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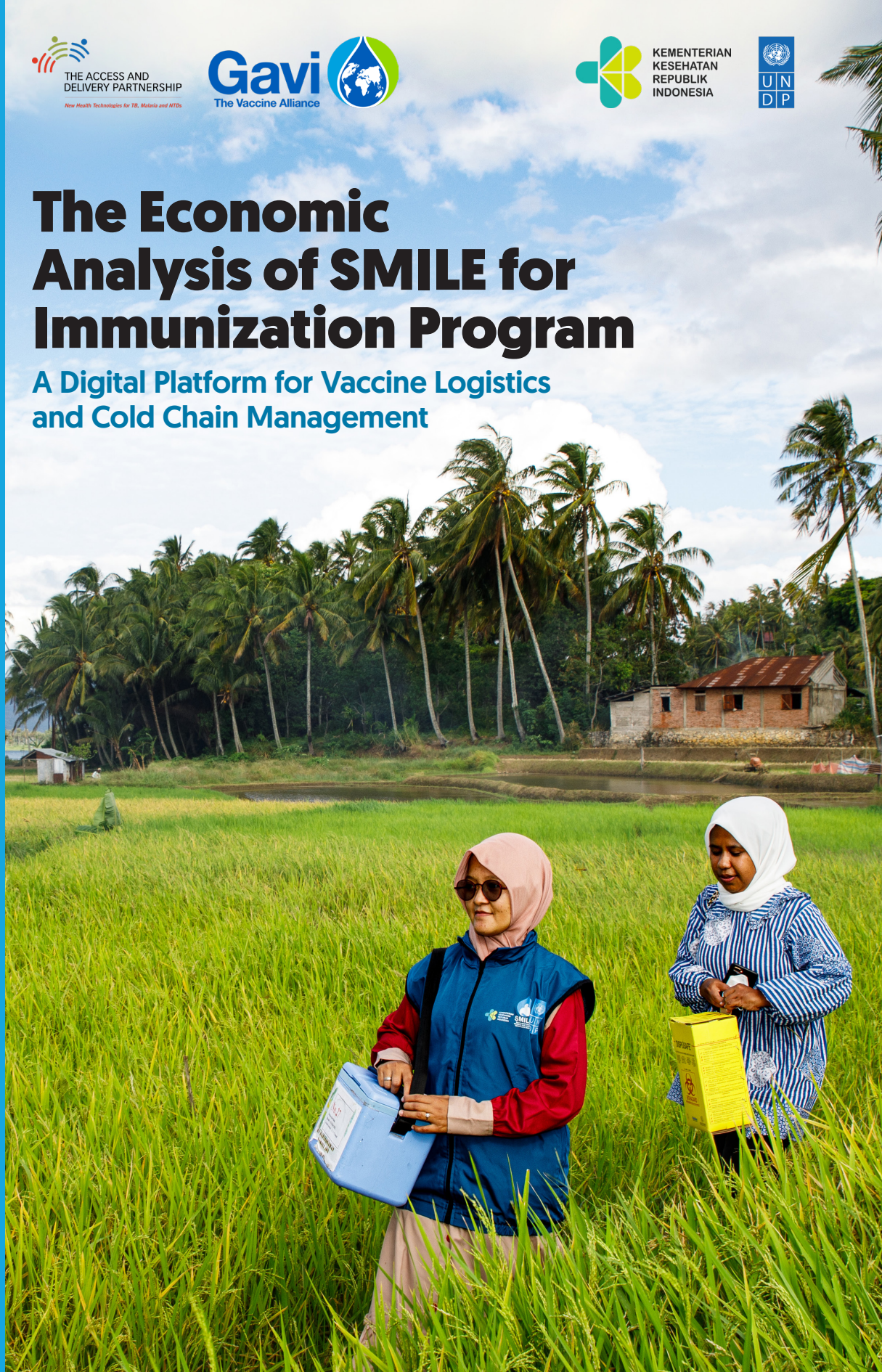
The Economic Analysis of SMILE for Immunization Program

A Digital Platform for Vaccine Logistics and Cold Chain Management



SMILE

SISTEM MONITORING
IMUNISASI DAN LOGISTIK
SECARA ELEKTRONIK

The Economic Analysis of SMILE for Immunization Program

A Digital Platform for Vaccine Logistics and Cold Chain Management

Foreword

Dr. dr. Maxi Rein Rondonuwu, DHSM, MARS
Director General of Disease Prevention and Control, Ministry of Health the Republic of Indonesia

IMMUNIZATION IS AN EFFORT TO CREATE or actively increase a person's immunity to a disease to reduce mortality and morbidity against the diseases, as explained in the Regulation of the Minister of Health Number 12 of 2017. Therefore, the Government has made the immunization program as one of the national priority development programs in the health sector.

Indonesia faces several challenges in the supply chain management of vaccine logistics and other health commodities, such as drugs and test kits due to poor visibility and unreliable stock monitoring (no real time stock monitoring) in health facilities. The current paper-based routine reporting of vaccine logistics is impeded by poor accuracy, validity and timeliness of the reports. Data are not available in real-time and electronically to all stakeholders, therefore very limited visibility in the pipeline at sub-national levels. These issues, in turn, cause delayed planning, unequal distribution and delivery, inaccurate and less transparent vaccines monitoring.

In order to implement an effective and efficient monitoring system, the Directorate of Immunization Management in collaboration with UNDP (United Nations Development Programme) Indonesia developed an Electronic Immunization and Logistics Monitoring System/*Sistem Monitoring Imunisasi dan Logistik secara Elektronik (SMILE)*. The development of SMILE system and app is in line with, even one step ahead, than the Ministry of Health's commitment to implementing one of the six pillars of transformations in health sectors, namely Transformation in the Health Technology Sector. SMILE has been roll out since 2018 before the Digital Health Transformation Strategy Blue Print was launched in 2021.

SMILE ensures all information and transactions of vaccines supply, distribution, storage, disposal, and destruction can be accessed anywhere. SMILE empowers health workers to order vaccines as

needed and managers to monitor program implementation in real-time. Armed with valid data, SMILE allows policy makers develop better program planning from Central to Regional levels. The data collected in the SMILE application becomes basic information that is accurate and crucial for improving the quality of vaccine planning, procurement, and distribution, so that it can be managed faster, easier, and on target.

As a learning objective for improving the program and providing evidence on the benefits of digitizing health programs, an economic analysis of the digitization in the immunization program was held by the Directorate of Immunization Management, UNDP Indonesia, together with SurveyMeter Research Institute, the Health Intervention and Technology Assessment Program (HITAP) Thailand, and health economic experts from University of Indonesia. Various economic aspects of the use of technology in supply chain management are analyzed, resulting in Return on Investment (RoI), Benefit Cost Ratio (BCR), resource savings, savings from vaccine disposal avoidance, savings on inefficient vaccine expenditure, and potential loss due to temperature excursions in vaccine storage refrigerators.

