing the monetary values of the spent time in data administration in the different systems considering the current salary scale of the employed human resources in the immunization system, which was incorporated in the cost analysis as well.

Lastly, the result was compared to the existing evaluation report by Mikaelsson et.al (9).

## Result

Considering the Time-Efficiency in general, the MCS system was more efficient dominating in all the different stages. The average observation times in different stages are depicted in *Table 3*. Among those stages, the highest efficiency was shown in the post-session data administration where 96% time was saved compared to the HMIS system. Subsequently around 49% and 85% time could be saved during the service delivery to the new born children and their follow up respectively.

Moreover, regarding the monetary value of efficiency, the cost was around four times higher in HMIS system compared to the MCS system, where the monetary value of HMIS system of

time spent in data administration was around 0.38 USD per child and 0.071 USD in MCS System. Additionally, this result was coherent to the findings of “Too many books to write” - an evaluation of administration for health workers before and after MyChild Card in Uganda” by Mikaelsson et al. (9) and thereby, the consistency between the availed data and the existing report could be confirmed.

*Table 3. The result from the collected observational study to estimate the efficiency gain*

Processes	Average time spent in existing HMIS system <i>(Pre-intervention observation result)</i>	Average time spent in MyChild Card system <i>(Post-intervention Observation Result)</i>	Potential time saved	Potential time saved %
Vaccinations for newborns/first visits	00:05:30	00:02:28	00:02:48 per child	49.09% reduction in time
Follow-up vaccinations	00:02:36	00:00:24	00:02:12 per child	84.6% reduction in time
Administrative tasks after sessions (end of the day) on a monthly basis	11:13:00	00:25:40	10:47:00 per month	96% reduction in time

# Analysis of Incremental Cost

## Specific Objective :

1. What is the variance in operational cost of MCS compared to the existing HMIS system?

## Methods

The study incorporated an incremental cost analysis of operations with the My Child Card (intervention focusing on the home based record), MyChild Form (intervention focusing on the facility based records) and the existing HMIS system. Although, the system of MCS Forms is not implemented in Uganda, the operational cost was assessed in the study to present the financial feasibility of both alternatives of MyChild Solution. The study adhered an 'ingredient' approach, where the total quantity of specific inputs were multiplied by the unit costs and presented separately to be represented in a transparent manner. In addition to the guideline suggested by evaluation appraisal tool, responses by Drummond et. al. (2005) were followed in the study (12). An average conversion rate between Ugandan Shilling and United States Dollar (USD) in the year of 2017 from OANDA<sup>2</sup> was considered in the study.

The steps followed in the analysis are:

1. Determination of all relevant costs for the three alternatives: HMIS, MCS Card and MCS Form
2. Identification of relevant data sources
3. Measurement of unit costs with cumulative amount in relevant fields
4. Valuation of costs
5. Sensitivity analysis

The cost-analysis was conducted from a healthcare perspective where the mutually exclusive components of the cost among the solutions were included only. For example, the scanners were only needed in both of the MCS solutions but not in the HMIS system, hence, the maintenance and depreciation cost of scanners were included. The utility of the scanners was estimated to be for seven years and applied to calculate the depreciation cost, using the straight-line method, where the expected value of the scanners at the end of the 7th year was assumed to be zero. Additionally, the health workers at the facility level receive monthly SMS with the key-performance indicators on their personal mobile phones. Therefore, the SMS charges were included in the calculation. As the incremental cost analysis was of the operational cost only, none of the initial implementation and change management costs were taken into account.

The printing cost in the existing HMIS system was assessed from the estimation of Ministry of Health (MoH) which was availed from the local correspondent of the Shifo Foundation in Uganda. On the other hand, the printing cost of both MCS Cards and MCS Forms were

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<sup>2</sup> [www.oanda.com](http://www.oanda.com)

based on the quotation by “Print Innovation and Publishers”, Uganda. Regarding the value of the time spent in data administration, there was a monetary valuation conducted on the basis of the analysis of the efficiency gain section of the study. In the study, the analysis was presented from two viewpoints: with and without considering the value of the time spent on data administration.

