Methods for Costing Vaccine-Preventable Disease Surveillance: Lessons Learned from Country Studies in Ethiopia and Nepal and Recommendations for Future Studies

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Disclaimer

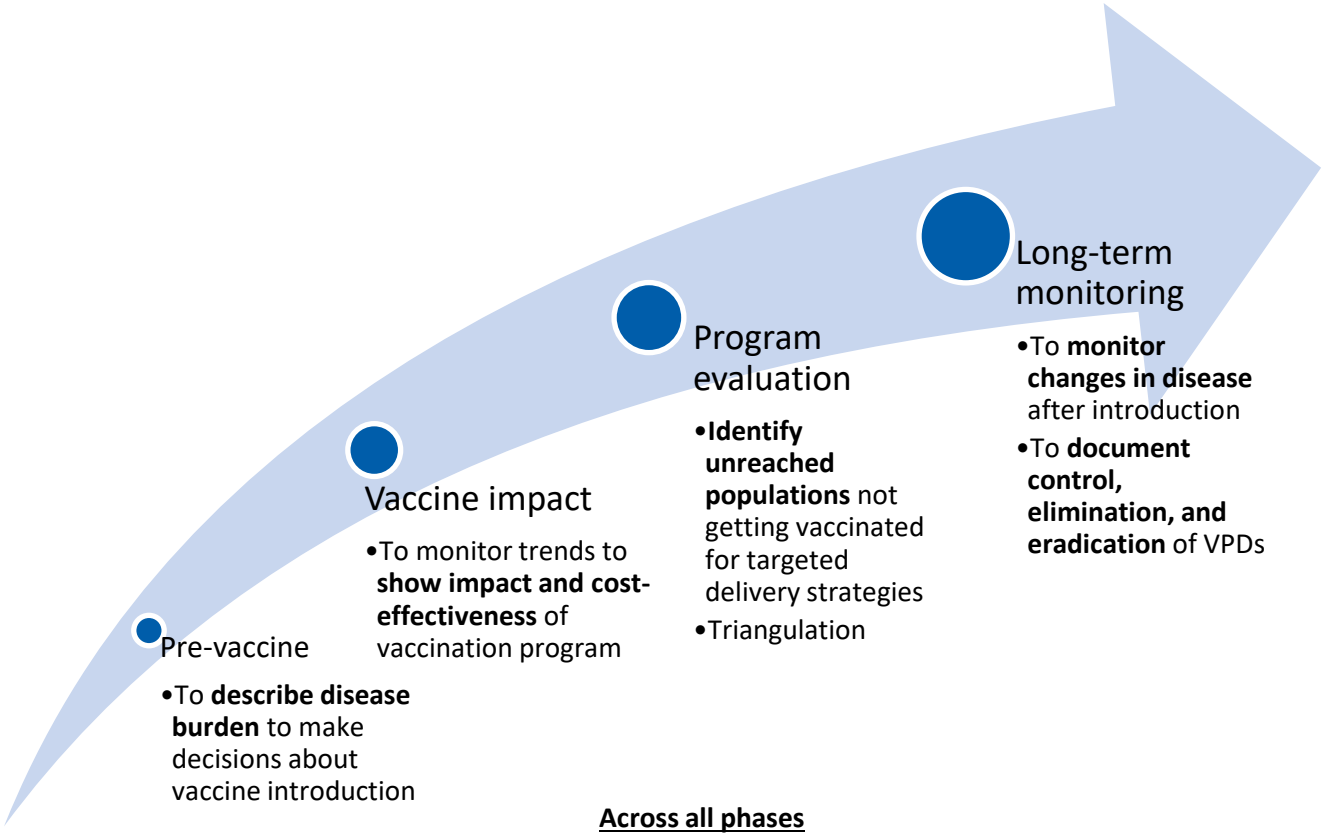
The views expressed in this presentation are solely those of the authors and do not necessarily represent the official positions of the Ethiopian Public Health Institute, U.S. Centers for Disease Control and Prevention, and World Health Organization.