It is hoped that the results of this study will provide an overview of the benefit values of digitizing the immunization program through the SMILE application to record, monitor, and report vaccines and logistics distribution from Central level to health care facilities. Despite some of the limitations found in this study, we are proud that this study is the first one conducted in Indonesia that present an economic analysis of an innovative health program monitoring through digitalization. We hope that the results of this study will inspire and convince all parties, especially policy holders and health program managers to apply technology and digitization in the health programs.

I thank all those who have contributed to this study. We hope that the results of this study will benefit all of us and can be used as a reference in monitoring the effectiveness of digitization in immunization and other health programs, not only in Indonesia, but also in other countries.

Foreword

Sujala Pant
Deputy Resident
Representative UNDP
Indonesia

UNDP HAS BEEN WORKING CLOSELY with the Government of Indonesia on its response to the COVID-19 pandemic while strengthening our support to increase the coverage of routine immunization, by contributing to the delivery effort of critical vaccines nationwide.

Indonesia has one of the most ambitious immunization programs in the world. To reach every child in the country, one of the most significant challenge has been the absence of real-time information on vaccine stocks and flows to make informed decisions.

Sistem Monitoring Imunisasi dan Logistik secara Elektronik (SMILE) was developed by the Ministry of Health and UNDP to support the immunization program by providing real-time monitoring of vaccine stocks, its flows, and the storage temperature across all cold chain points. This innovative solution is in line with SDG 3 and UNDP Digital Strategy 2022–2025. Importantly, it supports the Ministry of Health's commitment to carry out one of the six pillars of transformation in the heath sector, which is about transformation in the Health Technology. As of today, SMILE has currently been implemented across 34 provinces, in 514 districts, benefitting over 10,000 community health centres and 3,000 public hospitals targeting at least 15 million children and 5 million pregnant women per year.

The economic evaluation has been an extensive exercise which has brought to light several benefits of SMILE, including the achievements and gaps from an economic perspective. I am happy to share the findings of the assessment including the return on investment (ROI), the benefit cost ratio (BCR), savings and potential loses. All these findings provide evidence that it is worthwhile to invest in digitalization for health program. We are hopeful that with an understanding of the benefits of digital transformation, the Ministry of Health and other agencies will have the necessary

evidence to guide their future investment to achieve country's health outcomes.

I am also pleased to share that this assessment also presents the success of a new initiative introduced by SMILE in ensuring vaccine quality while in storage. As we are aware, vaccines lose their efficacy when exposed to excessive heat and cold. Study findings showed that the IoT-based remote temperature loggers installed in 633 vaccine storages and connected to SMILE could potentially prevent loss from temperature excursion valued at an estimate of as much as USD 32,000 per community health center in a month.

I would like to thank the experts who contributed on this study. Colleagues from SurveyMeter Research Institute, the Health Intervention and Technology Assessment Program (HITAP) Thailand, and the health economic experts from the University of Indonesia, who provided systematic feedback of the study findings. Sincere appreciation to the Ministry of Health especially to the Immunization Management Directorate who has been a steadfast supporter in the use SMILE for immunization even prior to the pandemic. I want to conclude by thanking all colleagues from the UNDP Bangkok Regional Hub, the Access and Delivery Partnership (ADP) for their continued support and connecting us with previous studies from UNDP India.

I am confident that these study findings would be helpful to use at national, provincial, and district levels to improve the quality of vaccine supply chain services. I convey my best wishes and look forward to its future success.

Acknowledgement

We are thankful for your vision and valuable inputs:

University of Indonesia: Professor Dr. drg. Mardiati Nadjib, MS., dr. Nugroho Soeharno, Euis Ratna Sari, MEKK., Poppy Yuniar, SKM., MM
HITAP Thailand: Saudamini Vishwanath Dabak, BA., MA, Kinanti Khansa Chavarina, MPH and Sarin KC., MSc
Surveymeter: Dr. Ir. Ni Wayan Suriastini, M.Phil., Dani Alfah, SSos., MPA
Ministry of Health: dr. Prima Yosephine, MKM., dr. Lily Banonah Rivai, MEpid., Edy Purwanto, SKM., MKes and Junghans Sitorus, SKM., MKes
UNDP/the Access and Delivery Partnership (ADP): Leslie Ong, MPhil., MPH
UNDP Indonesia/SMILE Project: drg. Vidia Darmawi, MPHC., Tina Rosalina, SKM., MSc., Sugih Hartono, Putri Warta, MC-BMEDSC

We acknowledge the sincere efforts of Surveymeter team for field data collection and their contribution in preparing the assessment report. We also recognize the sincere efforts of Dwidjo Susilo, MBA for the economic analysis of SMILE.

This study was supported by the Access and Delivery Partnership (ADP). The Access and Delivery Partnership (ADP) works with low- and middle- income countries to ensure life-saving medicines and health technologies reach the people who need them. We support countries to strengthen and harmonize policies and systems, and build the capacities of key people and institutions to drive the necessary reforms for sustainable, country-led progress towards universal health coverage. ADP is supported by the Government of Japan and led by the United Nation Development Programme, in collaboration with the World Health Organization, the Special Programme for Research and Training in Tropical Diseases and PATH.

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No.27
Dinkes Kab Solok
Masuk : 31 Maret 2022
Jumlah Sampel : 2 + 1 =3 Sampel
RC PANINGGAHAN
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List of Abbreviations

ADP	:	Access and Delivery Patnership
BCG	:	Bacillus Calmette-Guérin
BCR	:	Benefit Cost Ratio
DPT	:	Diphteria, Pertussis, and Tetanus
DPT-HB-HiB	:	Diphteria, Pertussis, and Tetanus – Hepatitis B – Haemophilus Influenza Type B
HITAP	:	Health Intervention and Technology Assessment Program
IoT	:	Internet of Things
IPV	:	Innactivated Poliovirus Vaccine
MoH	:	Ministry of Health
MR	:	Measles-Rubella
PD3I	:	Diseases that can be Prevented with Immunization
ROI	:	Return on Investment
SDGs	:	Sustainable Development Goals
SMILE	:	Sistem Monitoring Imunisasi dan Logistik secara Elektronik
UNDP	:	United Nation Development Programme
VCCM	:	Vaccine Cold Chain Manager

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Executive Summary

***Sistem Monitoring Imunisasi Logistik secara Elektronik* (SMILE)** is an electronic immunization logistics monitoring system, a program developed by the Government of Indonesia supported by UNDP to ensure the availability of safe and effective vaccines in Indonesia. SMILE inception was carried out in Bogor and South Tangerang City in 2018. The pilot phase showed satisfactory results where the SMILE system achieved a high-level of user satisfaction and acceptance among cold-chain handlers and managers, as evidenced by over 9,000 to 15,000 transactions since August 2018. The system reduced vaccine stockouts by 70% in the first six months of its introduction. Building on the success of the pilot projects, SMILE was then used in 25 districts/cities for routine immunization, and in all districts/cities for the COVID-19 vaccination program in 2021. At the end of 2022, SMILE reached all districts/cities as an effort to catch up with the routine immunization program for children nationwide. All calculations of the benefits focused on activities related to the use of the SMILE application for the routine vaccine cold chain management and logistics at the health centers that directly provided services to beneficiaries.