However, the data verification time was an exclusive component in both of the MCS systems and hence included, where the system detects and sends unrecognisable data to a Verification officer for review and correction. As the verification phase in the Ugandan observational study included research components to improve machine-learning algorithms, the verification time from the Gambian study was included in the calculation to depict a more realistic timeframe. The time spent on verification was calculated by the system based on Verification Officer's login and logout time. The salary of the verification officer (Medical Record Assistant- Mukono Municipality) was derived from the report of Payroll 2018 by the *Ministry of Health Uganda*. In the study, the monthly salary of the administrator was divided by monthly working hours of 208 (considering 6 working days per week and 8 working hours per day) to calculate the salary per hour and then deducted to calculate the salary per minute to use in monetary valuation of time spent in the process of verification. Similarly, from the salary of the vaccinators (Nursing Assistant H- Mukono Municipality), the monetary value was calculated for data administration in the facilities.

Regarding the units, a total number of children under 1 year were estimated from the Statistical Abstract 2010 by Ministry of Health Uganda. Financial costs of MyChild Solution were extracted from the project accounts.

Finally, there was a sensitivity analysis conducted with annual discounting rates of 3% and 5% to estimate the future cost savings to “present value”.

The analysis adhered an assumption that the following specific aspects were following the same way in the different systems of HMIS and MCS:

- Delivering Smart Paper Forms from facility to District
- Storing Smart Paper Forms in District and facility
- Procurement and distribution processes of Smart Paper Forms
- Electricity, computer/laptop and internet access at district level
- Data storage and maintenance costs
- In the existing HMIS System, time spent on manually validating and entering monthly aggregated reports into national database is insignificant; therefore, those costs are not included in the calculations

## Result:

From part by part analysis of the project cost, it was found that annual incremental costs for HMIS, MCS card and MCS form in Uganda were 872 199 USD, 506 396 USD and 480 605 respectively while considering the value of time spent during vaccination and data administration (The gross annual saving is depicted in Table 4). Moreover, this can also be interpreted as 42% cost savings in MyChild Card solution and 45% in MyChild Form solution. On the contrary, the proportion was altered if the value of time spent was not taken into consideration.

The move from current HMIS to the MyChild Card amounts to a potential 17% increase in cost without considering the value of time spent in data administration. When moving from current HMIS to MyChild Form potential increase in cost is 10% if value of time spent in data administration was not considered. The shifts within the systems are illustrated in Figure 1.

A summary of the finding from the incremental cost analysis on the per-child basis, is illustrated in *Table 6*, in addition to the detailed analysis of the cost components in the tables 7, 8 and 9. Additionally, the basis of the estimations is mentioned accordingly. The incremental operational cost was the highest in the existing HMIS system cumulatively when the value of time was considered (0.638 USD per child), but in the contrary, excluding the valuation of time, HMIS system was subjected to the lowest expense amongst the three systems (0.256 USD per child). Conversely, including the value of time, the lowest incremental cost was observed in the MyChild Form system (0.352 USD per child).

*Table 4 Annual incremental cost of operation*

	HMIS (USD)	MyChild Card (USD)	MyChild Forms (USD)
Annual incremental cost	872 199	506 396	480 605
Annual cost without considering the value of time spent in data administration	349 247	408 902	383 111
Annual Value of time spent in data administration per child	522 952	97 494	97 494

*Table 5 Costs per beneficiary*

	HMIS (USD)	MyChild Card (USD)	MyChild Forms (USD)
Total cost per child	0.638	0.371	0.352
Cost Per child without value of time	0.256	0.299	0.280
Value of time spent in data administration per child	0.383	0.071	0.071

