The Cost of Preparation and Delivery of Td Vaccine to 7-Year-Old Children in Vietnam

November 2019

This study was conducted by the Hanoi University of Public Health (HUPH) in Hanoi, Vietnam, in close collaboration with the Ministry of Health National Expanded Programme on Immunization (NEPI) as part of the Immunization Costing Action Network (ICAN). ICAN was facilitated by ThinkWell and John Snow, Inc. (JSI) and supported by the Bill & Melinda Gates Foundation.
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### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AEFI</td>
<td>Adverse event following immunization</td>
</tr>
<tr>
<td>BCG</td>
<td>Bacillus Calmette-Guérin</td>
</tr>
<tr>
<td>BMGF</td>
<td>Bill &amp; Melinda Gates Foundation</td>
</tr>
<tr>
<td>CBAW</td>
<td>Women of child-bearing age</td>
</tr>
<tr>
<td>CI</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td>CPI</td>
<td>Consumer price index</td>
</tr>
<tr>
<td>DTP</td>
<td>Diphtheria, Tetanus, and Pertussis</td>
</tr>
<tr>
<td>EPI</td>
<td>Expanded Programme on Immunization</td>
</tr>
<tr>
<td>EPIC</td>
<td>EPI Costing and Financing Project</td>
</tr>
<tr>
<td>FIC</td>
<td>Fully immunized child</td>
</tr>
<tr>
<td>FTE</td>
<td>Full-time equivalent</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>HepB</td>
<td>Hepatitis B</td>
</tr>
<tr>
<td>Hib</td>
<td>Haemophilus influenzae type B</td>
</tr>
<tr>
<td>HPV</td>
<td>Human Papilloma Virus</td>
</tr>
<tr>
<td>HSPH</td>
<td>Harvard T.H. Chan School of Public Health</td>
</tr>
<tr>
<td>HTA</td>
<td>Health Technology Assessments</td>
</tr>
<tr>
<td>ICAN</td>
<td>Immunization Costing Action Network</td>
</tr>
<tr>
<td>IDC</td>
<td>Immunization delivery cost</td>
</tr>
<tr>
<td>IDCC</td>
<td>Immunization Delivery Cost Catalogue</td>
</tr>
<tr>
<td>IEC</td>
<td>Information, education and communication</td>
</tr>
<tr>
<td>IHEA</td>
<td>International Health Economics Association</td>
</tr>
<tr>
<td>IPV</td>
<td>Inactivated Polio Vaccine</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
</tr>
<tr>
<td>IVAC</td>
<td>The Institute of Vaccines and Medical Biologicals</td>
</tr>
<tr>
<td>JSI</td>
<td>John Snow, Inc.</td>
</tr>
<tr>
<td>LMIC</td>
<td>Low- and middle-income countries</td>
</tr>
<tr>
<td>MR</td>
<td>Measles/Rubella</td>
</tr>
<tr>
<td>NEPI</td>
<td>National Expanded Programme on Immunization</td>
</tr>
<tr>
<td>NITAG</td>
<td>National Immunization Technical Advisory Group</td>
</tr>
<tr>
<td>OOP</td>
<td>Out-of-pocket expenditure</td>
</tr>
<tr>
<td>OPV</td>
<td>Oral Polio Vaccine</td>
</tr>
<tr>
<td>PCV</td>
<td>Pneumococcal Conjugate Vaccine</td>
</tr>
<tr>
<td>PHC</td>
<td>Primary health care</td>
</tr>
<tr>
<td>PI</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>SE</td>
<td>Standard error</td>
</tr>
<tr>
<td>UHC</td>
<td>Universal Health Coverage</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children's Fund</td>
</tr>
<tr>
<td>USD</td>
<td>US dollar</td>
</tr>
<tr>
<td>VND</td>
<td>Vietnamese Dong</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
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EXECUTIVE SUMMARY

Background
Viet Nam eliminated maternal and neonatal tetanus in 2005 and has maintained this achievement. However, diphtheria outbreaks have occurred in some communities in the highland and central regions. In response, the National Expanded Programme on Immunization (NEPI) provided Td vaccine in those areas through campaign delivery.

Aligned with global World Health Organization Tetanus guidelines (WHO/UNICEF, 2018), the WHO Viet Nam recommended that the Ministry of Health (MOH) now focus on achieving dual protection against tetanus and diphtheria by replacing delivery of the (TT) vaccine with the tetanus-diphtheria (Td) vaccine. Hence, the NEPI is preparing a recommendation to the National Immunization Technical Advisory Group (NITAG) to guide their decision-making regarding Td introduction. To inform their recommendation, NEPI requested evidence on the cost of TT vaccine delivery and the budgetary impact of the potential replacement with Td vaccine.

This study was carried out as part of the Immunization Costing Action Network (ICAN), led by ThinkWell and John Snow Inc. (JSI) and supported by the Bill & Melinda Gates Foundation (BMGF). The ICAN is a research and learning community working to increase the visibility, availability, understanding, and use of immunization delivery cost information. During the period 2016-2019, the ICAN aimed to build country capacity to generate cost evidence that is policy relevant and a priority for the immunization program. The ICAN also worked with countries to improve interpretation and translation of cost evidence so that it is used in country decision-making processes and informs routine planning and budgeting.

Designed and implemented by researchers from the Hanoi University of Public Health (HUPH), with technical support from ThinkWell, the study benefited from strong engagement from the NEPI, the MOH Planning & Finance department, and other key stakeholders.

Box 1. Research Question and Key Findings

Research question:
− What are the total costs, incremental costs and unit costs of Td vaccination provided to 7-year-old children in Vietnam, which includes a program of introduction of Td for 7-year-olds and future cessation of TT vaccination of women of childbearing age (CBAW)? Would the introduction of Td and cessation of TT be cost saving (i.e., have a lower impact on the immunization budget)?

Key findings:
− The cost per dose for current TT vaccination for CBAW was found to be $1.49 for school-based delivery, US$1.76 for facility-based delivery and US$3.86 for delivery via outreach. Td vaccination through campaigns costs US$3.56 per dose (all fiscal costs). Overall, the total cost of the current schedule for TT for CBAW and Td for outbreak control in 2017 was estimated to be US$2.4 million.

− Future delivery of Td vaccine is based on cost per dose estimates from current delivery. The budget impact over the period 2018-2025 (compared to the current schedule) depends on choice of delivery strategy:
  o The school-based strategy is estimated to generate savings of nearly US$7 million.
  o A facility-based delivery strategy is estimated to save over US$4 million.
  o An additional cost of US$2.3 million would be incurred if a mixed strategy of facility-based delivery with outreach is used.

Use of findings:
− Study results have already informed the National Expanded Program of Immunization (NEPI), who are piloting delivery of Td to 7-year-old children during the last quarter of 2019 using both school- and facility-based strategies.
**TT and Td Vaccination in Vietnam**

TT vaccine is currently delivered to pregnant women through facility-based delivery and outreach, and to women of childbearing age (i.e., 15-35-year-olds) through facility-based delivery, outreach, and school-based delivery. Meanwhile, diphtheria outbreaks have occurred in some communities in the highland and central regions. In response, NEPI has delivered Td vaccine in those areas through campaigns targeting 5-40-year-olds. Tetanus is an indicator of inequities – particularly affecting ethnic minorities in the northern highlands and the urban poor. The ethnic minorities in the northern highlands have increasingly worse health indicators and the urban pockets of unimmunized are leading to outbreaks for diphtheria.

**Study Methods**

The Viet Nam ICAN costing study estimates the program costs of introducing Td vaccination of 7-year-old children in Viet Nam, and ceasing the current delivery of TT vaccine to women of childbearing age and the delivery of Td for outbreak control. The study specifically focused on:

a. The costs of delivery of TT vaccine to women of childbearing age (historical unit and total delivery costs)

b. The costs of Td campaign vaccination for diphtheria outbreak control (historical unit and total delivery costs)

c. The one-time costs associated with introduction of Td vaccine for 7-year-old children (projected new vaccine introduction costs and incremental costs)

d. The costs of routine delivery of Td vaccine to 7-year-old children through three potential scenarios under consideration: routine facility-based delivery, facility-based delivery and outreach, and school-based delivery (projected total costs, incremental costs, and unit delivery costs).

The aim was to determine if the introduction of Td and cessation of TT would be cost saving (i.e., would have a lower impact on the immunization budget). The period under consideration was 2018 to 2025, with complete cessation of TT vaccination of women of childbearing age and a three-year transition period where Td outbreak control campaigns would likely still occur.

The study compared the cost of the current TT delivery schedule with the cost of introducing Td to 7-year-old children through the three scenarios under NEPI consideration, specified above. Current delivery costs were based on one year of actual delivery, in 2017 (historical costing). The costing of Td introduction and future delivery used unit costs from the historical costing combined with planning, assumptions and draft service delivery protocols provided by the NEPI. The costs incurred at all levels of the health system (central, provincial, district and commune levels) were included in the study. Contributions are included from the health system, schools, local government and community organizations. Both economic and fiscal costs were included.

The study costed 37 commune health stations (11 urban and 26 rural), which included vaccine delivery at 19 schools, and participation in 4 Td campaigns. The sites were

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1 Fiscal costs represent actual spending in 2017, whereas economic costs include actual time spent, annualized capital costs, and Ministry of Finance regulations for payment of per diems and travel (accommodation and transport).
randomly selected from 23 districts from three large cities and six provinces. The districts represented different geographies and levels of socioeconomic development.