Outline

1. Background
    - Rationale for vaccine-preventable disease (VPD) surveillance costing studies
2. Methods
    - Themes and identification of methodological recommendations
3. Results
    - Characteristics, strengths, limitations of methodologies from country-level studies in Ethiopia and Nepal and recommendations for future VPD surveillance costing studies
4. Discussion
    - Summary of key recommendations

Background

Importance of Vaccine-Preventable Disease (VPD) Surveillance



<u>Across all phases</u>

·**Identify outbreaks for** immediate action for effective **reactive vaccination campaigns**

·**Components** of surveillance **for one VPD can be leveraged to monitor other VPDs** and other diseases without vaccines

Adapted from Cohen, A. *et al.* Using surveillance and economic data to make informed decisions about rotavirus vaccine introduction. *Vaccine.* 2018.

Rationale for Costing VPD Surveillance

- Understanding country-level VPD surveillance costs will:
  - Facilitate **planning and budgeting** and allow national programs to **include sufficient funds for VPD surveillance** activities
  - **Support advocacy efforts** at country and international levels to solicit supplemental donor funds to implement optimal surveillance as needed

- WHO and CDC have spearheaded the initiative to conduct VPD surveillance costing studies in multiple country settings (2018-2022) to fill evidence gaps
  - **Nepal** (completed)
  - **Ethiopia** (delayed due to COVID-19 pandemic; analysis completed and discussion in progress)
  - *Thailand (discontinued due to COVID-19 pandemic)*

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Vaccine preventable diseases surveillance in Nepal: How much does it cost?

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Methods

Themes and Identification of Methodological Recommendations

- Studies were **systematically compared by key themes**:
  a. Perspective and study design
  b. Costing approach, activity categories used, disease inclusion criteria
  c. Sampling criteria
  d. Extrapolation strategies
  e. Data collection activities, allocation of time or use, payer determination
  f. Cost analysis methods

- For each theme:
  - Its **methodology** was characterized
  - Related **strengths** and **challenges/limitations** in each country-level evaluation were identified
  - **Potential strategies** to incorporate strengths and address challenges/limitations were considered

- Practices for future such studies were recommended based on best methodological practices identified

Results

Perspective and Study Design

Methods Overview		
Description	*Ethiopia*	*Nepal*
Retrospective empirical cross-sectional costing study with primary data collection on surveillance resource utilization and costs over one fiscal year	✓ (Fiscal Year 2018-19)	✓ (Fiscal Year 2016-2017)
Perspective of the public health sector, including government and implementing partners	✓ (Implementing partners: WHO, Core Group / U.S. Development Agency for International Development)	✓ (Implementing partner: WHO)

Perspective and Study Design cont.

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Allowed collection of data from period prior to COVID-19 pandemic and assessment of system costs without bias towards intensified surveillance during pandemic	✓	✓	No outbreak response costs collected (underestimation of surveillance costs)	✓	✓
Collection of data from perspective of organizations/agencies leading implementation and decision-making for VPD surveillance	✓	✓	No cost data related to the surveillance of the COVID-19 pandemic (potential underestimation of current/up-to-date surveillance system costs)	✓	✓ (data collected in 2018 prior to COVID-19 pandemic)
			No data about the quality of surveillance at all sampled sites (unable to relate cost and quality of surveillance)	✓	✓ (collected only in aggregate at national level)

Perspective and Study Design – Recommendations

- Depending on objective of study, evaluate if necessary to assess system pre-/post-COVID-19 pandemic, especially with increased surveillance costs

- To understand system costs prior to and following the COVID-19 pandemic:
    - It is recommended to **consider a retrospective empirical cross-sectional costing study** with primary data collection on surveillance resource utilization and costs before, during, and after the height of the COVID-19 pandemic

- **Consider cost data collection of specific interventions and resources to improve surveillance** quality, integration, and/or efficiency (not only cross-section but also pre-, during, and/or post-intervention)

Perspective and Study Design – Recommendations cont.