Figure 1. Incremental cost of operations within different systems

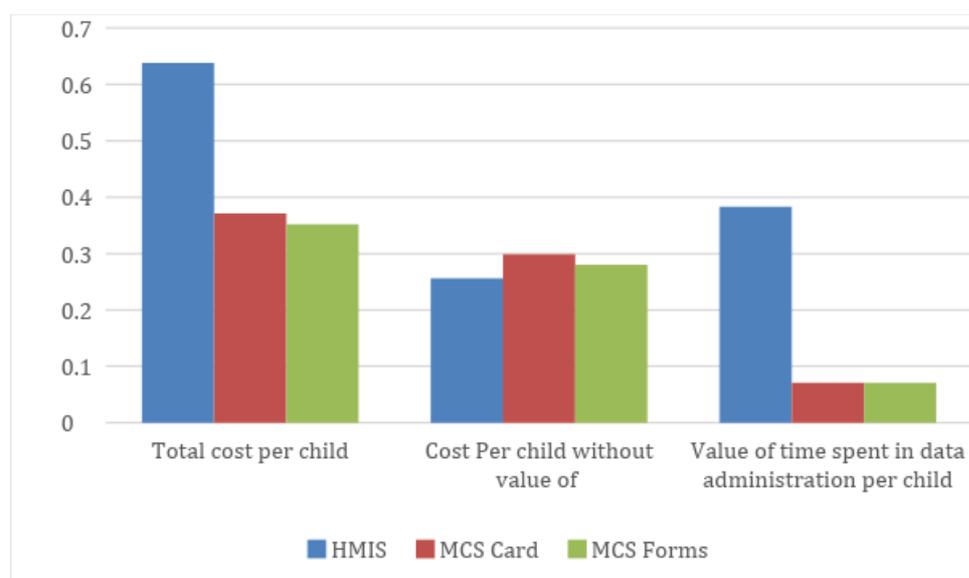


Table 6 Annual incremental cost of operations with HMIS system.

	Quantity	Unit price (USD)	Total amount (USD)	Remarks
1. Child health cards	1,366,688	0.15	205,003	Both quantity and price is estimated based on the Statistical Abstract 2010 by Ministry of Health Uganda
2. Child Register HMIS Form 073	15,140	3.8565	58387	Based on the estimation from the Ministry of Health Uganda
3. Child Tally Sheet HMIS Form 073a	423898	0.0162	6867	
4. Deworming Register HMIS Form 075	15,140	3.8565	58387	
5. Table 3a: Health Unit EPI daily attendance summary1	635847	0.0162	10301	
6. Table 3b: Health Unit EPI monthly attendance summary	423898	0.0162	6867	
7. Monthly HMIS 105 report (section 2.11 child health services)	211949	0.0162	3434	

8. Value of time spent on administrative tasks during service delivery				
New born visit	7516784	0.008	59099	The valuation of spent time in data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator was according to the Payroll 2018 by Mukono Municipal Council
Follow up visit	15306906	0.008	120346	
9. Value of time spent on administrative tasks after service delivery				
Monthly data administration	43690752	0.008	343507	The valuation of spent time in data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator was according to the Payroll 2018 by Mukono Municipal Council
<b>Cost per child</b>			<b>0.638</b>	
<b>Cost per child without the value of spent time</b>			<b>0.256</b>	
<b>Value of time spent in data administration</b>			<b>0.383</b>	

*Table 7 Incremental operational Cost with MyChild cards*

	Quantity	Unit price (USD)	Total amount in (USD)	Remark
1. MyChild Cards	1366688	0.09	120761	The quantity is estimated based on the Statistical Abstract 2010 by Ministry of Health Uganda and price is based on the quotation from the "Print Innovation and Publishers", Uganda
2. Maintenance of scanner	116	50	5800	In MCS, there would be one scanner in each of the 116 districts in Uganda and the scanner rollers should be replaced on a yearly basis.