An economic evaluation of SMILE in 2022 found that the return on investment (ROI) was 2.77. It means every Rupiah (IDR) invested in the SMILE program yields a return of IDR 2.77 along with the initial investment. The benefit-cost ratio (BCR) of SMILE was 3.77 indicating the SMILE program has a huge positive benefit to the routine vaccination program. In addition, it was estimated that the Internet of Things (IoT) Logger could prevent the potential loss due to temperature excursion by as much as IDR 457 million per month per community health center (*Puskesmas)* although it is possible that this calculation may lead to an overestimation.

The study recommended each vaccine storage should be equipped with an IoT Logger to avoid waste due to temperature excursion and to ensure the quality of the vaccines. Continuous training is key to improve the skills of pharmaceutical personnel to support the implementation of the one-gate policy in vaccine logistics management. Inter-sectoral collaboration plays a significant role to brand SMILE as a reference for the examination and reporting of vaccine management and logistics. SMILE would be an integrated solutions in logistics monitoring, not limited to digitalization but also innovation and development financing, with impact and scale to be accelerated in other health programs in Indonesia.

Introduction

IMMUNIZATION IS A PRIORITY PROGRAM of the Government of Indonesia, which aims to reduce child morbidity and mortality due to diseases that can be prevented with routine immunization/ *Penyakit yang Dapat Dicegah dengan Imunisasi* (PD3I), such as polio, hepatitis B, pertussis, diphtheria, Haemophilus, type B influenza, measles, and tetanus. Efforts to strengthen the vaccine logistics and cold chain management system are crucial in achieving the government's targets for the health sector under the Sustainable Development Goals (SDGs). Recording and reporting of the use and distribution of vaccines and manual temperature monitoring have an impact on the accuracy, validity, and time of reporting. Monitoring temperature manually also affects the quality of the vaccine.

To overcome the logistics and cold chain management issues, the Indonesian Ministry of Health, with the support of the United Nations Development Program (UNDP), developed a web-based and mobile digital application to monitor vaccine supplies and cold chains. An application called Electronic Immunization Logistics Monitoring System/*Sistem Monitoring Imunisasi Logistik secara Elektronik* (SMILE), adapted from India's Electronic Vaccine Intelligence Network (EVIN), provides visibility of cold chain vaccine logistics in real-time, including monitoring the temperature of vaccine storage at each location. Through the SMILE interface, health officials can find out vaccine stocks, whether overstock, shortfall, or complete

stockout, making it easier to manage programs by providing data even from difficult to reach areas (UNDP, 2022). After introducing the system in two districts in 2018, SMILE was implemented in 25 districts/cities for routine immunization in 2021, and in 514 districts/cities for the COVID-19 vaccination program. At the end of 2022, all districts/cities used SMILE for routine vaccinations to support the national immunization program.

Economic analysis of SMILE was conducted in 2022 as requested by the Minister of Health. Obtaining data for one year period prior to the use of SMILE was challenging. Data for six months in SMILE areas were selected as a reference period for pre- and post-SMILE phases. The six month-period was chosen due to the rationale that the data was valid enough and the health staff were trained to optimally utilize the SMILE app. The study assessed routine immunization vaccines, such as BCG, Measles-Rubella (MR), DPT-HB-Hib, Hepatitis B, IPV, and Polio.

The objectives of the analysis were to assess the efficiency of vaccine management and logistics using SMILE, conduct an economic assessment of SMILE (Return on Investment), propose recommendations to the Ministry of Health to improve SMILE's business model and scale-up the SMILE usage, and provide important lessons for Indonesia and other countries to develop similar policy decisions on digital health and the immunization program.


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Economic Analysis of SMILE

1 Methodology

a. Study Design

This study applied primary and secondary data. Primary data related to vaccine logistics and immunization cold chain management were obtained from the officers-in-charge in Puskesmas, and District and Provincial Health Offices. The secondary data in the form of records related to Pharmacy and Immunization program were gathered from Puskesmas, District and Provincial Health Offices, and Ministry of Health as well as the finance departments at the Ministry of Health and UNDP. The vaccines observed in this study were vaccines for routine immunization for children, including BCG, Measles-Rubella (MR), DPT (Diphtheria, Pertussis, and Tetanus), DPT-HB-Hib, Hepatitis B, and IPV (Inactivated Poliovirus Vaccine).

The study was carried out in seven districts/cities in seven provinces, namely West Java, DKI Jakarta, Riau, Central Java, West Sumatra, East Java and East Kalimantan from June to December 2022. The data collected were related to vaccine benefits, vaccine sustainability, and program challenges in 2018 to 2022.

b. Sample Size

1) The study involved 21 Puskesmas facilities spread across seven districts/cities in seven provinces in Indonesia.

- A total of 12 Puskesmas facilities in four districts/cities within four provinces using SMILE for routine immunization logistics and cold chain management were grouped into Routine SMILE Puskesmas.
- Nine Puskesmas facilities in three cities within three provinces that did not use SMILE for routine immunization logistics and cold chain management were classified as Routine Non-SMILE Puskesmas.
- The graph below depicts the sample size in Routine SMILE Puskesmas and Routine non-SMILE Puskesmas.

