



# DEVELOPMENT OF DISEASE SEASONAL CALENDARS FOR PUBLIC HEALTH PREPAREDNESS

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**TDDAP2**  
Strengthening health  
systems to protect against  
public health threats

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# Introduction

In disease epidemiology, **seasonality** refers to a consistent and predictable pattern in the timing and frequency of disease occurrence that recurs at approximately the same time each year. A disease is considered seasonal when case counts rise and fall in regular cycles. Such patterns may be driven by environmental factors (e.g. temperature, rainfall, and humidity), human behaviour (e.g. school terms or religious pilgrimages), or pathogen and vector biology (e.g. seasonal increases in mosquito populations).

This consultancy aimed to develop **evidence-based seasonal disease calendars** for infectious diseases included in Kenya's Integrated Disease Surveillance and Response (IDSR) priority list. The calendars are intended to support the Ministry of Health, KNPHI, and county governments to anticipate periods of increased disease detection, strengthen preparedness, and guide prevention, surveillance, and response activities.

Importantly, this work **does not seek to explain the underlying causes of seasonality**. Rather, its purpose is to objectively describe and test for the presence of seasonal patterns in routine surveillance data. By identifying periods of consistently higher or lower disease detection, the seasonal calendars aim to enhance surveillance interpretation, early warning, and preparedness planning.

## Objectives of the work

- **Objective 1:** To identify and analyze seasonal patterns of priority infectious diseases in Kenya.
- **Objective 2:** To develop visual seasonal calendars to inform public health decision-making.
- **Objective 3:** To recommend strategies for integrating seasonal calendars into surveillance and forecasting systems.

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# Methodology and Outputs

## Objective 1: To identify and analyze seasonal patterns of priority infectious diseases in Kenya

### Disease selection

The IDSR priority disease list was reviewed to determine which infectious diseases were suitable for seasonality analysis. Seasonal patterns are easier to detect when infection results in symptomatic disease, symptoms occur shortly after infection, and cases are reported consistently over time. The final list of diseases that were considered for the seasonal calendar are described in **Supplementary Table 1**.

For the selected diseases, monthly case data were extracted from the Kenya Health Information System (KHIS) at the sub-county level for the period 2014 to 2025. Within KHIS, diseases have multiple indicators/data elements that report on the number of cases detected of a disease, however, these differ in completeness and internal consistency. As such, for each disease, all relevant indicators were reviewed, and the indicator with the **highest reporting completeness and total case counts** was selected for analysis. The final list of indicators used from KHIS is provided in **Supplementary Table 2**.

### Data preparation and cleaning

Data from the most recent five-year period (2021 – 2025) were aggregated into **monthly case counts**. Earlier years were excluded due to substantial missingness and inconsistent reporting, which could introduce artificial seasonality driven by data gaps rather than true epidemiological patterns.

### Determining whether a disease is seasonal

Before classifying individual months as peak, high, moderate, or low, we first assessed whether each disease demonstrated meaningful and repeatable seasonality. This step is essential to avoid misclassifying random variation or reporting artefacts as seasonal patterns.

A disease was considered seasonal only if it met the criteria described below:

#### i. **Seasonal-Trend Decomposition (STL)**

STL (Seasonal-Trend Decomposition using Loess) was applied to the full monthly time series to separate trend, seasonal, and residual components. We quantified the proportion of total variance explained by the seasonal component. If the seasonal component accounted for  $\geq 20\%$  of total variance, this was considered meaningful evidence of seasonality.

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## ii. Statistical testing using ANOVA

A one-way ANOVA test was used to assess whether mean case counts differed significantly across months. A **p-value  $\leq 0.05$**  indicates statistically significant month-to-month differences, consistent with a seasonal pattern rather than random fluctuation.

## iii. Coefficient of Variation (CV)

The coefficient of variation (standard deviation divided by the mean) was calculated to assess the relative magnitude of seasonal fluctuations. A **CV  $\geq 0.25$**  was required to ensure that observed seasonal swings were large enough to be operationally meaningful.