8. Replacement of scanners	116	114	13257	The depreciation cost calculated for 7 year period in Straight-line method
3. Smart Paper Technology Engine operations and continuous development	1366688	0.10	136669	Based on costs of operations in Uganda, Gambia and Afghanistan provided by Shifo.
4. Key Performance Indicators sent by SMS to health workers	65016	0.01	498	Key Performance Indicators are sent by SMS to health workers on monthly basis. Quantity of SMS is calculated based total number of facilities (5418 Health Facilities that provide vaccination services) and SMS is sent to 1 health workers from each facility (5418*12)
5. Session voucher	361981	0.21	76729	Required quantity was estimated based on the operational data of MCS in Mukono and the printing cost was obtained from the quotation of the "Print Innovation and Publishers"
6. Extra visit voucher	289058	0.15	44154	
7. Extra registr. voucher	72240	0.15	11035	
8.Value of time spent on administrative tasks during service delivery				
New born	3826726	0.008	30087	The valuation of spent time in data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator was according to the Payroll 2018 by Mukono Municipal Council
Follow up visit	5685422	0.008	44700	
9. Value of time spent on administrative tasks after service delivery				
Total time spent on administrative tasks at health facility	1670911	0.008	13137	The valuation of time spent in data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator, according to the Payroll 2018 by Mukono Municipality
Total time spent on verification at the district level	797462	0.012	9570	
<b>Cost per child</b>			<b>0.371</b>	
<b>Cost per child without the value of spent time</b>			<b>0.299</b>	
<b>Value of time spent in data administration</b>			<b>0.071</b>	

Table 8 Incremental operational Cost with MyChild Forms

	Quantity	Unit price (USD)	Total price (USD)	Remarks
1. Current home based records	1366688	0.150	205003	Estimation of one record for every child
1. Shifo child health form	462230	0.016	7359	The quantity is estimated based on the number of session vouchers used in MyChild Card solution and the unit price was from the quotation by "Print Innovation and Publishers", Uganda
2. Shifo birth record form	91113	0.028	2558	Estimation based on MyChild Form solution in Gambia where birth records of 15 children can be accommodated per sheet.
3. Shifo birth record update form	65016	0.016	1035	Estimating that one sheet is required in each facility per month
4. Shifo monthly return-vaccine management form	65016	0.015	958	
5. Smart Paper Technology Engine operations and continuous development	1366688	0.100	146557	Based on costs of operations in Uganda, Gambia and Afghanistan provided by Shifo.
6. Key Performance Indicators sent by SMS to health workers	65016	0.009	584	Key Performance Indicators are sent by SMS to health workers on monthly basis. Quantity of SMS is calculated based total number of facilities (5418 Health Facilities that provide vaccination services) and SMS is sent to 1 health workers from each facility (5418*12) (Price from the quotation from the service provider Twilio)
7. Maintenance of scanners	116	50	5800	From cost of Shifo
8. Replacement of scanners	116	114	13257	Depreciation cost calculated for 7 year period in Straight-line method
9. Value of time spent on administrative tasks during service delivery				
New born	3826726	0.008	30087	The valuation of spent time in

				data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator was according to the Payroll 2018 by Mukono Municipal Council
Follow up visit	5685422	0.008	44700	From the efficiency study in the Gambia as the observation in Mukono did not fit to the criteria for verification.
<b>10. Value of time spent on administrative tasks after service delivery</b>				
Total time spent on administrative tasks at health facility	1670911	0.008	13137	The valuation of spent time in data administration during the session was based on the required time obtained from the efficiency study and salary of the vaccinator was according to the Payroll 2018 by Mukono Municipal Council
Total time spent on verification at the district level	797462	0.012	9570	From the efficiency study in the Gambia as the observation in Mukono did not fit to the criteria for verification.
<b>Cost per child</b>			<b>0.352</b>	
<b>Cost per child without the value of spent time</b>			<b>0.280</b>	
<b>Value of time spent in data administration per child</b>			<b>0.071</b>	

In order to calculate the cost savings in 5 years, the study considered an annual growth of 3.29%, according to the World Bank report<sup>3</sup>. The detailed calculation of cost saving in 5 years with both MyChild Cards and MyChild Form system in contrast to the current HMIS system, is depicted in *Table 9*.

Considering the value of time spent in data administration in the calculation, around 2072752 USD was forecasted to be saved with the MyChild Form system in 5 years. But when the value of time was not considered, on the contrary, HMIS system was subjected to save 180 833 USD compared to MyChild Form system in the timespan.