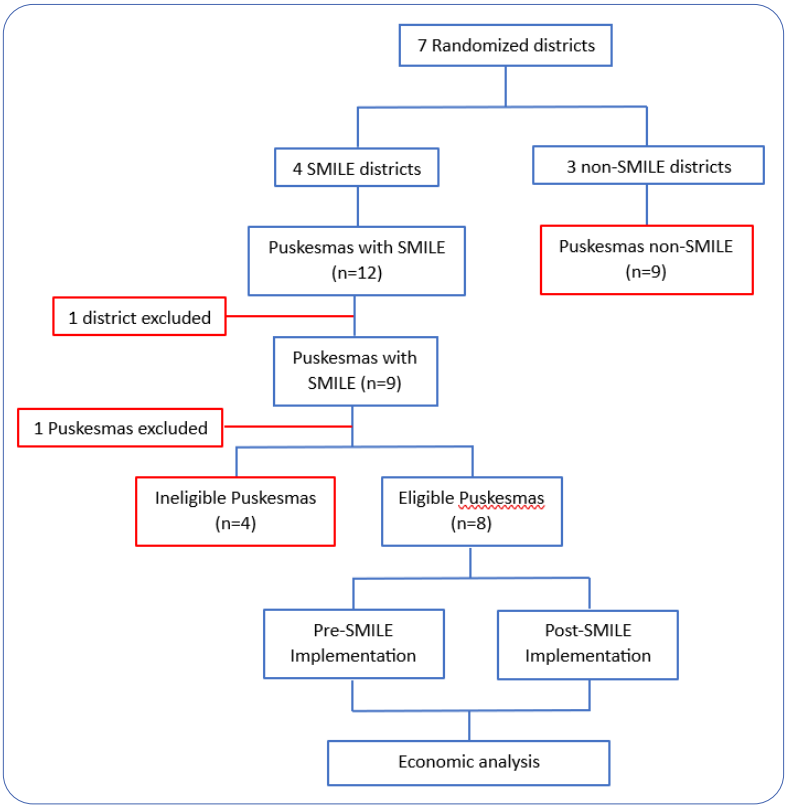


Figure 1. Sample Selection

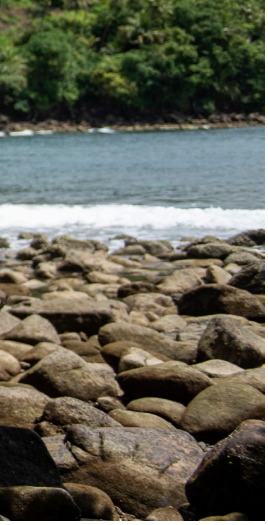
2) Data collected in the SMILE Routine Area-2 could not be used because the SMILE program in that area started in February 2020, coinciding with the COVID-19 pandemic. The government policy to restrict public activities during the COVID-19 pandemic resulted in a decrease in the number of routine vaccinations for children. As a result, the data obtained during the pandemic could not be compared with the data collected before the pandemic. Therefore, data from the three Routine SMILE Puskesmas facilities in Area-2 were excluded from the assessment.

3) Among the remaining nine Routine SMILE Puskesmas sampled, there was one Puskesmas that used a different reporting format which caused an inconsistency. This Puskesmas was then excluded from the assessment.

4) Thus, only eight Routine SMILE Puskesmas facilities were eligible to be sampled for this study because the pre- and post-SMILE data were comparable. The pre- and post-SMILE data in three Puskesmas in West Java was from 2018 (before the COVID-19 pandemic). Meanwhile, the pre-and post-SMILE data in the rest of the five Puskesmas in Riau and Central Java were during the COVID-19 pandemic.

5) The Routine Non-SMILE areas (n=9) were not part of the economic analysis because the observation on these areas were only for one time period (January – March 2022). It was for qualitative analysis purposes.

6) Selected districts and Puskesmas which used SMILE for routine immunization program were randomized using Stata.



7) Observations were made with the following conditions:

- A pre-SMILE versus post-SMILE comparative analysis was carried out to calculate the cost evaluation: Six months prior to the SMILE program implementation and six months after the SMILE program was implemented.
- January – March 2022 as current condition (for qualitative study only).

Table 1. Samples of Routine SMILE Puskesmas

Area	Province	Sample (N=8)	Start of SMILE	Pre-SMILE	Post-SMILE
Area 1	West Java	Puskesmas 1	July 2018	Jan-June 2018	July-Dec 2018
Area 1	West Java	Puskesmas 2	July 2018	Jan-June 2018	July-Dec 2018
Area 1	West Java	Puskesmas 3	July 2018	Jan-June 2018	July-Dec 2018
Area 3	Riau	Puskesmas 1	June 2021	Dec 2020-May 2021	June-Nov 2021
Area 3	Riau	Puskesmas 2	May 2021	Nov 2020-April 2021	May-Oct 2021
Area 3	Riau	Puskesmas 3	March 2021	Sept 2020–Feb 2021	March-Aug 2021
Area 4	Central Java	Puskesmas 1	May 2021	Nov 2020-April 2021	May-Oct 2021
Area 4	Central Java	Puskesmas 2	June 2021	Dec 2020-May 2021	June-Nov 2021

Source: Survey Meter, 2022

Table 2. Characteristics of the Routine SMILE Puskesmas

Area	Province	Sample (N=8)	Puskesmas	Urban/Rural	Population
Area 1	West Java	Puskesmas 1	East Bogor	Urban	105,188
Area 1	West Java	Puskesmas 2	Merdeka	Urban	96,180
Area 1	West Java	Puskesmas 3	Tanah Sereal	Urban	220,764
Area 3	Riau	Puskesmas 1	Sapta Taruna	Urban	47,045
Area 3	Riau	Puskesmas 2	Sail	Urban	20,450
Area 3	Riau	Puskesmas 3	Umban Sari	Urban	46,674
Area 4	Central Java	Puskesmas 1	Muntilan 1	Urban	39,678
Area 4	Central Java	Puskesmas 2	Tempuran	Urban	52,894

Source: Survey Meter, 2022

c. Economic Assessment

1) Return on Investment (ROI) and Benefit-Cost Ratio (BCR) are two forms of economic evaluation that assess the benefits of an intervention against the total costs of its delivery.[1]

2) Return on Investment (ROI) was used to find out how much benefits were generated from investment spending.[2]

ROI = Net National Savings/Total Investment Expenditures

- Net National savings was calculated from total national savings minus total investment expenditures.
- ROI = 1 means that $1.00 is returned for each dollar invested, ROI = 0 indicates break-even investment, ROI < 1 means the investment costs exceed the dollars returned (an investment loss), and ROI > 1 indicates the benefits derived from the program exceeding the investment costs incurred.
- Cost components to calculate the ROI were obtained in 2021 with an adjustment of 2018's cost to 2021.

3) Benefit-Cost Ratio (BCR) was applied as an indicator of the profitability or the ratio of benefit generated relative to the costs required of the SMILE program for vaccine management and logistics intervention.

BCR = Total National Savings/Total Investment Expenditures

A BCR >1 indicates that the program had positive benefits and vice versa, a BCR=1 indicates that the expected profits equals the costs.