**Key Findings**

**Cost of current TT and Td delivery schedule**

The study reviewed the cost of the three strategies currently used for TT vaccination of women of childbearing age (CBAW): facility-based delivery, outreach delivery and school-based delivery, as well as the cost of Td vaccination through campaigns. The study found the average unit cost per TT dose delivered to be lowest for school-based delivery (US$1.49 per dose) and highest for delivery via outreach (US$3.86 per dose); facility-based delivery costs US$1.76 per dose. Td doses delivered via campaigns cost US$3.56 each (all fiscal costs). The reason for these differences lies in outreach and campaigns being more resource intensive in terms of staff time and travel cost than delivery in schools or at facility fixed sites. Overall, the total fiscal cost of the current schedule for TT for CBAW and Td for outbreak controls in 2017 was estimated to be US$2.4 million.

For TT vaccination, salaries made up 86% of costs at the facility level. Differences in salaries were the main driver behind variations in cost per dose between regions, with higher staff costs in remote and mountainous areas leading to a higher cost per dose.

**Cost of routine delivery of Td vaccine through three potential scenarios**

The study found that considerable savings could be made if a school- or facility-based delivery strategy were to be selected for Td vaccination. In contrast, use of multiple delivery strategies (facility-based and outreach) would result in additional costs compared to current delivery. In comparison to a continuation of the current schedule, a school-based delivery strategy is estimated to generate savings of US$6.8 million during the period 2018-2025, while a facility-based delivery strategy will save US$4.2 million. These savings are expected to continue in subsequent years. However, an additional cost of US$2.3 million would be incurred if multiple delivery strategies (i.e., facility-based and outreach in combination) would be used.

**Opportunities for Use of Results**

This study has a clear use case, in that the research was requested by the NEPI to inform their recommendation to the NITAG regarding Td introduction. The research team worked closely with the NEPI throughout the study to define the research questions, develop the study protocol, and collect, analyze and interpret the data (Figure 1).

**Figure 1. Stakeholder engagement**

Study results have already been used by NEPI to prepare for piloting the delivery of Td to 7-year-old children during the last quarter of 2019 using both school- and facility-based strategies. This decision was taken in light of the cost implications of the different strategies, in addition to ensuring those children not attending school are reached. Evidence provided from this study has also been shared with sub-national EPI units in briefings about the Td replacement and pilots. Broader future dissemination will consider the study results as a helpful input for annual budgeting and planning.

In addition to providing helpful evidence for decision making in Vietnam, this study can also help inform other countries that have not yet introduced Td corresponding with cessation of TT.
BACKGROUND

IMMUNIZATION COSTING ACTION NETWORK

The Immunization Costing Action Network (ICAN), led by ThinkWell and John Snow Inc. (JSI) and supported by the Bill & Melinda Gates Foundation (BMGF), is a research and learning community working to increase the visibility, availability, understanding, and use of immunization delivery cost information. During the period 2016-2019, the ICAN aimed to build country capacity to generate cost evidence that is policy relevant and a priority for the immunization program. The ICAN also worked with countries to improve interpretation and translation of cost evidence so that it is used in country decision-making processes and informs routine planning and budgeting.

ICAN facilitated a suite of costing exercises in three countries (Indonesia, Tanzania and Vietnam) with teams in each country that included health economist researchers, immunization managers, and planners from Ministries of Health. The country teams conducted research that explored the cost of delivering vaccines through different delivery strategies to distinct target populations in diverse geographies. The three country teams also came together during two cross-country workshops to help sharpen methods and learn from each other regarding how to use cost evidence to influence routine planning and budgeting and decision-making processes.

VIETNAM AND THE EPI

Vietnam is a lower middle-income country in Southeast Asia with a population of 91 million people, 65% of whom live in rural areas and 10% of whom are under the age of five (Vietnam GSO, 2017). The country is divided into six geographical regions consisting of the northern midlands and mountains, the red river delta, the central coast, the highlands, the south east and the Mekong river delta. For administrative purposes, the country is organized in four levels: national, provincial (consisting of five megacities and 58 provinces), district (829 districts) and communes (11,626). The Vietnam healthcare system follows this administrative organization: primary healthcare, including immunization, is delivered through the community at commune level, while the upper levels (district, provincial, and national) are more focused on preventive care, management, planning, and secondary and tertiary care (Ministry of Health of Viet Nam and Health Partnership Group, 2007). For the national Expanded Program on Immunization (NEPI), however, there are some deviations from this overall organization of the healthcare system. In addition to provincial, district and commune levels, four regional offices (in the north, the centre, the highlands and the south) support the national level with management and administrative tasks.

Vietnam’s Expanded Program on Immunization (EPI) dates back to 1981 and has maintained immunization coverage at 90% for decades (Vietnam GSO, 2015). Infant and child mortality rates have declined significantly over the last 30 years (Figure 2), reflecting the successful implementation of the EPI and other social and health interventions.

Figure 2. Child mortality per 1000 live births (1994-2015)
EPI is a priority program in Vietnam and receives funding annually from the State Budget. In 2016, the total budget for the EPI was estimated to be approximately US$29 million, with funding coming from the government budget (63.6%), Gavi (35%, mainly for vaccine and immunization supplies) and others (1.4%) (NEPI, 2016).

There are distinct planning and budgeting processes for EPI at national and sub-national levels. At national level, NEPI develops a workplan every five years. In that five-year plan, they estimate the demand for vaccines and immunization supplies (e.g. syringes, needles, cotton, etc.) based on actual usage in previous years. They also budget for expected future campaigns, research and administration of the NEPI at central level and the regional offices. The Ministry of Health (MOH) reviews and submits this five-year workplan (with budget) to the Government Office for final approval. Ministry of Finance (MOF) then manages the approved five-year budget, allocating funds on an annual basis to NEPI via the Vietnam State Treasury. NEPI then makes the budget allocation to themselves at central level and their four regional offices accordingly.

For sub-national levels, district-level EPI units develop their own annual plans (with budget), covering district- and commune-level activities. These plans are submitted to the EPI units at provincial level, where they are combined with the provincial-level plan. This overall plan, including budget for province, districts and communes, is sent to the head of megacities/provinces. Depending on capacity of the local budget, which includes local revenues (from taxes, fees, investments and other sources), some financial support from the State Budget (only available for very poor and poor provinces) and other sources of funding such as donor/community contributions, the EPI annual plan will be reviewed and approved (or partly approved). The approved EPI budget then will be sent in a vertical, hierarchal system from provincial level to district and then from district to commune level. Remote areas also receive some supplementary funds from the State Budget based on the number of fully immunized children (FIC) achieved. The budget flow of the EPI is described in Figure 3.

**Figure 3. The budget flow for EPI in Vietnam**
The Vietnam EPI currently protects children from eleven diseases, including Hepatitis B (HepB); Polio; Diphtheria, Tetanus, Pertussis; Pneumonia; Hib meningitis; Measles-Rubella (MR); Japanese Encephalitis (JE); Cholera and Typhoid (in high-risk areas). The schedule for routine vaccination is presented in Table 1.

### Table 1. Schedule for vaccination in Vietnam, 2017

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccines</th>
</tr>
</thead>
</table>
| Birth     | – Hepatitis B vaccine: birth dose as soon as possible after birth (within 24 hours)  
<p>|           | – BCG vaccine                                                             |
| 02 months | – DPT-HepB-Hib: 1st dose                                                 |
|           | – OPV vaccine: 1st dose                                                  |
| 03 months | – DPT-HepB-Hib: 2nd dose                                                  |
|           | – OPV vaccine: 2nd dose                                                  |
| 04 months | – DPT-HepB-Hib: 3rd dose                                                  |
|           | – OPV vaccine: 3rd dose                                                  |
| 09 months | – Measles vaccine: 1st dose                                               |
| 18 months | – DPT booster dose                                                       |
|           | – Measles-Rubella: 2nd dose                                               |
| Over 12 months | – JE vaccine: 1st, 2nd (2 weeks after 1st) and 3rd (one week later)  |</p>
<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccines</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 2 to 5 years</td>
<td>Cholera vaccine: 2 doses given 2 weeks apart (in specific geographical areas)</td>
</tr>
<tr>
<td>From 3 to 10 years</td>
<td>Typhoid vaccine: 1 dose (in specific geographical areas)</td>
</tr>
<tr>
<td>Pregnant women and women of child-bearing age (15-35 years, CBAW) in high-risk areas*</td>
<td>TT for pregnant women or for CBAW in high-risk areas*:</td>
</tr>
<tr>
<td></td>
<td>o 1st dose as soon as possible in pregnancy or at earliest contact with CBAW in high-risk areas</td>
</tr>
<tr>
<td></td>
<td>o 2nd dose at least 1 month after the 1st dose</td>
</tr>
<tr>
<td></td>
<td>o 3rd dose at least 6 months after the 2nd dose or in a subsequent pregnancy</td>
</tr>
<tr>
<td></td>
<td>o 4th dose at least 1 year after the 3rd dose or in a subsequent pregnancy</td>
</tr>
<tr>
<td></td>
<td>o 5th dose at least 1 year after the 4th dose or in a subsequent pregnancy</td>
</tr>
</tbody>
</table>

* High-risk areas include those 1) remote, hard-to-reach areas with ethnic minorities; 2) areas with low coverage of TT for pregnant women; 3) areas with low facility-based delivery rates, or 4) areas with detected neonatal tetanus cases.