However, with the MyChild Card system, estimation of saving was around 1 932 672 USD compared to the HMIS system when the value of time was included. Conversely, excluding

<sup>3</sup> ( World Bank Data :<https://data.worldbank.org/indicator/SP.POP.GROW?locations=UG>)

the valuation of time, around 1 615 098 USD was predicted to be lost compared to the HMIS system.

Finally, the additional sensitivity analysis depicts the saved amount in 5 years within the range of 3% to 5% rate of annual discounting. To exemplify the interpretation, the saving with MCS form can be considered (including the value of time) where the present value of saving 2 938 543 USD in 5 years, would range from around 1 624 056 USD to 1 787 974 USD, considering the annual discounting of 5% and 3%.

*Table 9 Cost saving in 5 years and sensitivity analysis*

		<b>Cost saving in MyChild Card system</b>		<b>Cost saving in MyChild Form system</b>	
		MyChild Card		MyChild Form	
Expected number of children aged below one		With the value of time spent in data administration (USD)	Without considering the value of time spent in data administration (USD)	With the value of time spent in data administration (USD)	Without considering the value of time spent in data administration (USD)
Cost saved in 1st year	1366688	362364	-59655	388155	-33864
Cost saved in 2nd Year	1411652	374286	-61617	400926	-34978
Cost saved in 3rd Year	1458095	386600	-63644	414116	-36129
Cost saved in 4th Year	1506066	399320	-65739	427741	-37318
Cost saved in 5th year	1546730	410101	-67514	441814	-38545
<b>Total</b>		<b>1932672</b>	<b>-318170</b>	<b>2072752</b>	<b>-180834</b>
<b>Sensitivity analysis on the basis of annual discounting</b>	<b>5%</b>	<b>1514299</b>	<b>-249295</b>	<b>1624056</b>	<b>-141688</b>
	<b>3%</b>	<b>1667140</b>	<b>-274456</b>	<b>1787974</b>	<b>-155989</b>

## Discussion

Health system strengthening efforts depend on how data will be accumulated, managed, analysed and acted upon in this data driven world. Expanded program on immunization is no exception as it generates huge amounts of data on a regular basis. The accumulation and utilization of immunization data relies on its quality and the cost to operate the collection method which is facilitated by the efficiency of the system. Hence the study estimated and illustrated the findings from the three different perspectives of data quality, time-efficiency, and incremental cost.

In the study, it was found that the data was collected, analysed, stored and distributed in a prescribed manner according to WHO data quality review toolkit, and the overall quality of data was up to the recommended threshold. Within the time frame of the evaluation, both metrics of data completeness and timeliness were 100% complete. In the second dimension, two metrics, namely: consistency between indicators i.e. relationship between DPT1, DPT2, DPT3 coverage and consistency between electronic data and scanned paper were evaluated. DPT1 coverage was higher than DPT2 and DPT2 coverage was higher than DPT3 which was consistent with WHO recommendation. Consistency between the electronic data and the scanned Smart Paper Forms was 100%, which proves that reliable data quality assurance processes have been setup by Shifo Foundation in Mukono District. In case of external consistency, DPT3 coverage from the system data was 13% lower than DHS data which was much lower than WHO prescribed acceptable limit (33%). Data recording error was minimal while evaluating, the two types of error are multiple doses of the same vaccine in same visit and the same dose of the same vaccine in two different visits.

From the analysis of Incremental cost and efficiency study, it could be anticipated that the value of time played the pivotal role in the analysis. Depending on its inclusion and exclusion, the whole status of the incremental cost of operations was altered. For instance, when the value of time spent in data administration was included, MyChild Form system was the most cost-efficient one where the current data collection tools within HMIS system were found to be the most expensive. On the contrary, when the value of time was discarded, the current data collection tools within HMIS system turned out to be the cheapest option. Even though, theoretically the value of time appeared to be the major contrast among the three systems, what can be the added value of saving time, can be argued. It can be anticipated that, with a proper planning to utilize the saved time, the quality of the data and service delivery can be improved, to minimize data errors and improve health outcomes. Potentially, the saved time can give a room to the vaccinators to conduct effective counselling and group discussions to avert missed opportunities for vaccination, improve timeliness and rates of fully immunised children.