**Seasonality decision rule:** A disease was classified as seasonal if it met: **STL seasonal variance  $\geq 20\%$  OR statistically significant ANOVA, AND CV  $\geq 0.25$**

Diseases that failed these criteria, or for which insufficient data were available, were classified as **non-seasonal** and were not assigned peak, high, moderate, or low months.

## Classifying months using percentiles

For diseases confirmed as seasonal, calendar months were classified as peak, high, moderate or low based on their relative position within the annual distribution of monthly case counts.

For each disease, a **trimmed mean** was calculated for each calendar month (January–December). This involved removing the highest and lowest 5% of values before calculating the mean. This approach reduces the influence of extreme values that may arise from reporting errors, although it carries the risk of reducing the influence of outbreak-related spikes if they were not consistent over time.

This process produces **12 monthly trimmed mean values**, representing the typical level of disease activity expected in each month under normal conditions. From the 12 monthly trimmed means, three percentile thresholds were calculated:

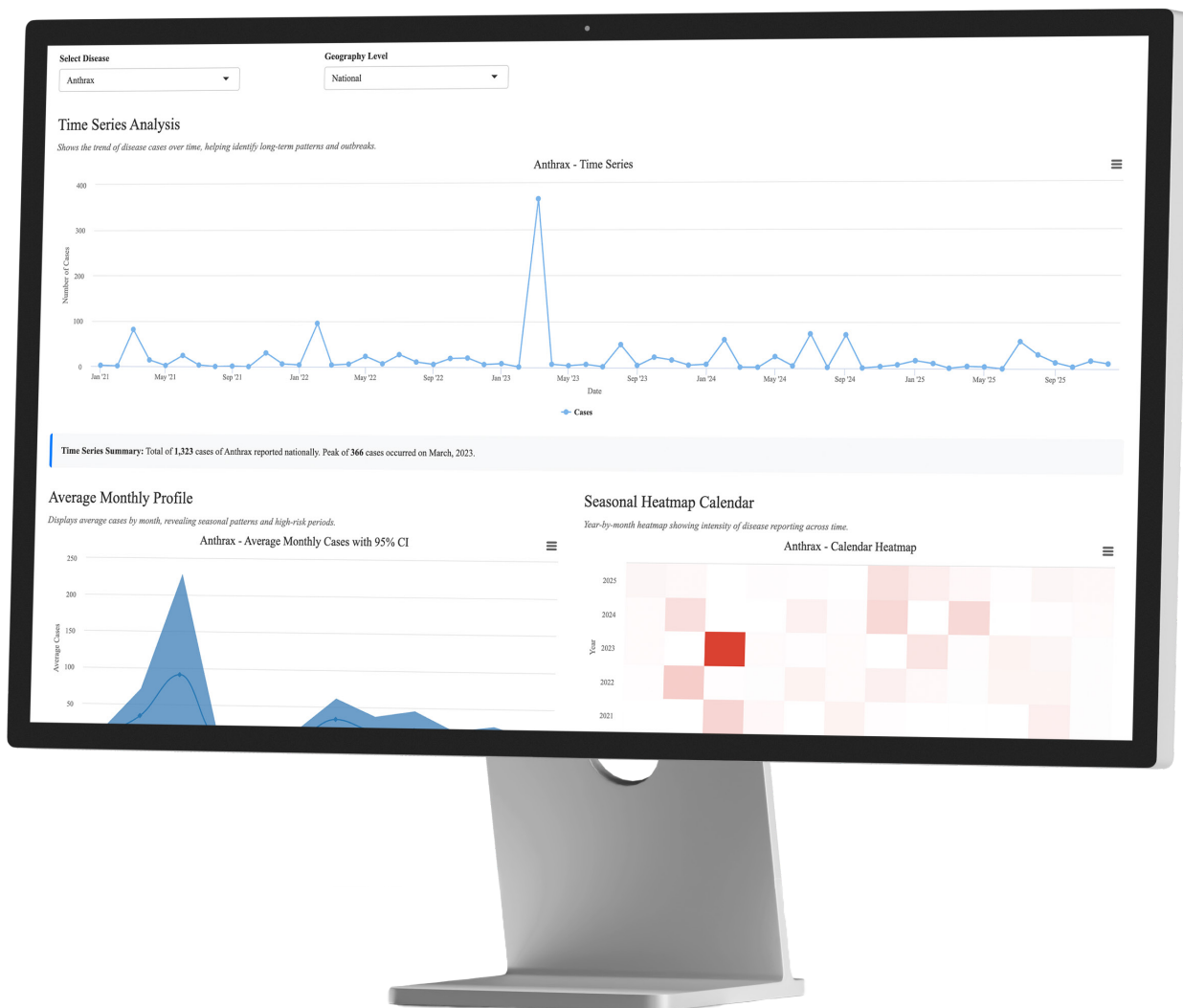
- **50th percentile (P50):** median month
- **75th percentile (P75):** moderately high activity
- **90th percentile (P90):** peak activity