The EPI is currently delivered via three main strategies, including (1) facility-based; (2) outreach (in the remote areas); and (3) campaigns for outbreak control. Non-facility-based vaccination is not recommended by NEPI, therefore the majority of immunization sessions are facility-based. Only 0.6% of facilities reported having non-facility based vaccination in 2017 (NEPI, 2017). Campaigns are often implemented for outbreak control or during immunization weeks and are conducted at both facilities and non-facility sites. According to the Ministry of Health’s guidelines on organization of immunization sessions, delivery through all strategies is limited to 50 children per session (Ministry of Health, 2014). Normally each facility conducts only a single session per day; in some cases staff from nearby facilities will also participate, making it possible to have two sessions per day, with 100 total children vaccinated. Outreach is primarily used for remote areas (e.g. mountainous areas, islands, etc.) where health facility staff will travel to residential areas.

School-based vaccination is not currently an official delivery strategy in Vietnam. Nevertheless, the school-based strategy has been integrated into other non-facility strategies. For example, schools are sometimes used to deliver vaccinations during campaigns or as outreach sites. In these cases health facility staff bring vaccines, vaccination supplies and other medical supplies to the schools. Health facility staff are responsible for organizing these sessions, including sending invitations, though for some sessions targeting school-aged children (6-15 years), teachers also support in providing student lists, inviting students and organizing the students during the sessions.
RATIONALE FOR THE STUDY

Vietnam eliminated maternal and neonatal tetanus in 2005. However, diphtheria outbreaks have occurred in the highland and central coast regions (Figure 4).

Figure 4a. Maternal and neonatal tetanus have been eliminated and maintained

![Graph showing prevalence of neonatal tetanus and TT coverage]

Figure 4b. History of diphtheria outbreaks despite sustained elimination of maternal and neonatal tetanus

![Graph showing number of diphtheria cases and deaths]

This phenomenon has been reported in other countries previously; since 1998, the World Health Organization (WHO) has recommended that tetanus toxoid (TT) vaccine be replaced by tetanus-diptheria (Td) vaccine to improve protection against both diseases (WHO/UNICEF, 2018). NEPI currently only provides the Td vaccine through campaigns in regions with outbreaks, while TT is administered to two target populations, namely pregnant women nation-wide and women of child-bearing age (aged 15-35 years, CBAW) in high-risk areas only (Table 1) (NEPI, 2016). The high-risk areas include those that: 1) are remote, hard-to-reach with ethnic minorities; 2) have low coverage of TT vaccine amongst pregnant women; 3) have low facility-based delivery rates; or 4) have detected neonatal tetanus cases. Tetanus and diphtheria vaccines (DPT, TT, Td) have been produced locally.
for several years by The Institute of Vaccines and Medical Biologicals (IVAC), which has the capacity to cover the annual target population with introduction of Td (Table 2). At the start of this study in 2016, 126 countries had made the change from TT to Td, yet there were about 68 countries remaining to fully implement the WHO recommendation (SAGE Working Group on Maternal and Neonatal Tetanus Elimination, April 2016).

Table 2. TT and Td vaccines produced in Vietnam

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Packaging</th>
<th>Form (liquid/reconstituted)</th>
<th>Number of doses required in EPI schedule</th>
<th>Types of syringes used to administer</th>
<th>Vaccine price/dose*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT</td>
<td>20 doses/vial</td>
<td>Liquid</td>
<td>2 doses at 1 month intervals</td>
<td>AD syringe 0.5ml</td>
<td>1.13 VND 0.05 USD</td>
</tr>
<tr>
<td>Td</td>
<td>10 doses/vial</td>
<td>Liquid</td>
<td>1</td>
<td>AD syringe 0.5ml</td>
<td>6.52 VND 0.28 USD</td>
</tr>
</tbody>
</table>

* Source: NEPI, average purchase price in 2016. Price fluctuates depending on order size.

In line with the WHO’s recommendation, NEPI is likely to recommend that Vietnam cease delivery of TT for CBAW and administer a Td booster dose before adulthood for children aged 7 years2 (both boys and girls). However, more evidence is needed on costs and feasibility of the possible delivery strategies for Td vaccination (school-based, facility-based or mixed approach).

**Aims/objectives of the research**

The objective of this research is to estimate total costs, incremental costs and unit costs of Td vaccination provided to 7-year-old children in Vietnam, which includes a program of introduction of Td for 7-year olds and future cessation of TT vaccination of CBAW.

The specific research questions are:

a. What are the total and unit delivery costs of the TT vaccine to women of childbearing age in Vietnam?

b. What are the total and unit costs of Td campaign vaccination for diphtheria outbreak control?

c. What are the one-time incremental preparation and start-up costs associated with new Td vaccine introduction for 7-year old children?

d. What are the total, incremental and unit delivery costs of Td vaccine to 7-year-old children through the four primary delivery strategies in Vietnam: routine facility-based, campaigns, outreach, and schools?

---

2 The booster dose follows three doses of DPT before aged 12 months and a DPT booster dose at 18 months of age. Age 7 was chosen for the routine immunization schedule, which requires an age to be specified within one year. In reality the vaccine will be given to all children aged 7 years and over. Vaccination may be given by grade (2nd grade) for ease of administration.
The objectives of the study are to:

a. Provide evidence for NEPI to obtain MOH’s approval to introduce Td vaccination for children aged 7 years old and eventually cease TT vaccination of CBAW.

b. Provide a solid basis for the development and justification of the expenditure plan for TT and Td vaccination activities at all levels for the period 2012-2025.

DEFINITIONS

Some terminology used throughout the report includes:

Child bearing age women (CBAW): women aged 15-35 years.

Cost line items: include the following:

- Capital costs: cold chain equipment; vehicles; other equipment; buildings
- Recurrent costs: labor; office supplies; transport and fuel; vehicle maintenance; cold chain repairs and energy; printing; utilities and communication; other recurrent.

Delivery costs: see Box 2. May include both recurrent and capital costs (see above).

Economic costs: estimated based on the actual time spent on each activity and MOF regulations for national cost norms (enacted since 2010) for per diem (training, supervision, etc.) and travel (accommodation and transport). Other recurrent costs which are not regulated by MOF are captured in a similar way to actual spending. Capital costs were estimated based on an annualization factor, which used the 2017 inflation rate of 3% and MOF’s useful years of life for each asset type.


Full time equivalent staff (FTE): number of staff calculated from total annual immunization working time reported through interviews divided by total annual working time as per Government regulations. Annual working time is defined as:

- For staff at facility level: 8 hours per day times the number of working days, based on the total number of days in a year (365 or 366) minus 21 national holidays and 48 weekend days
- For staff at non-facility levels: 8 hours per day times the number of working days, based on the total number of days in a year (365 or 366) minus 21 national holidays and 96 weekend days

We define immunization delivery costs (IDCs) as the costs associated with delivering immunization services to target populations, exclusive of vaccine and immunization supplies (e.g. safety boxes, diluents, reconstitution syringes) costs. Delivery costs may include any or all of the following recurrent and capital cost items: (1) paid human resources, (2) per diem and travel allowances, (3) cold chain equipment and their overheads (e.g. energy, maintenance, repairs), (4) vehicles, transport and fuel, (5) program management, (6) training and capacity building, (7) social mobilization and advocacy, (8) disease surveillance and activities related to adverse events following immunization (AEFI), (9) buildings, utilities, other overheads and shared costs, (10) waste management, (11) other supplies and recurrent costs, and (12) other non-vaccine costs.

Source: Adapted from Vaughan et al., 2019.
**Target populations:** defined per vaccine
- TT: Women aged 15-35 years (CBAW) and pregnant women
- Td: 7-year-old children

**METHODOLOGY**

**STUDY DESIGN**

This research is designed as a cost analysis of discontinuing one vaccine and introducing a new vaccine into the immunization program, and has four main research components:

- Cost of TT vaccine delivery (TT vaccination costing) - based on one year of actual practice in 2017 (empirical costing study)
- Cost of Td campaign vaccination for tetanus/ diphtheria outbreak control - based on one year of actual practice in 2017 (empirical costing study)
- Cost of introduction (preparation costs or start-up costs) of Td delivery to 7-year-old children, including three years post-transition from TT to Td vaccination – based on planning and assumptions provided by NEPI (normative costing study)
- Cost of Td vaccine delivery (Td vaccination costing) - based on planning and assumptions about the service delivery protocol provided by NEPI for one year of Td vaccination (normative costing study)

**SAMPLING STRATEGY**

We used a three-stage purposive and random sampling strategy designed to be nationally representative. This took into account geographic diversity, as well as differences in socioeconomic development across the country, based on the hypothesis that costs may vary across these settings.

The sampling frame is drawn from the MOH’s administrative system as of 2017 and was used to select study sites to be used for both TT and Td vaccination costing (Table 3).

**Table 3. Sampling frame**

<table>
<thead>
<tr>
<th>Administrative area</th>
<th>Provincial level</th>
<th>District level</th>
<th>Commune level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. mega-cities</td>
<td>No. provinces</td>
<td>No. urban</td>
</tr>
<tr>
<td>Northern midlands and mountains</td>
<td>0</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Red River</td>
<td>2</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>North centre and centre coast</td>
<td>1</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>Centre highlands</td>
<td>0</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>South east</td>
<td>1</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>Mekong River</td>
<td>1</td>
<td>12</td>
<td>32</td>
</tr>
</tbody>
</table>
Described below is each step in the process of selecting the sample sites:

1 Selection of provinces:
  - The national level (NEPI) and 3 regional offices were selected.
  - 3 of the country’s 5 megacities were purposively selected for their geographical distribution (Hanoi in the North, Da Nang in the Center and Ho Chi Minh City in the South).
  - 1 province each from 6 geographic regions was selected based on: (1) average level of GDP/capita (near the average regional GDP/capita); (2) average level of immunization performance (near the average regional number of immunization doses provided in 2016); and (3) good health information/reporting system (based on NEPI evaluation). The provinces included are: Hai Duong (from Red Delta River); Dien Bien (from northern mountainous area); Gia Lai (from central highland); Quang Nam (from central coast); Binh Phuoc (from south east); and Dong Thap (from Mekong Delta River).