Integrating Smart Paper Technology as part of HMIS System will further strengthen health system, by minimising administration time of health workers, generating digitalised data at a patient level from all health facilities, irrespective of technical limitations, and the ability of governments to sustain this innovative solution.

# Strength and Limitation

Following measures could be remarked as the strength of the study:

- *Triangulation of perspectives:* The evaluation design is comprised of three different perspectives of data quality, cost, and efficiency, is a strength of the study as it gives room to the stakeholders and readers to take an insight from different viewpoints. The significance of data quality, operational cost and efficiency complement one another, which is usually a challenge with alternative eHealth solutions.
- *Following the standard guidelines:* The data quality was assessed according to the WHO toolkit including an additional dimension whereas the economic evaluation followed the criteria by Drummon et. al. to enhance the validity of the study. Even more, the efficiency study was based on the observation guideline by Taylor-Powell and Steele.
- *Depreciation cost:* The depreciation cost of the scanners was included, so the estimation could be applied beyond the timeframe of the study without adding any bulk amount for the replacement. According to the incorporated depreciation process, there will be enough amounts secured from the yearly expenses for the replacement of the scanners by the seventh year.
- *Yearly average conversion rate:* To reduce the uncertainty of the conversion rate between Ugandan Shillings and USDs, an average yearly conversion rate (1st Jan 2017- 31st December 2017) was used.

However, there were a number of limitations in the study as well:

- *Inconsistency of time-frame:* Data completeness was checked for 3 months and there is a possibility that the result could be different if it was checked for a longer time. For external consistency, indicators were compared with DHS 2016 which is two years older than the research data.
- *Unevaluated metrics:* Few metrics included in the WHO data quality review toolkit were not possible to include in this evaluation as described earlier (presence of outliers and external consistency in population data).
- *Recording error versus medical error:* Incidence of data recording errors in the data can be due to recording errors on the part of the health worker (data entry errors) but they can also be due to medical errors, where an inappropriate vaccine was administered and accurately recorded in the forms. We defined 2 data errors that are most likely due to an error in entering the data rather than a medical error.
- *Considering the cost analysis,* some of the estimations were made from different contexts (e.g.: the cost of MyChild Forms from Uganda). Even more, there was a proportionate discounting on basis of quotations from Uganda included in the study while estimating the incremental cost of operation in MyChild Card systems where the price gets lower for printing in a larger amount. Theoretical background could not be found to address this issue hence the pattern of the quotation was adhered. The legitimacy of the discounting for larger production can also be argued, as the larger production is associated with larger cost of transportation and logistics. But the authors presented the costs with and without discounting for mass production to show the perspectives.

## Recommendations

- In the study, it was evident that MyChild Solution could minimize the time spent in every step of data administration. Moreover, with a verification process comprising of both digital and manual assessment, it has the potential to reduce the workload from the engaged professional and thus reflect in mitigating errors. A further qualitative study can be conducted in order to illustrate the experience of the professionals engaged in immunization process and explore the contrast in both systems. From the perspectives of the vaccinator, mothers, and stakeholders, a social pathway can be explored for the highest utilization of the time and result in expanding the coverage in an efficient way.
- Additionally, a health economic evaluation can be conducted with a probabilistic Markov model to estimate the cost-effectiveness among the three systems and predict the cost saving in a meticulous way where the uncertainties can be addressed as well. The evaluation can then predict the cost per case averted in the different systems and can estimate the savings in the long run. Furthermore, the contribution of counselling in the saved time can be also incorporated there.
- Quotations for the required amount of printing should be availed from the local settings to increase the validity of the further study.

To sum up, MyChild Forms were subjected to highest cost saving with inclusion of value of time; even without considering the value of time, the difference of the prices between the forms and the HMIS system is 0.024 USD per child (around 8.5%), which is reasonable compared to the benefits MyChild Solution brings. Significantly, the saved time in the intervention is also an asset to the settings as the number of health workers is scarce. Hence, there is a possibility that the health workers would be able to serve more children in the given time with the MyChild Forms and focus more on providing higher quality of preventive health services to children.