- Consider the **perspective of the public health sector, including any external donors or technical assistance** agencies involved in funding, implementation and performance of the VPD surveillance system

- Include outbreak response costs, depending on intended use of results

Costing Approach, Allocation of Time Use, and Activity Categories

Methods Overview		
Description	*Ethiopia*	*Nepal*
Bottom-up, ingredients-based approach	✓	✓
Retrospectively estimated shares to VPD surveillance support function/activity category and VPDs for shared activities or items	✓	✓
Activity categories based on study-specific categorization including a subset of WHO-defined surveillance core[1] and support functions		✓
Activity categories based on *Global Strategy on Comprehensive VPD Surveillance* support functions[2]	✓	

[1] Core functions of surveillance refer to case detection, case registration, case confirmation, reporting, data analysis and interpretation, and public health response.
[2] Support functions facilitate the implementation of core functions.

Activity Categories Overview

Ethiopia	Nepal
Activity categories based on Global Strategy on Comprehensive VPD surveillance support functions: • Field logistics and communication • Laboratory • Data management and use • Governance • Workforce capacity • Supervision • Coordination	Activity categories based on study-specific categorization including a subset of WHO-defined core surveillance and support functions: Study-defined surveillance activity categories: • Case detection: passive and active surveillance, reporting • Case investigation and case confirmation + specimen collection and handling • Laboratory test: confirmation including quality and assurance of laboratory procedures • Data management and analysis • Communication Study-defined program event categories: • Training • Monitoring and supervision • Coordination

Blue text = Similar activity categories between the two classifications

Costing Approach, Allocation of Time Use, and Activity Categories cont.

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Comprehensive estimate of resources used at service delivery level	✓	✓	Support function categories posed certain challenges for respondents and stakeholders to understand during cost data collection and analysis due to novelty of categorization	✓	N/A (activity categories used for classification)
Activity categories based on global standardized definitions that allow for comparability with other countries	✓	N/A (*Global Strategy* not yet published during data collection. Definitions based on study-specific categorization including a subset of WHO-defined core surveillance and support functions)	Allocating time or use of resources by VPD by support function, rather by VPD for general use, posed some challenges for respondents during data collection	✓	N/A (allocation of time by activity categories)
			Estimating shares of time or use of resources from years prior to data collection is subject to recall bias	✓ (Shares of time from 3-4 years prior to data collection in 2022)	✓ (Shares of time from 1-2 years prior to data collection in 2018)

Costing Approach, Allocation of Time Use, and Activity Categories – Recommendations

- For data collection, **use ingredient-based approach** and **inform respondents of complete definitions** and examples of surveillance support functions to allow for increased understanding of category composition

- Recommend using **Global Strategy on Comprehensive VPD Surveillance standardized definitions** for data analysis and presentation

- For comparability of VPD surveillance costs across countries, **determine methods to identify categories in budget corresponding with those in Global Strategy on Comprehensive VPD Surveillance**

Costing Approach, Allocation of Time Use, and Activity Categories – Recommendations cont.

- **Establish operational definitions for time allocated** to a specific activity or VPD

- Determine the final audience and use case for VPD-specific estimates to determine importance of accurate allocation
  - If important, **explore time-motion, time sampling,** or other techniques to obtain more accurate estimates of the share of resource use by VPD
    - May not require estimation of time allocation for all diseases, but only for diseases potentially forecasted as requiring most time or use
    - **Conduct sensitivity analysis varying time allocations** and determine impact of time variation on cost estimates
  - If feasible, conduct **intensive prospective data collection in a small number of sites** with clear operational definitions and inclusion/exclusion criteria per VPD

Disease Inclusion Criteria

Methods Overview		
Description	*Ethiopia*	*Nepal*
All diseases for which vaccines were included in the National Immunization Program	✓	✓
All diseases recommended for inclusion in the National Immunization Program	✓	✓
Certain diseases grouped together for data collection and analysis considering the country context	✓ (e.g., diphtheria, pertussis, typhoid, smallpox)	✓ (e.g., invasive-bacterial diseases resulting from infection of *Streptococcus pneumoniae*, *Haemophilus influenzae*, or *Neisseria meningitidis*)

Disease Inclusion Criteria cont.