2 Selection of districts:
  - From each selected megacity, we randomly selected one urban district.
  - From each selected province, two strata (urban and rural) were defined, within which we used random sampling to select one district from each urban stratum and two districts from each rural stratum.

3 Selection of facilities and schools:
  - From each selected urban district, we randomly selected one urban facility.
  - From each selected rural district, we randomly selected two rural facilities after excluding all the township/urban facilities.

The final study frame included 73 sites, including national level (NEPI); 3 sites at the regional administrative level (south, central and highland); 9 sites at provincial level (from 3 megacities, 6 provinces); ten sites at urban district level; 13 sites at rural district level; 11 urban facilities and 26 rural facilities. Among the visited sites, 18 facilities reported having school-based vaccination and 4 facilities reported having had a Td campaign for outbreak control (Table 4. Selected sample). Figure 5 shows the sites visited for data collection.

### Table 4. Selected sample

<table>
<thead>
<tr>
<th>Cities/regions/provinces</th>
<th>Province</th>
<th>Districts (urban)</th>
<th>Districts (rural)</th>
<th>Communes</th>
<th>Commune health stations</th>
<th>Schools</th>
<th>Total facilities and schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megacity 1 (Hanoi, North)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1 urban, 0 rural</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Megacity 2 (Da Nang, Center)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1 urban, 0 rural</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Megacity 3 (Ho Chi Minh City, South)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1 urban, 0 rural</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cities/regions/provinces</td>
<td>Province from Geographical Region 1</td>
<td>Province from Geographical Region 2</td>
<td>Province from Geographical Region 3</td>
<td>Province from Geographical Region 4</td>
<td>Province from Geographical Region 5</td>
<td>Province from Geographical Region 6</td>
<td>Total facilities and schools</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>1 ( 2 )</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>9 urban, 24 rural 33 33 66</td>
</tr>
<tr>
<td>MA</td>
<td>Districts (urban) Districts (rural) Communes Commune health stations Schools Total facilities and schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 urban, 4 rural</td>
<td>5 5 10</td>
<td>5 5 10</td>
<td>5 5 10</td>
<td>5 5 10</td>
<td>5 5 10</td>
<td>5 5 10</td>
<td>9 urban, 24 rural 33 33 66</td>
</tr>
</tbody>
</table>

Figure 5. Mapping the data collection sites
COSTING

The provider perspective was applied in this study, including all service providers involved in immunization such as the public health system, schools, local government and community organizations. The study focused on the cost of vaccination delivery which provides for program running costs, both recurrent and capital. The costs of vaccines and immunization supplies were not included as part of this study. The study covered economic and fiscal costs of all vaccination delivery activities in 2017 with the costs being adjusted to 2018 price-levels using the Vietnam commercial price index (Vietnam GSO, 2017).

The cost estimates were determined using an activity-ingredient-based costing method. Generally, local staff provided information regarding the resources (ingredients) used for each activity. We allocated shared costs among immunization activities according to the methodology in Annex 1. Overall, the costs were dissected by activity groups, including:

- Routine facility-based vaccination;
- Outreach vaccination;
- School-based vaccination (for the TT vaccine for CBAW only);
- Campaigns (for the Td vaccine at outbreak areas only);
- Vaccine and immunization supply storage;
- Vaccine and immunization supply transport (collection and distribution);
- Immunization safety;
- Waste management;
- Supervision;
- Training;
- Record keeping;
- Cold chain maintenance;
- Program management; and
- Social mobilization & advocacy.

Thirteen cost ingredients were used to estimate the full costs, including both recurrent and capital costs. The recurrent costs were as follows:

- Salaried labor: annual salary and all benefits (insurance, performance bonus, etc.)
- Volunteer labor: allowances for human resources who are not classified as staff (e.g. village health workers)
- Per diem and travel allowances: travel allowances (excluded from fixed salary/allowances)
- Other supplies: stationary, photocopy, printing office materials
- Transport and fuel: plane tickets, car rental, fuel used, accommodation and related costs
- Vehicle maintenance
- Cold chain repairs and energy: fuel/electricity used for the cold chain
- Printing: printing costs of stationary directly for EPI (e.g. vaccination card, registers, immunization information, education and communication (IEC) materials)
- Utilities and communication: costs related to building overheads, including general maintenance, telephone, internet connections and other costs to operate the working building (electricity, water, fuel, etc.)
- Other recurrent: outsourced services including hygiene services, equipment quality evaluations, etc.); non-labor cost for regular meetings/trainings (backdrops, hall renting, etc.).
Capital costs included in the cost estimates were:

- Vehicles: costs related to vehicles used for EPI (vaccine trucks, supervision cars/motors)
- Equipment: cold chain (freeze room, fridge, etc.), medical supplies (medical pincers, scissors, etc.) and general equipment (computers, air conditioner units, etc.)
- Buildings: space allocated for cold chain and storage; vaccination services and for EPI staff to perform administrative and related tasks

**Costing approach**

This study included both a historical costing component and a prospective costing component, to capture costs related to delivery of the current and proposed future schedule of TT and Td vaccines:

- For the *historical costing approach*, all cost information was based on actual EPI activities and expenditure in 2017. Where actual expenditure was not available the cost norms published by the MOF were used. The historical costing provided estimations of total EPI delivery costs and cost per dose (via the four main delivery strategies: facility based, outreach, school based and campaign). The costs incurred above facility level (i.e. at national, regional, provincial, and district levels) were also included.
- The *prospective costing* provided estimations for 2019-2025 of changing from TT vaccine for CBAW to Td vaccine for 7-year-old children, including the full cost and incremental cost. We assumed that NEPI will replace the current schedule of TT vaccine for CBAW with the new schedule of Td vaccine for 7-year-old children by 2021 after a pilot in 2019-2020 (Table 5).

**Table 5. Current and proposed schedule for TT and Td vaccination**

<table>
<thead>
<tr>
<th>The current schedule (for 2017)</th>
<th>TT vaccine</th>
<th>Td vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target group</strong></td>
<td>Pregnant women</td>
<td>Women of childbearing age (CBAW)</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>All pregnant women</td>
<td>CBAW from high-risk areas</td>
</tr>
<tr>
<td><strong>Delivery strategy</strong></td>
<td>Facility-based and outreach</td>
<td>Facility-based, outbreak and school-based</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The proposed replacement plan</th>
<th>TT vaccine</th>
<th>Td vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target group</strong></td>
<td>Pregnant women</td>
<td>CBAW</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>All pregnant women</td>
<td>Complete cessation</td>
</tr>
<tr>
<td><strong>Delivery strategy</strong></td>
<td>Same as the current schedule</td>
<td>Complete cessation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Coverage estimations for the current and new schedules are illustrated in Table 6. The number of doses of Td vaccine for the new schedule is assumed to be the same as the number of doses of TT vaccine delivered to CBAW in 2018. The number of doses of TT vaccine administered to CBAW in 2018 was estimated by inflating the number of doses administered in 2017 (1.1 million) by 1%, resulting in 1,111,000 doses for 2018. A transitional period for the Td campaign was also added to the first three years of the 2018-2025 period. This transitional period aims to help control diphtheria outbreaks while the new schedule of Td vaccine for children is still to be fully implemented. The number of Td doses for outbreak control in 2018 was adjusted to 83,429 doses in 2018, based on the number of doses delivered in 2017.

### Table 6 Coverage assumptions for the replacement plan

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Td for 7-year-old children</td>
<td>70%</td>
<td>90%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Transition for Td campaigns</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In the case of no replacement</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TT for CBAW</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Td campaign in outbreak areas</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Three possible delivery scenarios were identified for the process of replacement. The first was that Td vaccine would be integrated into routine vaccination and would be delivered at the facility-level only. Hence the cost/dose for Td vaccine in this scenario is identical to the cost/dose delivered via the facility-based strategy. The second scenario was that Td vaccine would be delivered as part of routine immunization via a mixed strategy, using both facility-based delivery and outreach. The proportion of doses to be delivered via each strategy were determined as part of the historical costing. The third scenario was that the new schedule of Td vaccine would be delivered at schools, given that the targeted population of the Td vaccine is 7-year-old children.

### Data collection

Data collection instruments were tested in one district in Hanoi over a two-day period, and revised significantly after the pilot. This is because the list of activities used to develop the original questionnaires was not detailed enough. With the additional information district and health facility staff provided during the pilot, the activities could be significantly revised and new questionnaires generated.

Data collection was carried out by four researchers from the Hanoi University of Public Health and three researchers from the NEPI who visited the selected sites during the period May to July 2018. We performed face-to-face interviews with local EPI staff using a semi-structured questionnaire and collected financial reports from each site.

The structured open-ended questionnaire was developed to capture the time spent and all related costs for EPI activities implemented in 2017. The detailed list of activities was
based on NEPI guidance. The Excel questionnaire template was structured according to cost ingredients and had sheets for staff costs, energy, fuel, travel, other supplies, maintenance and other recurrent and capital costs (vehicles, equipment and buildings). Some cost items, like cold chain, were split across multiple sheets (energy, maintenance and equipment). Cost items were allocated to activity groups and specific activities where necessary. Details of the allocation methods can be found in Annex 1.