[1] Masters R, et al. 2017. *Return on investment of public health interventions: a systematic review*. J Epidemiol Community Health; 71:827–834.

[2] Arrieta, A., Woods, JR., Qiao, N., Jay, S. 2014. *J Cost–Benefit Analysis of Home Blood Pressure Monitoring in Hypertension Diagnosis and Treatment: An Insurer Perspective*. Hypertension; 64:891–896.

4) The economic assessment in this study was calculated from the perspective of the provider, not from the beneficiaries.

5) The ROI and BCR assessments used investment expenditures for equipment procurement, application development and maintenance, renting a server and public cloud hosting, staff training, and helpdesk.

- The investment expenditures used the 2021 data obtained at national level.
- The SMILE program has been implemented in the routine SMILE Puskesmas since 2018. It means that the SMILE application was developed in 2018 or even before 2018. The availability of investment costs data was found in 2021. The value of money did not need to be adjusted because the data was the accumulation of investment costs from 2018 to 2021.
- Data collection in the field in 2022 discovered that all Puskesmas utilized the SMILE application for the COVID-19 vaccination program although many of them did not use SMILE for children's routine immunization. In addition, all Provincial, District, and City health offices took advantage of SMILE application for supporting the COVID-19 vaccines distribution.

6) Data on benefits were savings generated from the implementation of the SMILE program, which were obtained both from SMILE and Puskesmas reports. The savings came from vaccine disposal avoidance, prevention of unnecessary vaccine distrbution, and human resources savings for temperature control and reporting activities.

- *Savings from prevention of unnecessary vaccine issuance*
  - The SMILE application minimized vaccine stock-outs and overstocks, ensuring effective vaccine utilization.
  - Savings from the prevention of unnecessary vaccine issuance was assessed by the change in the number of vaccines distributed during the pre- and post-SMILE periods for each vaccine type.
  - Savings occur when the total difference between issuance costs after SMILE implementation and the cost before the implementation is negative. This shows that by using the SMILE application, the vaccine distribution is in accordance with the needs based on the set immunization coverage targets.
  - Field survey data was used as the source of vaccine issuance in the pre-SMILE period, while data from the SMILE database was used as the source of vaccine issuance data in the post-SMILE period.

- *Savings from vaccine disposal avoidance.*
  - Vaccine disposal is caused by expired, damaged, and remaining vials that are not possible to be utilized.
  - The SMILE application contains information on the batch number of doses per vial which makes it easier to monitor vaccine expiry dates. It is very useful to minimize the wastage of vaccines. Vaccine dispensing is based on the expiry date with those near expiry to be used first.
  - Savings occur when the difference between disposal costs of various vaccines after SMILE implementation and the costs before the implementation is negative.
  - Field survey data was used as the source of vaccine disposal in the pre-SMILE period, while data from the SMILE database was used as the source of vaccine disposal data in the post-SMILE period.

7) The SMILE application supports and encourages the one-gate policy in logistics management and the implementation of vaccinations under the Pharmacy unit. The SMILE application reduced the working hours of staff in handling vaccine logistics and management, as well as provided opportunities for staff to develop themselves through training on digitalized logistics and vaccine cold chain management.

- *Savings from human resource activities in monitoring the temperature twice a day.*
  - Real-time temperature monitoring using SMILE from each officer's smartphone is considered to increase the efficiency of monitoring vaccine logistics and has the potential to save human resource activities.
  - Temperature measurement is carried out twice a day in accordance with MoH Regulation No. 12/2017 on the Implementation of Immunization.
  - Salaries were calculated based on salary data of temperature monitoring staff involved in vaccine and cold chain logistics monitoring activities.
  - It was assumed that temperature monitoring activity was carried out by one officer in every Puskesmas.

- *Human Resources Savings from preparing vaccine logistics reports*
  - SMILE application makes it easier for staff to prepare vaccine logistics reports, which were previously done manually using data recapitulation of vaccine transaction records.
  - It is assumed that the preparation of vaccine logistics reports is carried out by one officer.
  - Before SMILE was implemented, the average frequency of preparing vaccine logistics reports is once a month, and took 3.7 hours for each activity.
  - The total cost required for the salary of logistics staff in preparing reports for one year was estimated from the total time required for preparing logistics reports for one year multiplied by the average hourly salary for report preparation.

8) Data on pre-SMILE period was obtained from monthly records in each Routine SMILE Puskesmas. While data on post-SMILE period was collected from the SMILE database for Routine SMILE Puskesmas.

9) The study also observed other benefits of using SMILE application, including SMILE for routine Childhood Vaccination Procurement Planning, and the usage of the Internet of Things (IoT)-based temperature monitoring tool (Logger).

- The application provides access to real-time vaccine stock information for all parties involved in the vaccine logistics management, such as Puskesmas, District/City Health Offices, Provincial Health Offices, and the Ministry of Health. The application simplifies the planning of vaccine procurement and vaccines distribution as well as providing more data for monitoring.
- The Internet of Things (IoT)-based temperature monitoring tool (logger) that was connected to the SMILE application helped maintain the quality of vaccines in storage. It provides notifications if the storage temperature was above 8°C or below 2°C. The use of the IoT Logger reduced potential loss from vaccine degradation due to temperature excursion.

2
Main Findings

a. Investment Costs

The investment costs for the SMILE program incurred in 2021.

Table 3. Investment Costs

Cost Components	IDR	USD
Software enhancement	5,594,412,954	373,284.4
Field Workers (VCCM) + Experts	11,310,000,000	754,654
Software maintenance	7,653,938,000	510,705.14
Public cloud hosting	828,996,858	55,314.4
Helpdesk	504,000,000	33,629.14
IoT-based Logger	2,804,067,524	187,099.98
Capacity Building (online and offline), e-Learning	6,842,962,400	456,593.21
Total Investment Costs	**35,538,377,736**	**2,371,280.27**

b. Savings

The savings obtained from the implementation of SMILE application were as follows (basic calculation of savings parameters is provided in the annex):

Table 4. Savings Indicators

Saving Indicators	Total (IDR)	Total (USD)*
Savings from prevention of unnecessary vaccine issuance	101,113,285,338	7,078,283.89
Savings from vaccine disposal avoidance	210,287,688	14,720.87
Human Resource Savings for temperature monitoring	18,243,223,167	1,277,089.48
Human Resource Savings for preparing reports	14,362,927,584	1,005,455.20
Total Savings	**133,929,723,777**	**9,375,549.44**

*1USD = IDR 14,285 as of December 2021

c. Return on Investment (ROI)

1) The study used actual return on investment[3] to estimate the true return on investment of the program.