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Included diseases considered most relevant for surveillance system in-country, especially pertaining to prevalence and disease elimination goals	✓	✓	Excluded costing surveillance for diseases for which vaccines are not included nor recommended for inclusion in the National Immunization Program (underestimation of surveillance costs)	✓	✓
			Retrospective recall of resource allocation by each VPD based on self-report resulted in erroneously allocating equal amounts of time across low incident VPDs or related VPDs (potential overestimation of surveillance costs for low incidence VPDs)	✓	✓ (VPD surveillance allocation; VPD allocation data collected but not presented in publication)

Disease Inclusion Criteria – Recommendations

- VPDs included in the cost analysis depend on the objective of the study. Potential VPD inclusion categories could concern:

  1. Inclusion only of VPDs for which **country has vaccines in the National Immunization Program,** as well as those **recommended for inclusion** by the National Immunization Technical Advisory Group

  2. Inclusion of **all VPDs** (even those for which vaccines have not been introduced or recommended in country but have been introduced or recommended in similar countries)

  3. Inclusion of all VPDs for which **WHO has recommended surveillance standards**

- **Consider grouping certain VPDs together** (e.g., measles and rubella; invasive-bacterial VPDs) based on integrated surveillance approaches at lower administrative levels

Sampling Strategy: Federal Level

Methods Overview		
Description	*Ethiopia*	*Nepal*
All relevant cost centers in-country included (Ministry of Health HQ, national laboratories, WHO Country Office, other implementing partner offices)	✓	✓
Excluded operations and testing costs of specimen from country to international laboratories as costs are not borne by country	✓	✓

Sampling Strategy: Federal Level

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Provides a complete representation of costs at national level	✓	✓	Excluded specimen shipping costs from country to international laboratory for testing (underestimation of surveillance system costs)	✓	

Sampling Strategy: Federal Level – Recommendations

- Include **all relevant national-level cost centers** in-country (i.e., census of costs at national level)

- Depending on objective of costing study and based on the intended use of the cost study results:
    - **Specimen shipping costs from country to international laboratory** for **testing of suspected cases of major diseases** (polio, measles, rubella, etc.) should be **included** in the system cost estimate, if shipping costs are borne by country
        - Exclusion of such costs should be clearly reported and interpreted as an underestimate of the total costs of VPD surveillance for the country

- **Exclude operations and testing costs of specimen** from country to international labs if costs are not borne by country

Sampling Strategy: Subnational Levels

Methods Overview		
Description	*Ethiopia*	*Nepal*
Combination of purposively selected and randomly selected sites	✓ (sentinel sites purposively selected; health facilities/hospitals randomly selected sites)	✓
Surveillance sites sampled across multiple administrative levels and strata	✓	✓
Sampled surveillance facilities needed to satisfy certain criteria: (a) administrative and financial records for last fiscal year would be available in the health facility (b) health facility chief or surveillance focal point had been in the position since at least the last financial year		✓

Sampling Strategy: Subnational Levels

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Included surveillance sites from all first-level administrative divisions	(included sites in three purposively selected regions out of 11 regions available in 2019)	✓ (included district health offices in all seven provinces)	Small sample size for subnational administrative levels	✓	
Captured costs from all administrative levels and strata of interest to account for variability of costs by geographical area type and/or administrative level	✓	✓	Budget/time resources restricted sampling more sites	✓	✓
			Security concerns and limited accessibility in certain administrative divisions restricted sampling specific sites	✓	
Sampling criteria requirements ensured availability of records and institutional memory of surveillance related information		✓			

Sampling Strategy: Subnational Levels – Recommendations

- If possible, and if intending to obtain results representative at country-level, **randomly sample sites within each administrative level**

- If possible, **sample sites from multiple strata** (e.g., rural, urban, ecological zone, health facility type) that could be drivers of VPD surveillance costs in-country