The number of administered doses, fully immunized children and vaccinated women (pregnant and CBAW) for each site were collected via the standard annual immunization reports submitted by all EPI units from facility level to provincial level, as required by NEPI. After the data was entered, any abnormalities were identified and clarified with local staff.

Data analysis
Data was entered in Microsoft Excel spreadsheets and analyzed in Stata version 14. Descriptive analyses were conducted to describe the proportion of total cost by activity and cost ingredients.

The unit costs analyses included cost per dose through different delivery strategies (facility-based; outreach; school-based and campaign). Unit costs were calculated according to a number of assumptions, varying by level:

- National unit cost (A): total cost at national level divided by total doses for Vietnam. This national unit cost was assumed to be similar for all facilities.
- Regional unit costs (B): total regional costs divided by the total number of doses by region. These cost were assumed to be similar among facilities in the same region.
- Provincial and district levels: total costs were split by campaign specific and non-campaign specific costs.
  - Non-campaign specific costs (C1): total cost at provincial/district level divided by total doses at the province/district (including both TT doses and Td doses if available).
  - Campaign specific cost (C2): total campaign related cost at provincial/district level divided by the total of Td doses at the province/district.
- Facility level: costs were separated by direct vaccination costs and non-vaccination costs. Direct vaccination costs covered all costs in the facility-based vaccination; outreach vaccination; school-based vaccination and campaign vaccination activity groups, while all others were non-vaccination costs.
  - Non-vaccination unit cost (D1): total non-vaccination cost divided by the total number of doses.
  - Vaccination direct unit cost (D2), by delivery strategy (facility-based, outreach, school-based and campaign): total direct vaccination cost per strategy divided by the total number of doses by strategy.
  - Full cost per dose:
    - For routine vaccination: A + related B + related C1 + related D1 + related D2
    - For campaign: A + related B + related C1 + related C2 + related D1 + related D2

The costs per dose were separated by type (fiscal or economic); area of residence (urban or rural) and geographical region.
Where possible, standard errors and 95% confidence intervals were calculated. These results can be seen in Annex 2.

The research team used scatter-plot graphs of unit costs and number of doses delivered, and unit costs and full-time equivalent staff, to identify any outliers.

Costs were originally collected in 2017 VND; they were first inflated to 2018 Vietnamese Dong (VND) based on the consumer price index (CPI) (CPI 2017 = 105.12, CPI 2018 = 103.44, CPI 2018/2017 = 0.98). Costs in 2018 VND were then converted to 2018 US$ using the conversion rate of 23,152 VND = 1 USD.

**Aggregation costing assumptions**

For national level data collection, we visited almost all EPI sites at this level whereas it was only possible to visit a few of them at the sub-national levels. Therefore, it’s important to aggregate the costs for these levels to estimate an overall picture for EPI delivery cost in Vietnam. The cost aggregation is based on the inversed sampling probability weights. We applied the inverse sampling probability weighting to estimate the national aggregated EPI program cost of all EPI units in sub-national levels in Vietnam. For the sub-national level, weights were based on the number of administrative units. By implication the total cost of the sampled province/district/facility was assumed to be the average cost of province/district/facility in the same geographic region. Regional level weighting was based on regional population share.

We analyzed costs separately by the four main levels of the health system, including the national level (national and regional), provincial, district and communal levels. We also analyzed by location (urban and rural).

**Budget impact**

Budget impact and cost savings were estimated as such:

$$\text{Savings} = A - (B + C),$$

- $A$ = the current schedule: TT for CBAW and Td for outbreaks
- $B$ = the new schedule: Td for 7-year-old children
- $C$ = transitional period (2018-2020)

**Stakeholder engagement**

Throughout the study, the research team benefited from close collaboration with the NEPI as well as other stakeholders. HUPH consulted NEPI at the start of the study to identify cost needs, define the research questions and co-develop the research protocol. NEPI was also involved later in the study, particularly on defining inputs for the prospective costing. There was also engagement with the MoH Department of Planning & Finance and other MoH staff in ICAN-organized cross-country workshops. There was early socialization with WHO.
Limitations
There are several limitations of this study relating to the data used. First, some cost data was sparse; assumptions had to be made, for example on the year of building acquisition or the purchase cost of equipment. A number of assumptions were also made to allocate shared costs to immunization and other health programs, and then to activities within immunization. These are well documented in Annex 1. Second, in some cases there were inconsistencies in the record keeping on the number of administered doses, with different numbers recorded at facility and district levels. In these cases the inconsistency was presented to facility and district staff and they were asked to select the number they thought to be most accurate.

Sensitivity Analyses
As the costs of the EPI in 2017 are based on a historical costing study, sensitivity analyses for these costs are less meaningful. However, we did carry out a one-way sensitivity analysis for the prospective costing study on the monthly basic staff salary, given that Vietnam is planning to increase the monthly basic salary from VND 3,252,600 to VND 3,486,600 (approximately US$142 to US$151).

Findings
This section presents findings, first in terms of the current immunization schedule, then for the replacement plan, and finally in terms of the overall budget impact. For all analyses, we present both total and unit (cost per dose) for fiscal and economic costs. Where relevant, we show findings separately for each of the four main levels of the health system, including the national level (national and regional), provincial, district and communal level, as well as by local (urban and rural). All findings are volume weighted averages (referred to in the text simply as “average”) and are presented in 2018 USD.

Current Immunization Schedule
Number of doses delivered
The number of doses delivered in 2017 as part of the current schedule, for TT vaccination for CBAW and Td vaccination through campaigns, is seen in Table 7. More TT doses were delivered than Td doses, and school-based delivery was the prominent strategy used for TT vaccination.

Table 7 Number of doses delivered in the current schedule

<table>
<thead>
<tr>
<th>Current Strategy</th>
<th>Total doses delivered (2017)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT vaccination for CBAW</td>
<td>1,100,000</td>
<td></td>
</tr>
<tr>
<td>Facility-based delivery</td>
<td>305,723</td>
<td>27.8%</td>
</tr>
<tr>
<td>Outreach</td>
<td>137,354</td>
<td>12.5%</td>
</tr>
<tr>
<td>School-based delivery</td>
<td>656,923</td>
<td>59.7%</td>
</tr>
<tr>
<td>Td vaccination through campaigns</td>
<td>82,603</td>
<td>100%</td>
</tr>
</tbody>
</table>
Average cost per dose delivered

Table 8 shows the average cost per TT dose delivered using the three main delivery strategies. The average fiscal cost for delivering a TT dose through the facility-based, outreach, and school-based strategies was US$1.76, US$3.86 and US$1.49, respectively. Accordingly, the average cost/dose for outreach was found to be more than double that of the facility- and school-based strategies. The higher cost of outreach is due labor cost associated with the greater amount of time spent by facility staff on outreach-based vaccination.

As the economic cost includes full personnel costs (salaries, per diems and bonuses) as well as costs of equipment and buildings (depreciation costs), the average economic cost/dose is slightly higher than the fiscal cost/dose. The average economic cost/dose for the facility-based, outreach, and school-based strategies was US$2.21, US$4.67 and US$2.06, respectively.

Table 8. Cost per TT dose delivered by delivery strategy (2018 US$)

<table>
<thead>
<tr>
<th>Delivery strategy</th>
<th>n</th>
<th>Fiscal cost per dose</th>
<th>Economic cost per dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility-based vaccination</td>
<td>37</td>
<td>1.76</td>
<td>2.21</td>
</tr>
<tr>
<td>Outreach based vaccination</td>
<td>5</td>
<td>3.86</td>
<td>4.67</td>
</tr>
<tr>
<td>School based vaccination</td>
<td>18</td>
<td>1.49</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Table 9 displays the average cost per dose for the three main delivery strategies (facility-based, outreach and school-based) by location (urban versus rural) and type of cost (fiscal versus economic). Costs are broken down by level of the health system (national, regional, provincial, district and facility); above-facility costs are non-vaccination specific, meaning not for actual immunization delivery, whereas facility-level cost include both the actual immunization delivery (vaccination-specific costs) as well as the supporting activities (non-vaccination specific costs).

In general for all three delivery strategies, fiscal costs per dose were higher at rural facilities compared to urban facilities. In urban areas, the fiscal cost per dose delivered at facilities was US$1.76, compared with a cost per dose for school-based delivery of US$1.33. Note that there is no outreach used in urban areas. For rural facilities, the cost per dose delivered via outreach was highest (US$3.59), followed by facility-based (US$1.79) and school-based delivery (US$1.40).

For urban facilities, the economic cost per dose delivered via facilities and schools was US$2.23 and US$1.95 respectively. The economic cost per dose delivered by rural facilities via outreach was US$4.29, followed by facility-based delivery (US$2.23) and schools (US$1.95).

The higher costs in rural areas are likely due to the additional support provided by the Government and NEPI itself to rural facilities in the form of higher bonuses for a successfully managed facility and/or higher monthly salaries for facility staff.

Table 9. Cost per TT dose delivered by delivery strategy, location and level of the health system (2018 US$)
<table>
<thead>
<tr>
<th>Location</th>
<th>Urban areas*</th>
<th>Rural areas</th>
<th>Urban areas*</th>
<th>Rural areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery strategy</td>
<td>Facility</td>
<td>School</td>
<td>Facility</td>
<td>Outreach</td>
</tr>
<tr>
<td>n</td>
<td>11</td>
<td>3</td>
<td>26</td>
<td>5</td>
</tr>
</tbody>
</table>

**Non-vaccination specific costs**

<table>
<thead>
<tr>
<th>Level</th>
<th>National level</th>
<th>Regional level</th>
<th>Provincial level</th>
<th>District level</th>
<th>Facility level</th>
<th>Vaccination session specific costs</th>
<th>Total cost per dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiscal cost per dose</td>
<td>0.03</td>
<td>0.05</td>
<td>0.07</td>
<td>0.33</td>
<td>0.27</td>
<td>0.96</td>
<td>1.70</td>
</tr>
<tr>
<td>Economic cost per dose</td>
<td>0.03</td>
<td>0.05</td>
<td>0.06</td>
<td>0.25</td>
<td>0.37</td>
<td>0.58</td>
<td>1.33</td>
</tr>
</tbody>
</table>

* There was no outreach done in urban areas.