Monthly classifications were assigned as follows:

**Table 1: Summary of categories**

Category	Rule (based on median monthly values)	Meaning
Peak	$\geq P90$ and positive seasonal component	Highest disease activity
High	$\geq P75$ but $< P90$ , seasonal component positive	Elevated activity
Moderate	$\geq P50$ but $< P75$	Typical seasonal activity
Low	$< P50$ and seasonal component non-positive	Reduced transmission
Non-seasonal	If disease failed seasonality tests	No reliable seasonal pattern

All data processing and analyses were conducted in R. The data and code are available in a private GitHub repository: Fshem/KNPHI-Project: Diseases seasonal calendar



## Objective 2: To develop visual seasonal calendars to inform public health decision-making

Seasonal calendars were operationalised through an **R Shiny dashboard**, structured to guide users from national overviews to detailed sub-county analyses.

### Dashboard components

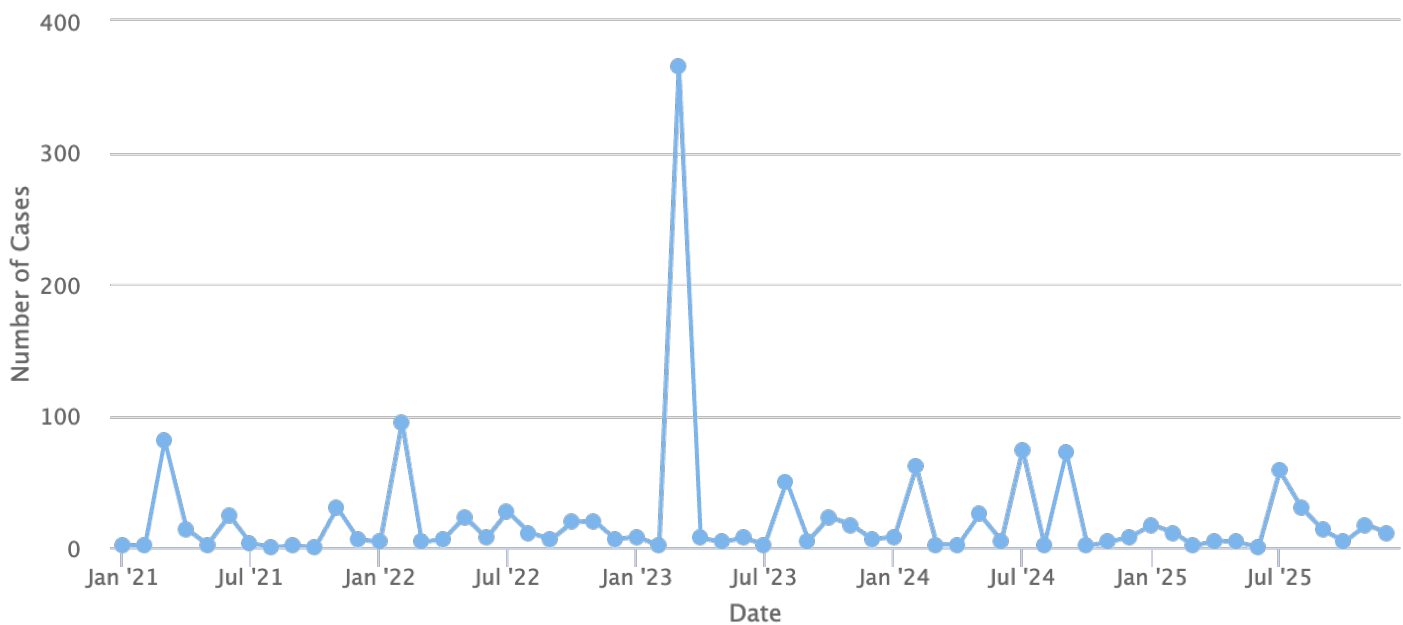
**Overview page:** Provides a national, multi-disease seasonal calendar summarising seasonal profiles for the priority diseases using the national STAR risk calendar as a template. Users can filter by county and sub-county to view location-specific calendars. Diseases are categorised as peak, high, moderate, low, or non-seasonal, indicating whether detection can be expected year-round (Figure 1).