Extrapolation Strategy for Country-Wide Estimates

Methods Overview		
Description	*Ethiopia*	*Nepal*
For randomly sampled cost centers:		
• Multiplied each cost by the product of the administrative-level weights for that cost center level and higher levels	✓	
• Sampling weight determined by inverse probability of selection	✓	
For purposively sampled cost centers:		
• Averaged costs across cost centers in the same administrative level and geographic area	✓	
• Sampling weight determined by number of cost centers of the same type within administrative level and geographic area	✓	
• Multiplied average costs for each variable by product of administrative level weights	✓	
For both sampling methods:		
• Costs were summed to regional level and then extrapolated to similar regions	✓	

Extrapolation Strategy for Country-Wide Estimates

Methods Overview		
Description	*Ethiopia*	*Nepal*
For provinces with two WHO-Immunization Program Division field offices, cost for the selected field office was used as proxy for the unselected office in the same province		✓
For government district health offices, costs of the selected district health offices were averaged by ecological zone and applied to all remaining district health offices in the same ecological zone		✓
Average costs were calculated for informing units and reporting units by hospital and health facility and were multiplied by the total number of units in their respective categories to obtain the nationwide cost at the hospital and health facility level		✓

Extrapolation Strategy for Country-Wide Estimates

Strengths			Limitations		
Description	*Ethiopia*	*Nepal*	*Description*	*Ethiopia*	*Nepal*
Allowed for project with limited budget to collect data at different administrative levels and strata and obtain partial representation of cost drivers in different geographies	✓	✓	Results are not statistically representative of the level in which they were collected	✓	✓ (not representative at district, ecological zone, and health facility levels)
Using appropriate weighting techniques, retrieved a proxy of the costs estimates at country level, by VPD and other categorization of interest	✓	✓	Required to receive expert advice to group regions for extrapolation	✓	
			Did not consider differences in transport costs and population densities within a region	✓	✓
			Uncertainty on the representativity of the unit cost	✓	✓
			Results are not statistically representative at national level	✓	✓

Extrapolation Strategy for Country-Wide Estimates – Recommendations

- If sampling is non-representative at country-level, **decide the basis for extrapolation** of sampled to non-sampled units for **in advance of data collection and analysis**, following in-country statistical or economic expert advice

- Review data from sentinel sites to **determine composition of sentinel site activities and practicality of extrapolating the sentinel site costs** to country-wide estimates

- If sampling is representative at country-level, employ appropriate statistical formulas to weight results from sampled sites

Discussion

Key Recommendations

1. To help understand the quality of surveillance:

    a. Simultaneously **collect programmatic data at each sampled site**, **including at subnational levels**, to contextualize costs:

        - E.g., incidence, number of case investigations, testing accuracy, system sensitivity, timeliness, non-polio acute flaccid paralysis rate, measles-rubella discard rate, or other epidemiological information

    b. Analyze the relationship between costs and quality of surveillance for different settings at subnational level, rather than aggregated at national level

2. To ensure representative results, if budget allows, **randomly sample surveillance sites in each:**

    a. Administrative level (e.g., region, zone)

    b. Stratum of interest (e.g., rural-urban, ecological zones, health facility type)

3. To compare costs across countries, **use standardized classifications of VPD surveillance support functions**

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Thank You

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Additional Slides

Limitations of Ethiopia Evaluation

- Recall bias
  - Retrospective allocation of share of time or use for support function and VPDs during FY18-19 (data collected March – May 2022)
- Non-representative statistical sampling at country-level, and small sample size for select administrative levels
- Limited accessibility in certain regions and/or certain woredas (third administrative level) of regions
- Potential underestimation of vehicle costs as certain dates of purchase and/or maintenance costs were unknown
- No simultaneous collection of programmatic data at subnational levels for context (e.g., incidence, annual number of cases)
- Exclusion of certain vaccine-preventable diseases (e.g., influenza)