Figure 6 shows the relationship between the fiscal cost per dose and the number of administered doses delivered via facility-based delivery, for urban and rural areas. The highest cost per dose among the urban facilities is in the megacity in the north, a result of an additional stipend paid for supervision. Among rural areas, the sampled province in centre coast is currently a priority province for the Government and NEPI, and has therefore received various forms of support, including in-kind and financial support. Hence, the highest cost per facility-based dose among rural facilities is in the centre coast. The cost per dose in both urban and rural facilities in the northern mountainous areas are higher than average due to the higher level of Government support in the form of monthly salary payments and bonuses for this region.

Figure 6. Fiscal and economic cost per dose via facility-based strategy by region (2018 US$)
Labor costs account for the highest proportion of total fiscal cost at facility level (86%) as shown in Figure 7 (right), followed by “per diem and travel allowances” (5%), “other recurrent costs” and “utility and communication” at 3%. The other cost ingredients combined account for around 3% of total fiscal costs. Looking at economic costs, which take annual depreciation into consideration, the cost of equipment and buildings increases and accounts for 3% and 4%, respectively, of total economic costs. Furthermore, when considering the full per diem and travel allowance costs for staff, this cost item accounted for 11% of the total economic cost, a markedly higher proportion than for overall fiscal cost.

**Figure 7. Costs by ingredients at facility level (2018 US$)**
Figure 8 shows the percentage of total costs by activity groups at the facility level. The direct service delivery activity groups “routine facility-based vaccination” and “outreach vaccination” account for the largest proportion of both fiscal and economic costs, representing over 70% when facility and outreach are taken together. As school-based vaccination is provided only for the TT vaccine, the proportion of “school-based vaccination” activities is small. Among the indirect activities, the main cost drivers are “record keeping and HMIS” and “vaccine collection, distribution and storage.”

Table 10 shows the average cost per dose in diphtheria outbreak control campaigns (n=4) classified by type of cost. In this case, the fiscal cost per dose was US$3.56 and the economic cost per dose was US$4.01. As the Td campaign was implemented to control the diphtheria outbreaks, most of the campaign activities were implemented by staff from the district and facility levels; districts generally provide 10-15 staff for each campaign whereas the maximum amount of staff members from a facility is 5-7 people.

Table 10. Cost per dose delivered in the Diphtheria outbreak control campaign (2018 US$)
There are differences in the cost per dose and the number of doses delivered as part of the diphtheria outbreak control campaigns by region (Table 11). Td campaigns are only conducted in outbreak areas; in 2017 this included the highlands and centre coast. The cost per dose results for the centre coast area are higher than for the highland facilities, despite much higher volumes of doses delivered. The outbreak had already been controlled in the highlands at time of vaccination and, thus, received far less support from the government for the campaign while also delivering much fewer doses when compared with the centre coast area. There was also more supervision in centre coast.

**Table 11. Cost per dose delivered in the Diphtheria outbreaks control campaign, by facility and region (2018 US$)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Fiscal cost per dose</th>
<th>Economic cost per dose</th>
<th>Number of doses delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility 1</td>
<td>Centre coast</td>
<td>4.52</td>
<td>5.08</td>
</tr>
<tr>
<td>Facility 2</td>
<td>Centre coast</td>
<td>4.62</td>
<td>5.23</td>
</tr>
<tr>
<td>Facility 3</td>
<td>Highland</td>
<td>1.86</td>
<td>2.14</td>
</tr>
<tr>
<td>Facility 4</td>
<td>Highland</td>
<td>2.85</td>
<td>3.19</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>3.56</strong></td>
<td><strong>4.09</strong></td>
</tr>
</tbody>
</table>

**Total cost of the current schedule**

Overall, the total fiscal and economic cost of the current schedule for TT for CBAW and Td for outbreak control in 2017 was estimated to be US$2.4 million and US$3.0 million, respectively (Table 12).

**Table 12. Total cost of the current schedule of TT vaccine for CBAW and Td vaccine for outbreak control campaign in 2017 (2018 US$)**
### REPLACEMENT COSTS AND BUDGET IMPACT

The replacement costs are based on the unit cost and volume findings from the historical costing, with delivery volumes adjusted to 2018 (Table 13).

**Table 13. Parameters for estimating the cost of replacing the current schedule of TT vaccine for CBAW and Td vaccine for outbreaks**

<table>
<thead>
<tr>
<th>Estimated doses</th>
<th>Fiscal cost per dose</th>
<th>Economic cost per dose</th>
<th>Estimated doses in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New schedule for Td vaccination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario 1: Facility-based</td>
<td>1.76</td>
<td>2.21</td>
<td>1,111,000</td>
</tr>
<tr>
<td>Scenario 2: 69% facility-based, 31% outreach-based</td>
<td>1.76</td>
<td>2.21</td>
<td>344,410</td>
</tr>
<tr>
<td>Scenario 3: School-based</td>
<td>3.86</td>
<td>4.67</td>
<td>766,590</td>
</tr>
<tr>
<td><strong>Transitional period (three years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Td campaign</td>
<td>3.56</td>
<td>4.01</td>
<td>83,429</td>
</tr>
</tbody>
</table>

**Estimating the budget impact for the period 2018-2025**

Within this section we present the estimated total fiscal costs of changing from the current schedule of TT vaccine for CBAW and Td vaccine for outbreak to the new schedule of Td vaccine for 7-year-olds. We estimate the total fiscal costs for the period 2018-2025 for each of the three possible delivery scenarios, compared to the cost of the current schedule over that same period. Using a facility-based delivery strategy, the total cost of the new schedule (US$18.0 million) would be lower than the cost of the current schedule (US$22.2 million) (Figure 9). The annual cost savings due to the replacement by year 2025 (US$558,161) are expected to continue in subsequent years.

**Figure 9. Estimated cost savings from the new schedule for Td vaccine to 7-year-old children via a facility-based delivery strategy (2018 US$)**
Using multiple delivery strategies (facility-based and outreach), the total cost of the new schedule is estimated at US$24.5 million, over US$2.3 million more than the current schedule over the period 2018-2025 (Figure 10).

**Figure 10. Estimated cost savings from the new schedule for Td vaccine to 7-year-old children via multiple delivery strategies (2018 US$)**

Figure 11 shows the estimated total costs of changing from the current schedule to the new schedule of Td vaccine for 7-year-old children via a school-based delivery strategy. This scenario is predicted to result in the greatest amount of cost savings, with these expected to be around US$6.8 million over the period 2018-2025.

**Figure 11. Estimated cost savings from the new schedule for Td vaccine to 7-year-old children via a school-based delivery strategy (2018 US$)**
In summary, when implementing the new schedule for Td vaccine, cost savings are obtainable only via facility-based delivery (saving US$4.2 million over 2018-2025) or via school-based delivery (saving US$6.9 million), with the latter resulting in higher savings. Figure 12 shows the total cost of the whole period 2018-2025 for the current schedule, the new schedule and the potential cost savings, for each of the three possible delivery strategies.

**Figure 12. Total cost of replacing TT delivery to CBAW with Td delivery to 7-year-olds during 2018-2025 (2018 US$)**
SENSITIVITY ANALYSIS

A change in the monthly basic staff salary from VND 3,252,600 to VND 3,486,600 (approximately US$142 to US$151) would be equivalent to a 7% increase on the current unit cost estimates, corresponding to the annual incremental cost for paid labor of VND 2,808,000 (approximately US$121, Table 14).

Table 14. Sensitivity analysis results

<table>
<thead>
<tr>
<th>Delivery strategy</th>
<th>Fiscal cost per dose</th>
<th>Economic cost per dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>With salary increase of 7%</td>
</tr>
<tr>
<td>Facility-based</td>
<td>1.76</td>
<td>1.86</td>
</tr>
<tr>
<td>Outreach</td>
<td>3.86</td>
<td>4.08</td>
</tr>
<tr>
<td>School-based</td>
<td>1.49</td>
<td>1.57</td>
</tr>
</tbody>
</table>

DISCUSSION

At the request of the NEPI, this study has provided evidence on the current cost of TT vaccine delivery and the budgetary impact of the potential replacement of TT vaccine with Td vaccine for 7-year-old children in Vietnam. Our findings show that the NEPI would be able to implement the new schedule for Td vaccine without overspending the budget if a school- or facility-based strategy were employed. In fact, these two strategies may result in cost savings as compared to current delivery: a school-based delivery strategy was found to generate the highest amount of savings, a total of nearly US$7 million over the period 2018-2025. A facility-based delivery strategy would also result in cost savings, albeit a smaller savings of around US$4 million over the same period. However, use of a mixed strategy of facility-based delivery with outreach would result in an additional cost of US$2.3 million over the period 2018-2025.