Table 5. Return on Investment (RoI)

Saving Indicators	Total (IDR)	Total (USD)*
Savings from prevention of unnecessary vaccine issuance	101,113,285,338	7,078,283.89
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Human Resource Savings for preparing reports	14,362,927,584	1,005,455.20
Total Savings	**133,929,723,777**	**9,375,549.44**
Total Investment Expenditures	**35,538,377,736**	**2,487,810.83**
Total Net Saving	**98,391,346,041**	**6,887,738.60**
Return on Investment (RoI)	**2.77**	

*1USD = IDR 14,285 as of December 2021

- Net savings was estimated from total national savings minus total investment expenditures.
- Net savings= IDR 133,929,723,777 – IDR 35,538,377,736 = IDR 98,391,346,041
- Return on Investment was obtained by dividing net savings with total investment expenditures.

ROI = IDR 98,391,346,041/IDR 35,538,377,736 = 2.77

2) The estimated Return on Investment (ROI) for the SMILE Program was 2.77. It means **every Rupiah invested in the SMILE program was estimated to result in a return of 2.77 times.**

[3] Stobierski, T. 2020. *Business Insights. How to Calculate ROI to Justify a Project*. HBS Online.

d. Benefit-Cost Ratio (BCR)

1) The Benefit-Cost Ratio (BCR) was calculated by dividing the total national savings in vaccine disposal, vaccine distribution, and human resources activities in monitoring and reporting by the total investment expenditures.

BCR = IDR 133,929,723,777/IDR 35,538,377,736 = 3.77

Table 6. Benefit Cost Ratio (BCR)

Saving Indicators	Total (IDR)	Total (USD)*
Savings from prevention of unnecessary vaccine issuance	101,113,285,338	7,078,283.89
Savings from vaccine disposal avoidance	210,287,688	14,720.87
Human Resource Savings for temperature monitoring	18,243,223,167	1,277,089.48
Human Resource Savings for preparing reports	14,362,927,584	1,005,455.20
Total Savings	**133,929,723,777**	**9,375,549.44**
Total Investment Expenditures	**35,538,377,736**	**2,487,810.83**
Benefit Cost Ratio (BCR)	**3.77**	

*1USD = IDR 14,285 as of December 2021

2) The estimated Benefit-Cost Ratio (BCR) for the SMILE Program was 3.77.

3) **BCR of 3.77 (BCR >1) indicated that the SMILE program had positive benefits to the routine children vaccination program**. The larger the BCR, the greater the benefits for the program.

e. The 2023 Routine Childhood Vaccination Procurement Planning with SMILE

1) The SMILE application simplifies the planning of vaccine procurement and vaccines distribution as well as providing more data for monitoring.

2) The Ministry of Health utilized SMILE application for the 2023 routine childhood vaccination procurement planning. The story can be read below.

Box 1. The 2023 Routine Childhood Vaccination Procurement Planning with SMILE

PLANNING FOR PROCUREMENT OF CHILDREN'S ROUTINE VACCINES FOR 2023 STARTED in early 2022. Following the National Budget cycle, in February-March 2022, the Directorate of Immunization, Ministry of Health (MoH) carried out a baseline review, compiled, and determined the indicative ceiling for the procurement of routine childhood vaccines for 2023, such as Hepatitis B, BCG, Polio/bOPV, DPT-HB-Hib, IPV, Measles-Rubella.

Based on the review, the Directorate of Immunization submitted a proposal of **13.284.485** vials for the routine children's vaccines for 2023 to the Pharmacy Directorate. As of December 31, 2022, the Immunization Directorate estimated **9.628.936** vials of vaccines were available nationwide. Thus, **3.665.550** vials should be procured in 2023.

At the end of 2022, as a directorate at the Ministry of Health that is responsible for the procurement of drugs and medical devices, including vaccines, the Pharmacy Directorate used the SMILE application to identify the availability of routine children's vaccine stocks as of December 31, 2022. Based on the records on SMILE, it was known that the availability of routine children's vaccine stocks as of December 31, 2022, was **12.207.138** vials. This information was then reaffirmed by the results of stock-taking conducted at 8,000 Puskesmas (80% of total Puskesmas). The stock taking recorded the remaining stock of routine children's vaccines that were not expired was **7,830,350*** vials.

Thus, the additional number of vaccines needed for 2023 based on SMILE information was 1,077,347 vials. This data could minimize irrelevant vaccine procurement and make it more precise as vaccine planning uses real-time vaccine stock data in the SMILE app to ensure an effective vaccine procurement strategy.

f. Potential Savings from Temperature Excursion

- Loggers that are connected to the SMILE application can prevent potential losses from temperature excursion events.
- Temperature excursion in a vaccine storage with no immediate actions taken will cause the vaccine to lose its efficacy (all vaccines spoilt and need to be discarded) which could lead to huge potential loss.
- Loggers that are connected to the SMILE application can prevent potential losses from temperature excursion events by as much as **IDR 457,152,196 or USD 32,002.25 per *Puskesmas* per month** from temperature breach below two degrees during weekdays and weekends.
- In the event of cold chain breach, vaccine storage temperature below two degrees will result in vaccine spoilage. In non-intervention areas (before the loggers were installed), vaccine handlers manually checked cold-chain temperature twice daily within office hours. As such, the vaccine temperature was not continuously monitored. Any temperature excursion will affect the vaccines if no action is taken immediately.
- Based on handling practices at Puskesmas during SMILE pilot and scale-up phase, the study assumed that vaccine handler at Puskesmas discarded vaccines which were frozen and/or exposed to heat for >eight hours regardless of the VVM status.
- Thus, the total savings from temperature excursion prevention nationwide is **IDR 4,598,951,091,760.00** or equal to **USD 321,942,673.55**
- The potential losses are predicted to be higher than the existing estimation because many Puskesmas facilities do not use IoT loggers.

3
Limitations and Assumptions

a. In this study, the benefits were estimated based on data collected from eight Routine SMILE *Puskesmas*. All of the puskesmas were located in cities and had adequate facilities because at the time this assessment was conducted (in 2022), SMILE had been used for routine immunization in 25 districts.

b. Benefits across different level *puskesmas*, and district and provincial health offices were assumed to be equal and were extrapolated to the national level.

c. Investment costs incurred for the development and maintenance of the SMILE application, such as cost for staff training at each level was low because many were held online during the pandemic and may not reflect the actual cost of offline training, therefore might overestimate the calculation of ROI and BCR.

d. The calculation of potential loss due to temperature excursion assumed that all vaccines stored in a day will be degraded. This may lead to overestimation because handling the vaccines from excursion exposure may differ from one to other Puskesmas staff due to level of knowledge to conduct shake

test and VCCM observation, as well as level of confidence prior their decision to keep or discard those vaccines. However, this potential loss calculation can provide an estimate of the loss that would be incurred if a temperature excursion occured without any alert from the IoT logger.

e. Differences in data sources, such as missing data, and different reporting format found in one Puskesmas were omitted in calculation, but might have some impact on the RoI calculation.

f. There is currently no standard methodology to evaluate the cost-effectiveness of a digital system like SMILE, and the research team encountered significant challenges in accurately defining and calculating all costs and benefits related to SMILE, and obtaining appropriate primary comparator/ baseline data. The approach implemented in this study is of an exploratory nature, and was refined based on consultations with various experts as the study progressed. As such, the study findings should be carefully interpreted with these limitations and assumptions in mind, and should be viewed as preliminary.