**Figure 1: Overview page of seasonal calendar dashboard showing occurrence of diseases at the national level**

**Disease explorer page:** Allows in-depth analysis of individual diseases at national, county, and sub-county levels. For each level, the dashboard displays:

- Time-series plots (Figure 2)
- Average monthly profiles (Figure 3)
- Heatmap-style seasonal calendars (Figure 4)
- Advanced diagnostics including spectral periodograms, ACF/PACF, and STL decomposition. Spectral periodograms identify dominant cycles; ACF and PACF plots assess recurring temporal dependencies, including annual (12-month) and semi-annual (6-month) patterns. STL decomposition separates long-term trends, seasonal components, and residuals, facilitating identification of deviations from expected seasonal behaviour.



**Figure 2: Time series plots of reported anthrax cases on the disease explorer page of the dashboard**

The dashboard is available at: <https://ken-seasonality.shinyapps.io/jdwork/>  
Username: moh  
Password: moh

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### Objective 3: To recommend strategies for integrating seasonal calendars into surveillance and forecasting systems

Findings from this work were presented to KNPHI on **15 January 2026**. Discussions focused on how seasonal disease calendars could be embedded into existing surveillance, preparedness, and response workflows rather than operating as a standalone analytic product. Key integration opportunities are summarised below.

**Routine surveillance interpretation:** Seasonal calendars can be incorporated into **weekly and monthly IDSR bulletins** to provide contextual interpretation of observed trends. Displaying current case counts alongside expected seasonal levels would help surveillance officers distinguish anticipated seasonal increases from unusual or concerning.

**Alert prioritisation:** Seasonality can be used to refine **alert thresholds**, particularly by prioritising investigation of outbreaks that occur **outside expected seasonal windows**.

**Preparedness and resource planning:** Seasonal calendars can inform **pre-positioning of diagnostics, laboratory reagents, supplies, and preparation of rapid response teams (RRTs)** ahead of predictable high-risk periods. This approach supports more efficient use of limited resources and reduces reactive procurement.

**Risk communication and public messaging:** Aligning risk communication with known seasonal patterns enables **timely public health messaging** to health workers and communities. Messaging can be scheduled ahead of peak periods to reinforce prevention, early care-seeking, and case detection.

**Sub-national planning:** At county and sub-county levels, seasonal calendars can be incorporated into **annual work plans, quarterly performance reviews, and preparedness assessments**, supporting more targeted planning of surveillance and response activities.