These estimates are based on assumptions about the future coverage and number of Td vaccine doses to be delivered, as well as unit costs of TT vaccine and Td vaccine delivery from the historical costing. The average cost per dose of TT vaccine delivered through routine immunization to CBAW varied widely depending on delivery strategy, with delivery via outreach being more than twice as costly as delivery using facility- and school-based strategies (US$3.86 versus US$1.76 and US$1.49, respectively). School-based delivery is particularly time-efficient, resulting in lower unit costs, while the high unit cost of outreach reflects the higher level of staff time required for outreach and the low volumes. Outreach is utilized only in rural areas and represented less than 4% of doses delivered, primarily targeting remote areas with smaller population sizes. Td vaccination through campaigns costed US$3.56 per dose (all fiscal costs). In general in outbreak response there are higher transport and fuel costs as compared to TT delivery, particularly at facilities, as there is greater movement of staff required during campaigns.

A variation in the cost per dose by geographical area can be expected given the different levels of funding for EPI at provincial and district levels, according to each local authority’s priorities and their budget capacity. These differences were noted even across areas where the number of doses delivered was similar, such as for rural facilities in the
highlands, centre coast and northern mountains. The differences in the average fiscal cost per Td dose delivered between the highlands (US$2.37) and centre coast area (US$4.57) are due to a number of factors such as the outbreak response being more advanced in the highlands and a higher level of supervision in centre coast. Some geographical fluctuations in cost, such as the higher costs seen in the northern mountainous areas, are due to the higher level of Government support for salary and bonus payments.

While the total fiscal cost per TT vaccine dose delivered through facility- or school-based strategies was higher in rural areas than urban areas, the total economic cost per dose for these two delivery strategies were both higher in urban areas. EPI experts asserted that the highest cost per dose among urban facilities, found in the megacity in the north, is due to an additional stipend paid for supervision there.

Comparing fiscal and economic costs, this study has noted that actual spending on EPI (fiscal costs) is currently much lower than the true resources used (economic costs). In particular, funding for cold chain maintenance, vaccine collection and distribution, social mobilization and advocacy are not adequate. Making available additional funds to cover all resources used may strengthen immunization delivery. Finally, a change in the basic monthly salary is estimated to increase the current cost per dose estimates by 7%. Further analysis is required to estimate the overall budget impact of this salary adjustment.

Comparison with global immunization delivery cost evidence

Our findings are largely in line with the global evidence about immunization delivery costs. Study findings have been converted to 2016 US$ for comparability with the global evidence from the Immunization Delivery Cost Catalogue, where unit cost findings reported in the published and grey literature are presented in 2016 US$ (Immunization Costing Action Network (ICAN), 2019).

For school-based delivery, the global estimates are for delivery of HPV vaccine, while our study focused on delivery of TT at schools. The global estimate of US$1.95 to US$2.24 (financial costs) per dose is higher than our estimate of US$1.42 (fiscal cost) for school-based delivery of TT vaccination for CBAW, especially considering that the global estimate only includes incremental costs (Vaughan K, 2019). Vietnam’s higher population density means a reduced distance to health facilities and vaccination sites in comparison to other more sparsely populated countries from which the global estimates are drawn. Differing salary levels and integration of services are also factors which influence delivery costs (Levin A, 2014). However, it should also be noted that the delivery of HPV vaccine was on a pilot/demonstration project basis where costs may be higher than at full-scale implementation. Estimates of the cost of HPV vaccine delivery at full-scale implementation are likely to be lower.

This study’s estimated delivery cost of US$2.10 per dose for facility-based delivery falls squarely in the global evidence range from low- and middle-income countries of US$0.75 to US$9.45 per dose for delivering a schedule of vaccines to children under one at health facilities and through multiple strategies (both economic costs) (Vaughan K, 2019). There is not enough comparable evidence at the global level on the cost of outreach delivery to be able to make a strong comparison, though the available estimates fall between US$0.54 and US$4.44, putting our financial cost estimate of US$3.67 for delivery via outreach well within range (Immunization Costing Action Network (ICAN), 2019). Similarly, there is limited global evidence on the cost of campaign delivery, making it difficult to locate our estimate of US$3.39 per Td dose delivered through campaigns (fiscal cost) amongst others.
OPPORTUNITIES FOR USE OF FINDINGS

Study results have already been used by NEPI to prepare for piloting the delivery of Td to 7-year-old children during the last quarter of 2019 using both school- and facility-based strategies. This decision was taken in light of the cost implications of the different strategies, in addition to ensuring those children not attending school are reached. Evidence provided from this study has also been shared with sub-national EPI units in briefings about the Td replacement and pilots. Broader future dissemination will consider the study results as a helpful input for annual budgeting and planning.

In addition to providing helpful evidence for decision making in Vietnam, this study can also help inform other countries that have not yet introduced Td corresponding with cessation of TT.

Other opportunities for use of study results include the annual national and provincial EPI planning cycle, and the development of the 2021-2025 National Health Plan. They may also inform the NEPI Annual Vaccine Introduction Plan, ongoing costing work on delivering essential health packages for the Government’s Universal Health Coverage (UHC) and primary health care (PHC) work, and policy discussions around the inclusion of vaccines in the health insurance package.
REFERENCES


ANNEX 1: COSTING AND ALLOCATION ASSUMPTIONS

Total cost assumptions

- Annual capital costs were estimated using the actual asset’s costs (purchasing and installation) which were adjusted using useful life years (according to Vietnam Ministry of Finance (MOF) guidance for each type of asset) and a 3% discount rate.

- Costs were classified as either (1) direct costs: the amount spent on a specific EPI activity only or (2) shared facility costs: the costs shared amongst all health service units at the sampled health facility (e.g. costs for building overhead; certain buildings; vehicles). In the case of shared costs, the EPI share was determined, and then the EPI share split among several EPI activities (e.g. travel costs for supervision and trainings).

- Shared costs of buildings were allocated to EPI by the percentage of area used (% area used for EPI/ total area). These EPI allocated costs were then allocated again to each of the activities based on the percentage of working time (% working time in activity A/ total working time).

- A number of different tracing factors were used to allocate shared costs to EPI activities, the most frequently used being the time spent by staff on each activity or a refined version thereof, i.e. the time spent on specific activities relevant to the cost being shared. The shared costs of buildings were allocated based on the area used for immunization.

- There was a difference between fiscal cost per diems and economic cost per diems. Fiscal cost per diems amounted to what staff actually received (based on budget availability), normally lower that what they were entitled by law to receive. Economic costs for per diems were estimated based on actual time spent and the MOF’s cost norm for a working day (VND 300,000 or US$12.90).

- Economic costs for volunteers are estimated based on the market prices for a general laborer.

- Facilities received a bonus for each FIC, though this was often lower due to local budget limits. These allowances were fully estimated and included in costs based on the MOF cost norm and the actual numbers of FIC and women in the economic costing. As FIC are not reported by delivery strategy, these allowances were allocated to facility-based, outreach, school-based and campaign vaccination based on the administered doses recorded for each delivery modality.

- The economic costs related to travel (e.g. car rental and plane tickets) were estimated based on actual time spent and MOF cost norms for travelling.

- The equipment and buildings costs for non-facility based vaccinations were estimated to reflect market priced rentals of VND 533,509 (approximately US$23.00) per day for equipment (tables, chair, air-conditioning units, etc.) and VND 410,648 (approximately US$18.00) for buildings (a room), respectively. This adjustment was made to acknowledge the consumption of resources during outreach service delivery at the outreach points. The fiscal cost for the use of outreach points (space and equipment) was zero.

- The cold chain energy economic costs were estimated based on a norm recommended by the NEPI, which allowed for an annual consumption of around 15,000 liters of fuel for a cold room and 200w of electricity for a 100 liter fridge.
Administrated dose assumptions

- The administered doses information was collected from all visited sites as well as at national, regional, provincial and district levels.
- Vaccination services were delivered only at facility level and therefore the total number of administered doses recorded at sites above the facility level were an aggregate of the facilities managed. These sites above-facility level participated only in a supportive capacity to the facilities through activities such as supervision, training and data management.
- The number of administered doses are stratified by school-based vaccination (for the TT vaccine for CBAW only), campaign (for the Td vaccine only) and facility-based and/or outreach (for TT vaccine for CBAW only). In facilities which implemented both facility-based and outreach strategies, the number of TT doses were retrospectively allocated between the strategies. Based on the recommendation of local staff, 69% of TT doses were allocated to facility-based and 31% to outreach.

Replacement plan assumptions

- Introducing the new schedule of Td vaccine for 7-year-old children will require additional resources (human, time) for training, supervision and social mobilization and advocacy. The additional resources required for the new Td vaccine schedule will be off-set against the savings realized from terminating the current TT vaccine schedule.
- The difference in total costs between the current schedule and the proposed replacement is taken into account.
- The delivery costs of the new schedule for the Td vaccine are estimated assuming three different implementation scenarios: (1) service delivery at facility only; (2) a multi-faceted strategy consisting of 69% facility based and 31% outreach-based service delivery and (3) providing school-based services.
- The cost/dose and doses for the period 2019-2025 are assumed to increase annually using the Vietnamese 3.5% inflation rate and 1% natural population growth rate (Vietnam GSO, 2017).
- The number of doses of Td vaccine for the new schedule is assumed to be the same as the number of doses of TT vaccine delivered to CBAW in 2018. The number of doses of TT vaccine administered to CBAW in 2018 was estimated by inflating the number of doses administered in 2017 (1.1 million) by 1%, resulting in 1,111,000 doses for 2018.
- A transitional period for the Td campaign was also added to the first three years of the 2018-2025 period. The number of Td doses for outbreak control in 2018 was adjusted to 83,429 doses in 2018, based on the number of doses delivered in 2017.
- The unit costs and number of potential administered doses for the new schedule of Td vaccine is taken from the historical costing. The estimated coverage for the new schedule of Td vaccine is assumed to reach full coverage by 2021.