Limitations of Nepal Evaluation

- Recall bias
  - Retrospective allocation of share of time or use for VPD surveillance during FY16-17 (data collected March – August 2018)
- Collection of data from small number of cost centers
- Potential underestimation of capital costs as useful life years of WHO assets reported were smaller than those for comparable government assets
  - Increased annual depreciation of capital assets
- No simultaneous collection of programmatic data at subnational levels for context (e.g., incidence, annual number of cases)
- Challenging to allocate appropriate time or use of shared resources for VPD surveillance
  - Difficult to separate funds spent exclusively on VPD surveillance from those spent for other disease surveillance due to structure of accounting systems

Huang, X. X., Bose, A. S., Gupta, B. P., Rai, P., Joshi, S., Gautam, J. S., et al. (2021). Vaccine preventable diseases surveillance in Nepal: How much does it cost?. *Vaccine*, *39*(40), 5982–5990.

Key Indicators of Comprehensive VPD Surveillance

- % of districts reporting any suspected VPDs in a 12-month period
- Non-measles/non-rubella (MR) discard rate of ≥2/100,000 persons
- Non-polio acute flaccid paralysis (NPAFP) rate of >1/100,000 among <15 years population in a 12-month period

World Health Organization. (2018). Overview of VPD Surveillance Principles. | World Health Organization. (2018). Global Strategy on Comprehensive VPD Surveillance.

VPD Surveillance Support Functions

VPD Surveillance Support Function	Definition and Examples
Coordination	**Linking surveillance program to relevant stakeholders** (e.g., EPI) for data review, dissemination, and use; improvement planning; **surveillance strengthening** as core function of IHR implementation framework, including rapid response teams and Emergency Operations Centers
Data management and use	**Information system** development, **data** harmonization, implementation, and use for performance improvement
Field logistics and communication	Airtime and internet for notification and reporting, **specimen collection and transport**; feedback of results; **any resource input besides personnel used for core functions** of case detection, notification, investigation, reporting
Governance	Standards and **guidelines** development, **policy**, laws/mandates, roles, and responsibilities (including for private sector), **funding**
Laboratory	Specimen **collection kits, reagents** and supplies, **equipment**, physical space, and training; expansion and diversification of regional and global networks; shared procurement processes; **quality management** systems; personnel
Program management	**Budget creation**, resource mobilization, financial **management**, sustainability, infrastructure/equipment management, **human resources**, **external** surveillance **assessments and reviews**
Supervision	Supportive **supervisory visits**, workplans, checklists
Workforce capacity	**Training**/capacity building at all levels; **staff for core functions** including case detection, notification, investigation, reporting, and response; epidemic **preparedness**

Surveillance Support Functions Facilitate Implementation of Core Functions

Support functions (inputs)

- Governance
- Program management
- Workforce capacity
- Field logistics & communication
- Laboratory
- Supervision
- Data management and use
- Coordination

Core functions (outputs)

- Case detection
- Case notification
- Case investigation/confirmation
- Reporting
- Data analysis & interpretation
- Feedback
- [Outbreak response & control]

Opportunities for

- Shared funding
- Linkage across areas
- Innovations

From Patel, M.K. and Pallas, S.W. (2020). Global Comprehensive VPD Surveillance.

Funding Source and Payer Determination

Ethiopia		Nepal		Recommendations
Methods	Limitations	Methods	Limitations	
• Requested respondents to indicate the payer/owner of a resource and the entity that provided funds to the payer/owner (funding source) for the resource • Requested information from national level if payer/owner or funding source was unknown by subnational levels	Certain woreda or health facility-level respondents may not have known the original funding source and may have assumed that funding originated from a lower-level entity (e.g., regional government)	*N/A, funding source mapping was not in the scope of the evaluation*	Challenging to track funding as multiple funds overlapped or covered a more general scope, such as VPD program, rather than specific to VPD surveillance	• Depending on objective of study, if knowledge of funding is essential as donor landscape changes, then **data collection should begin at national level to identify original funding sources** • If collecting data in a decentralized country, note that all resources may not flow into the national level, and it may be more optimal to begin data collection at the first administrative level • **Subnational data collection should be tailored to validate costs** collected at national level and to complement by **focusing on resource use funded from other sources** and any allocation of time/resource use that is not evident from national-level records