Overall, considering the data quality, incremental cost and efficiency in MyChild solution, mitigating the data administration time and hurdles during service delivery with sustained standard quality of data from WHO parameters, MyChild Form system can be recommended to be integrated within HMIS System and scaled up at a regional level with proper planning of utilizing the time saved to further improve data quality and quality of care.

Since a number of studies determined the lack of knowledge and community engagement as a hindrance to immunization coverage and narrated the importance to address this with targeted interventions and counselling (10,11), the saved time with MyChild Solution can be utilized with targeted interventions to engage the communities and focus on utilising reliable data to improve health outcomes in Uganda.

Followed by the implication, a further evaluation can be conducted to assess the pragmatics at the regional level and evaluate the possibility to scale up at a national level.

# Reference

1. Tara Nutley & Heidi W. Reynolds (2013) Improving the use of health data for health system strengthening, *Global Health Action*, 6:1, DOI: [10.3402/gha.v6i0.20001](https://doi.org/10.3402/gha.v6i0.20001)
2. AbouZahr C, Boerma T. Health information systems: the foundations of public health. *Bull World Health Organ.* 2005; 83: 578–83.
3. Grevendonk J & Wilson K (2013). A case for better immunisation information systems [http://bit.ly/ 2d78HrN](http://bit.ly/2d78HrN)
4. Cline GB & Luiz JM (2013). Information technology systems in public sector health facilities in developing countries: the case of South Africa. *Jan* [http://bmcmmedinformdecismak.biomedcentral.com/articles/ 10.1186/1472-6947-13-13](http://bmcmmedinformdecismak.biomedcentral.com/articles/10.1186/1472-6947-13-13)
5. Anderson T et.al , Improving Child Healthcare in Low Resource Settings: A Pilot Study of MyChild Solution in Afghanistan Glance [Internet]. [cited 2018 May 20]. Available from: <https://shifo.org/doc/MyChildEfficiencyEvaluationAfghanistan.pdf/>
6. Ministry of Health Uganda, Health in a Glance [Internet]. [cited 2018 May 20]. Available from: <http://moph.gov.af/Content/Media/Documents/Healthinaglance96201716121427553325325.pdf>
7. Tumusiime P, Gonani A, Walker O, Asbu EZ, Awases M & Karyo PC (2012). Health systems in subSaharan Africa: what is their status and role in meeting the health Millennium Development Goals? *African Health Monitor*, nr.
8. Favin M, Steinglass R, Fields R, Banerjee K & Sawhney M (2012). Why children are not vaccinated: a review of the grey literature, *International Health* vol. 4, nr. 4 <http://bit.ly/2e130lJ>
9. Mikaelsson M, Kyoziira C, Sabiiti JN, Rahimi N, Ogwok K, Anderson T, et al. This report is written by. :22.
10. International Initiative for Impact Evaluation (3ie), Sabarwal S, Bhatia R, International Initiative for Impact Evaluation (3ie), Dhody B, International Initiative for Impact Evaluation (3ie), et al. Engaging communities for increasing immunisation coverage: what do we know? [Internet]. International Initiative for Impact Evaluation (3ie); 2016 Dec [cited 2018 Jun 11]. Available from: <http://www.3ieimpact.org/en/publications/3ie-scoping-paper-series/3ie-scoping-paper-3/>
11. Gupta P, Prakash D, Srivastava JP. Determinants of immunization coverage in lucknow district. *North Am J Med Sci.* 2015 Feb;7(2):36–40.
12. Drummond, M., Sculpher, M., Claxton, K., Stoddart, G., & Torrance, G. (2015). *Methods for the economic evaluation of health care programmes* (Fourth edition / Michael F. Drummond, Mark J. Sculpher, Karl Claxton, Greg Stoddart, George W. Torrance. ed.). Oxford: Oxford University Press.