Shared cost allocation

For most shared costs, there was a two-step allocation process: first, costs were often allocated to EPI on the basis of % time spent. The second step allocated the EPI share of costs to different EPI activities. Details of the cost allocation process for different cost ingredients is listed below.

- Personnel
• Fixed personnel (salary + benefit of EPI team)
  o Allocated to EPI by %spending time to EPI activities.
  o Allocated cost for all EPI activities by % time spent (activity time/ total EPI time).
• Variable personnel (supervision allowance, training allowance, promotion allowance, EPI report allowance)
  o Allocated 100% to specific EPI activities.
– Supplies
• All facilities applied the same supply costs (under the MOH norm – Circular 06/2009/TT-BYT), as shown below.

<table>
<thead>
<tr>
<th>Items</th>
<th>How to calculate</th>
<th>Price per dose (VND)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloves</td>
<td>1 pair/1 dose</td>
<td>3,360</td>
</tr>
</tbody>
</table>
| Cotton              | 1g/10 doses                                           | Market price 138,000/500g  
  1 dose = 138,000/500 * 1/10  
  = 27.6                |
| Alcohol             | 1ml/1 dose                                            | Market price 22,000/1,000 ml  
  1 dose = 22,000/1,000 = 22      |
| Hand washing liquid | 5ml/1 dose                                            | Market price 150,000/500ml  
  1 dose = 150,000 / 500 * 5  
  = 1,000               |
| Syringe             | 1 needle/1 dose                                       |                      |
| BCG                 | 0.1 ml                                                | 3,071                |
| OPV (drink)         | 0                                                     | 0                    |
| DPT-VGB-Hib         | 0.5 ml                                                | 614                  |
| DPT                 | 0.5 ml                                                | 614                  |
| Measles             | 0.5 ml                                                | 614                  |
| HpB                 | 0.5 ml                                                | 614                  |
| Encephalitis        | 1 ml                                                  | 1,040                |
| MR                  | 5 ml                                                  | 1,031                |
| TT                  | 0.5 ml                                                | 614                  |
| Td                  | 0.5 ml                                                | 614                  |

– Energy for cold chain (gasoline and electricity)
- Estimated the cost based on NEPI norm of cold chain's energy consumption
- Allocated 100% cost for the activity related cold chain maintenance and operation (code 130)
  - EPI logbooks (printing)
    - Allocated 100% cost for the activity related data management (code 811)
  - Other office stationary (paper, pens, ink, etc.)
    - Allocated to EPI by % time spent (EPI total working time/ Institution total working time)
    - Allocated to EPI activities by % time spent (activity time/ total EPI time)
  - Communications (phone, internet)
    - Allocated to EPI by % time spent
    - Allocated cost for the indirect activities (among group 8 only) by % time spent. e.g. data management, reporting, training, supervision, meetings
  - Other electricity (deducted from the cold chain)
    - Allocated to EPI by % time spent
    - Allocated cost for all activity by % time spent, except the cold chain activity (code 130)
  - Other gasoline (deducted from the cold chain)
    - Allocated to EPI by % time spent
    - Allocated to specific activities by % time spent including:
      - Travel to receive vaccine/ supply (code 213 and 216)
      - Travel to distribute vaccine/ supply (code 222 and 224)
      - Travel for supervision (outreach – code 527, Td campaign – code 627, TT school based event – code 1327 and activity group 850)
      - Travel for training (activity group 830)
      - Travel for investigating the severe reaction after immunization (nested in code 310)
  - Water
    - Allocated to EPI by % time spent
    - Allocated 100% cost for all activities by % time spent.
  - Cold chain maintenance
    - Allocated 100% cost for the activity related cold chain operator (code 130)
  - Maintenance costs for other equipment and buildings (deducted cost for cold chain)
• Allocated to EPI by % time spent
• Allocated cost for all activities by % time spent, except for activity related cold chain (code 130)

  – Equipment for cold storage
    • Allocated 100% to the cold chain (code 110).
  – Equipment for other storage (computer, tables, fire alarm system, fire extinguisher, etc.)
    • Allocated to EPI by % time spent (as this equipment share at institution as the whole).
    • Allocated to activities in group 1 (storage) by % time spent, except for activity cold chain (code 130)

  – Equipment for vaccine transport (cold box, etc.)
    • Allocated to activities related travel by % time spent
      ▪ Travel to receive vaccine/ supply (code 213 and 216)
      ▪ Travel to distribute vaccine/ supply (code 222 and 224)
      ▪ Travel and storage during out-door vaccination (outreach – code 524, Td campaign – code 625, TT school based event – code 1325)

  – Vehicles
    • Allocated to activities related travel by % time spent
      ▪ Travel to receive vaccine/ supply (code 213 and 216)
      ▪ Travel to distribute vaccine/ supply (code 222 and 224)
      ▪ Travel for supervision (outreach – code 527, Td campaign – code 627, TT school based event – code 1327 and activity group 850)
      ▪ Travel for training (activity group 830)
      ▪ Travel for investigating the severe reaction after immunization (nested in code 310)

  – Vaccination equipment
    • Allocated to fiscal cost for activities in group 4 (routine vaccination) by % time spent (Time of group 4/ total working time)

  – Office equipment
    • Allocated to EPI by % time spent (as this equipment share at institution as the whole)
    • Allocated to activities in group 8 (indirect activities, e.g. data management, reporting, training, supervision, meeting) by % time spent
- Building for cold storage
  - Allocated depreciation cost by % area square (cold room area square / total area square)
  - If the cold room is not 100% use for EPI, allocated to group 110, except for cold chain (code 130) by % EPI time spent
  - If the cold room is 100% used for EPI, allocated all to group 110, except for cold chain (code 130)
- Building for supplies storage
  - Allocated depreciation cost by % area square (storage room area square / total area square)
  - Allocated to activities in group 120 (supply storage) by % time spent
  - If the supply room is not 100% use for EPI, allocated to the activities in group 120 (supply storage) by % EPI time spent (or based on the local staff estimation)
  - If the supply room is 100% used for EPI, allocated 100% to the activities in group 120 (supply storage)
- Vaccination buildings (routine, outreach, campaign)
  - Allocated depreciation cost by % area square (area square / total area square)
  - Allocated to fiscal cost for activities in group 4 (routine vaccination) by % time spent (Time of group 4/ total working time)
- Buildings for office activity
  - Allocated depreciation cost by % area square (room area square / total area square)
  - Allocated to EPI by % time spent (as these building share at institution as the whole)
  - Allocated to activities in group 8 (indirect activities, e.g. data management, reporting, training, supervision, meeting) by % time spent
ANNEX 2: DETAILED FINDINGS – STANDARD ERRORS AND 95% CONFIDENCE INTERVALS

The 95% confidence interval (CI) is the sample mean plus or minus 1.96 times its standard error (SE). It gives an indication of the best estimate of the true mean cost per dose across all facilities nation-wide, not just those sampled. Based on this sample, we are 95% confident that the true mean cost per dose falls within the 95% CI low and high bounds. Note that the standard error increases for smaller samples, for example for the outreach-based vaccination estimates (n=5) and smaller for those with a larger sample size (for example, facility-based vaccination where n=37). This produces a wider 95% CI.

Table 15 presents the SEs and 95% CIs for the findings on cost per TT dose delivered by delivery strategy (2018 US$) while Table 16 presents this information for the cost per dose delivered in the Diphtheria outbreak control campaign. These findings without SEs and 95% CIs are presented in Table 8 and Table 10, respectively, in the findings section of the report.

Table 15. Cost per TT dose delivered by delivery strategy (2018 US$)

<table>
<thead>
<tr>
<th>Delivery strategy</th>
<th>n</th>
<th>Cost per dose</th>
<th>SE</th>
<th>95% CI low</th>
<th>95% CI high</th>
<th>Cost per dose</th>
<th>SE</th>
<th>95% CI low</th>
<th>95% CI high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility-based vaccination</td>
<td>37</td>
<td>1.76</td>
<td>0.01</td>
<td>1.74</td>
<td>1.79</td>
<td>2.21</td>
<td>0.02</td>
<td>2.18</td>
<td>2.24</td>
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<tr>
<td>Outreach based vaccination</td>
<td>5</td>
<td>3.86</td>
<td>0.12</td>
<td>3.63</td>
<td>4.09</td>
<td>4.67</td>
<td>0.12</td>
<td>4.43</td>
<td>4.92</td>
</tr>
<tr>
<td>School based vaccination</td>
<td>18</td>
<td>1.49</td>
<td>0.02</td>
<td>1.46</td>
<td>1.52</td>
<td>2.06</td>
<td>0.02</td>
<td>2.02</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Table 16. Cost per dose delivered in the Diphtheria outbreak control campaign (2018 US$)

<table>
<thead>
<tr>
<th>Fiscal costs</th>
<th>Fiscal costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per dose</td>
<td>SE</td>
</tr>
<tr>
<td>Non-vaccination specific costs</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>0.03</td>
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<tr>
<td>-----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>From national level</td>
<td></td>
</tr>
<tr>
<td>From regional level</td>
<td>0.03</td>
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<tr>
<td>From provincial level</td>
<td>0.72</td>
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<tr>
<td>From district level</td>
<td>1.43</td>
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<tr>
<td>From facility level</td>
<td>0.42</td>
</tr>
<tr>
<td>Vaccination specific costs</td>
<td>0.92</td>
</tr>
<tr>
<td>Total cost per dose</td>
<td>3.56</td>
</tr>
</tbody>
</table>