No.27
DISPOSAFE
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Conclusions

1. The Return on Investment (RoI) is almost three-fold for every Rupiah invested in SMILE system.

2. The Benefit Cost Ratio (BCR) is 3.77 (almost 4 times), meaning that SMILE has quite huge benefits for immunization program.

3. Savings from SMILE as a whole amounted to USD 9.3 million per year.

4. Vaccine damage from exposure to cold temperature for more than one hour (with an absence of remote temperature loggers connected to SMILE) causes a potential loss of USD 32 thousands per month per *Puskesmas*.

Recommendations

1. Continuous training is key to improve the skills of cold chain handlers to reduce unnecessary vaccine issuance and avoid vaccine disposal.

2. Each vaccine storage should be equipped with an IoT Logger to avoid waste due to temperature excursion and to ensure the quality of the vaccines.

3. SMILE is an integrated solution in logistics monitoring. It is not limited to digitalization but also includes innovation and development financing, with impact and scale to be expanded and replicated in other health programs in Indonesia.

4. Through the experience of conducting this study, a number of methodological challenges have been uncovered and documented. The lessons learned will be immensely valuable in informing the design of future economic evaluations of similar interventions.

5. There are more opportunities to discuss on how we can leverage the experience of this study to explore other priority policy questions on digital health and the immunization programme.

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Annex – Basic Calculation

Some important findings from SMILE's economic analysis report that are used as the basis for estimating Return on Investment (ROI) and Benefit-Cost Ratio (BCR) are as follows:

1. Cost for capacity building was divided as follows

Table 7. Costs for Capacity Building

Capacity Building	Training cost	Number of Puskesmas
Online Trainings	52,425,000.00	1,165*
	42,180,000.00	1,406**
	112,125,000.00	7,475***
Offline Trainings	6,336,492,400	-
e-Learning	299,740,000	-
Grand Total	**6,842,962,400.00**	**-**

*1,165 Puskesmas with active rate of 0% – 25%
**1,406 Puskesmas with active rate 26% – 50%
***7,475 Puskesmas with active rate 51% - 100%

2. Savings from the prevention of unnecessary vaccine issuance

Table 8. Vaccine Issuance and Immunization Coverage
at Eight Routine SMILE Puskesmas Before and After SMILE Implementation

Type of Vaccine	Vaccine Issuance (Dosis)[a,b]				Immunisation Coverage (%)[a,b]		
	Pre	Post	Gap between Post - Pre	% Gap (Post – Pre) /Pre	Pre	Post	Gap between Post - Pre
BCG	7675	6240	-1435	-18,7	44,3	43,4	-0,9
Measles-Rubella (MR)	4293	4680	387	9,0	37,8	36,4	-1,3
DPT-HB-Hib	5971	2975	-2996	-50,2	82,1	77,2	-4,9
Hepatitis B	1460	1088	-372	-25,5	46,8	43,3	-3,5
IPV	1525	1300	-225	-14,8	42,0	26,4	-15,7
Polio	8190	4480	-3710	-45,3	85,6	83,6	-2,0
Total	**29114**	**20763**	**-8351**	**-28,7**	**56,4[c]**	**51,7[c]**	**-4,7**

- In all types of vaccines, after six months of SMILE implementation it is assumed that there will be savings in terms of vaccine expenditure.
- This is due to the decrease in the coverage after the implementation of SMILE is smaller (4.7%) compared to the decrease in the percentage of vaccine expenditure (28.7%).
- This decrease can be assumed as a result of improvements in logistics management and the cold chain of routine immunization programs after the implementation of SMILE.
- Savings occur when the total difference between issuance costs after and before SMILE implementation is negative. This shows that by using the SMILE application, the vaccine distribution is in accordance with the needs based on the set immunization coverage targets.

Table 9. Savings from the Prevention of Unnecessary Vaccine Issuance at Eight Routine SMILE Puskesmas

Vaccine Types	Vaccine Issuance Costs (IDR)			
	Pre	Post	Difference (Post – Pre)	USD
BCG	37,523,075	30,507,360	(7,015,715)	(491.12)
Measles-Rubella (MR)	72,062,298	78,558,480	6,496,182	454.76
DPT-HB-Hib	101,630,003	50,636,285	(50,993,718)	(3,569.74)
Hepatitis B	37,724,940	28,112,832	(9,612,108)	(672.88)
IPV	48,493,170	41,338,440	(7,154,730)	(500.86)
Polio	17,603,586	9,629,312	(7,974,274)	(558.23)
Total 8 Puskesmas samples	**315,037,072**	**238,782,709**	**(76,254,363)**	**(5,338.07)**
Total per Puskesmas			**(9,531,795)**	**(667.26)**

(Source: Survey Meter, 2022)

- This study found the difference was negative (minus IDR 76,254,363). It means the use of the SMILE application in eight Puskesmas succeeded in preventing unnecessary vaccine issuance by as much as **IDR 76,254,363.00** or equal to **USD 5,338.07**.
- The result was then escalated to the national level by dividing the total differences by 8 Puskesmas samples and multiplying by 10,608 (the total Puskesmas, Provincial, District, and City Health Offices).
- Total savings per Puskesmas was IDR 9,531,795.00 or equal to USD 667.26.
- The total national savings from the prevention of unnecessary vaccine issuance was IDR 101,113,281,360.00 or equal to USD 7,078,283.61.
- The savings can be assumed as a result of improvements in logistics and cold chain management of routine immunization programs following the use of SMILE.

3. Savings from vaccine disposal avoidance

- Savings occurs when the total difference between disposal costs after SMILE implementation with the ones before the implementation is negative.