Data Collection: Piloting and Data Validation

Category of Data Collection	Ethiopia		Nepal	
	Methods Overview	Limitations	Methods Overview	Limitations
Piloting tool	Data collection tool piloted at two hospitals in Addis Ababa before initiating data collection in the field	N/A	Questionnaire piloted in Kathmandu before initiating data collection in the field	N/A
Data validation	• Data validated by daily checks by U.S. CDC • If data entered in tools included errors, data collectors revised tools and/or revisited sampled sites to gather more comprehensive or accurate information	Minor delays in data validation (due to time difference between Eastern U.S. and Ethiopia and advancing field movement) occasionally required follow-up with respondents via phone at a later point, rather than in-person immediately after the data were collected	• Data collected from tablets was transferred to WHO HQ on daily basis. It was then reviewed at HQ. • If any data issue is detected, WHO HQ sent the query to the data collection team the following day to review the issue. The final dataset was shared with a group of experts for further control. • WHO country office supervised the progress. WHO HQ controlled the quality during the data collection.	N/A
Format of data collection	Excel-based tool with guiding questionnaire; data collected via electronic (tablet) format	N/A	Paper forms based on questionnaire; data collected via electronic (tablet) format	N/A

Data Collection – Enumerators and Sources of Data

Ethiopia		Nepal		Recommendation
Methods Overview	Limitations	Methods Overview	Limitations	
• Enumerators: former public health officers with knowledge of local languages in sampled regions hired as enumerators/data collectors. As former public health officers, data collectors had extensive experience with VPD surveillance • Data sources: financial, HR, and transportation records; interviews with key informants at sampled sites • Data collector training: Week-long training on costing methodologies, variables in study, and refresher on surveillance system and VPDs • Supplementary material: interviewees and interviewers were provided with handouts summarizing variable definitions and costing concepts in the context of the study	Enumerators had limited experience with public health costing methodologies prior to study	• Enumerators: Local company specializing in data collected was engaged to lead on data collection • Data sources: Interview with VPD surveillance focal point at sampled stations and records • Data collector training: Explanation section was organized with the data collection team • Supplementary material: Questionnaire provided tailored explanation for interviewers and interviewees	Enumerators had limited experience with public health costing methodologies prior to study	• Provide ample information on costing concepts, dimensions of study, and supplementary material with variable definitions to enumerators • Enumerators provide interviewees with handouts on costing category definitions

Costing Analysis Methods

Category	Ethiopia		Nepal		Recommendations
	Methods Overview	Limitations	Methods Overview	Limitations	
Annuitization of capital asset costs	Annuitization for economic costs; straight-line depreciation for financial costs	N/A	Straight–line depreciation for economic and financial costs	Potential underestimation of economic costs	Per costing recommendations for immunization programs (Levin et al., 2022), **include annuitization of capital assets for economic cost estimates**, and **straight-line depreciation for financial cost** estimates.
USD-local currency exchange rate	Applied time-specific average monthly exchange rate for each activity	N/A	Applied median exchange rate during study period to all activities	Variations in exchange rates over the study timeframe not captured	If possible, **use average monthly exchange rate** for more accurate estimates, especially in country settings in which there may be substantial variation in exchange rates over the study time frame.
Contextualizing cost estimate and calculating costs to improve quality of surveillance	*No programmatic or surveillance performance data collected at national nor subnational sampled sites.*		Programmatic surveillance performance data collected at national level	Programmatic or surveillance performance data not collected at subnational sampled sites. Performance aggregated at country-level only	To help understand the quality of surveillance, **collect programmatic data** (e.g., incidence, number of case investigations, non-polio AFP rate, MR discard rate, other epidemiological information) **at each sampled site** to contextualize costs in different settings in-country.