Table 10. Savings from Vaccine Disposal Avoidance at Eight Routine SMILE Puskesmas

Vaccine Types	Total Cost Savings or Waste Due to Vaccine Disposal (IDR)			USD
	Pre	Post	Difference (Post – Pre)	
BCG	635,570	-	(635,570)	(44.49)
Measles-Rubella (MR)	-	-	-	0,0
DPT-HB-Hib	-	-	-	0,0
Hepatitis B	-	-	-	0,0
IPV	-	476,982	476,982	33.39
Polio	-	-	-	0,0
Total 8 Puskesmas samples	**635,570**	**476,982**	**(158,588)**	**(11.10)**
Total per Puskesmas			**(19,823)**	**(1.39)**

(Source: Survey Meter, 2022)

- This study found the difference to be negative (minus Rp 158,588). It means the use of the SMILE application in eight Puskesmas succeeded in preventing vaccine disposal by as much **IDR 158,588,00** or equal to **USD 11.10.**
- The result was extrapolated at the national level by dividing the total difference by eight Puskesmas samples and multiplying by 10,608 (the total Puskesmas, and Provincial, District, and City Health Offices).
- The total savings per Puskesmas was IDR 19,823,00 or equal to USD 1.39.
- The total national savings from vaccine disposal avoidance was **IDR 210,282,384.00** or equal to **USD 14,720.50.**

4. Savings from less human resource activities for temperature monitoring

- The total savings per year nationally was calculated by multiplying the total salary of personnel per Puskesmas for temperature monitoring per year by the total number of Puskesmas in Indonesia, i.e. 10,060 Puskesmas.

Table 11. Potential Savings in Human Resources for Temperature Monitoring at Puskesmas (MoH Guidelines) with SMILE Implementation

Saving Indicator	Administration Level	Average time per temperature monitoring activity (minutes)	The average frequency of temperature monitoring in a day	Average hourly salary for temperature monitoring	The total salary of staff per Puskesmas for temperature monitoring per year
Temperature Monitoring	Puskesmas	4.4	2	IDR 33,875	IDR 1,813,442
			Total potential national human resource savings per year		**IDR 18,243,226,520**

(Source: Survey Meter, 2022)

- The cost to be incurred as a salary for one staff for temperature monitoring activities for one year was **IDR 1,813,442.00.** Thus, with the national implementation of SMILE, the potential savings that can be obtained was **IDR 18,243,226,520.00.**
- With an exchange rate of IDR 14,285 for every USD as of 31 December 2021, the potential human resource savings was USD 126.95 per *Puskesmas* or **USD 1,277,089.71** at the national level.

5. Savings from less work hours spent preparing vaccine logistics reports

- Before SMILE was used, the average frequency of preparing vaccine logistics reports was once a month, and took 3.7 hours for each activity.
- The total cost required for the salary of logistics staff in preparing reports for one year was estimated from the total time required for preparing logistics reports for one year multiplied by the average hourly salary for report preparation.

Table 12. Potential Savings in Human Resources
at Puskesmas Related to Vaccine Logistics Reporting Activities with SMILE

Saving Indicator	Administration level	Average time per vaccine logistics report generation activity (hours)	Average frequency of vaccine logistics report generation per month	Average salary for vaccine logistics report generation per hour	Total salaries of staff per Puskesmas for vaccine logistics report generation per year
Vaccine logistics report	Puskesmas	3.7	1	IDR 32,156	IDR 1,427,726
			Total potential national human resource savings per year for report generation		**IDR 14,362,923,560**

(Source: Survey Meter, 2022)

- The results of the analysis showed that the cost incurred for salaries for logistics report preparation per *Puskesmas* per year was **IDR 1,427,726.00**.
- Assuming that the salaries of staff at all *Puskesmas* in Indonesia (10,060 units) were the same, then the potential savings in human resources was **IDR 14,362,923,560.00**.
- The potential savings that can be obtained from human resource was **USD 99.95** per *Puskesmas* or **USD 1,005,454.92** at the national level.

6. Potential losses due to temperature excursion events

- The presence of temperature excursion events - temperatures outside the range of 2°C to 8°C for freeze-sensitive vaccines (should not be frozen), can result in vaccine spoilage. Some vaccines, such as Hepatitis B, DPT-HB-Hib, IPV, DT, and Td will potentially become degraded if exposed to freezing temperatures. Meanwhile, Polio, BCG, and Measles vaccines will be potentially degraded if exposed to hot temperatures.
- The degraded vaccines due to temperature excursion will be discarded and replaced with new ones. Otherwise, the vaccines would not be effective when used or they might have unwanted side effects on children.
- The potential losses due to temperature excursion was estimated from 633 units of logger that were spread in a number of Puskesmas facilities nationwide, including in Provincial and District Health Offices.
- The estimation of maximum vaccine value was calculated from the maximum storage capacity of Puskesmas and the price of the vaccine per dose, obtained by calculating the average of the 15 months between the highest initial stock, final stock, or quantity received in one month.

Table 13. Potential Losses due to Temperature Excursion Events per Puskesmas per Month

Description	The maximum value of vaccine stored in a Puskesmas (IDR) * (A)	Average Frequency Excursion in a month (N=633) ** (B)	A x B (IDR)	USD***
Weekdays				
Occurrence of temperatures below 2 degrees	144,212,049	2.32	334,571,954	
Occurrence of temperatures above 8 degrees		2.69	387,930,412	
Weekends				
Occurrence of temperatures below 2 degrees	144,212,049	0.85	122,580,242	
Occurrence of temperatures above 8 degrees		0.54	77,874,507	
Total Potential Savings per Puskesmas per month			**457,152,196**	**32,002.25**

(Source: Survey Meter, 2022)

- Loggers that were connected to the SMILE application can prevent potential losses from temperature excursion events by as much as **IDR 457,152,196** or **USD 32,002.25** per Puskesmas per month from a temperature breach below two degrees during weekdays and weekends.
- In the event of cold chain breach, vaccine storage temperature below two degrees will result in vaccine spoilage. In non-intervention areas (before the loggers were installed), vaccine handlers manually checked cold-chain temperature twice daily within office hours. As such, the vaccine temperature was not continuously monitored. Any temperature excursion will affect the vaccines if no action is taken immediately.
- Based on handling practices at Puskesmas during SMILE pilot and scale-up phase, the study assumed that vaccine handler at Puskesmas discarded vaccines which were frozen and/or exposed to heat for >eight hours regardless of the VVM status.
- Thus, the total savings from temperature excursion avoidance nationwide would be **IDR 4,598,951,091,760.00** or equal to **USD 321,942,673.55.**
- The potential losses were predicted higher than the existing estimation because many Puskesmas facilities did not have IoT loggers.

ACKNOWLEDGEMENTS

This activity is supported by the Access and Delivery Partnership (ADP), a global project led by UNDP and implemented in collaboration with the WHO, TDR (Special Programme for Research and Training in Tropical Diseases) and PATH, with funding from the Government of Japan.