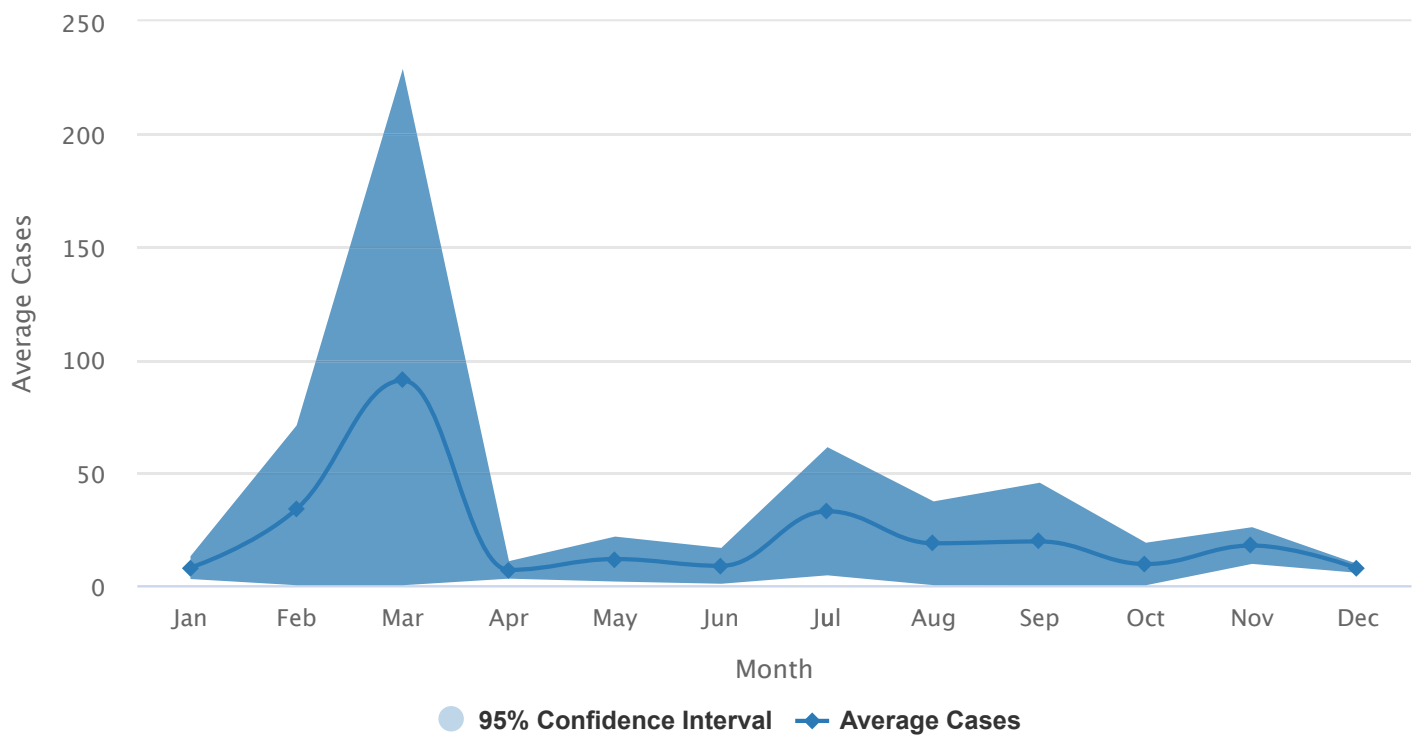


Figure 3: Average monthly cases of reported anthrax cases on the disease explorer page of the dashboard

# Challenges and limitations

Several challenges were identified during the implementation of this work:

**Data availability and completeness:** Not all IDSR priority diseases had sufficient data quality or completeness to support seasonality analysis. In some cases, reporting was sporadic or inconsistent across years, limiting interpretability (Refer to supplementary table 1). It is important to keep in mind that these disease calendars were developed using routinely collected surveillance data. As such, they are only as accurate as the data that was collected. If there were gaps in reporting of diseases or inaccuracies in reporting of diseases these will affect the outputs provided.

**Indicator inconsistencies within KHIS:** Multiple indicators exist for the same disease, often with differing levels of completeness and internal consistency. Indicator selection required manual review and judgement, which is not scalable without improvements in the quality of data collected.

**Limited integration of vertical programme data:** Data from vertical programmes and disease-specific units (e.g. laboratory-confirmed case databases or programme registers) were not consistently available through KHIS, resulting in missed opportunities to conduct analyses on additional diseases.

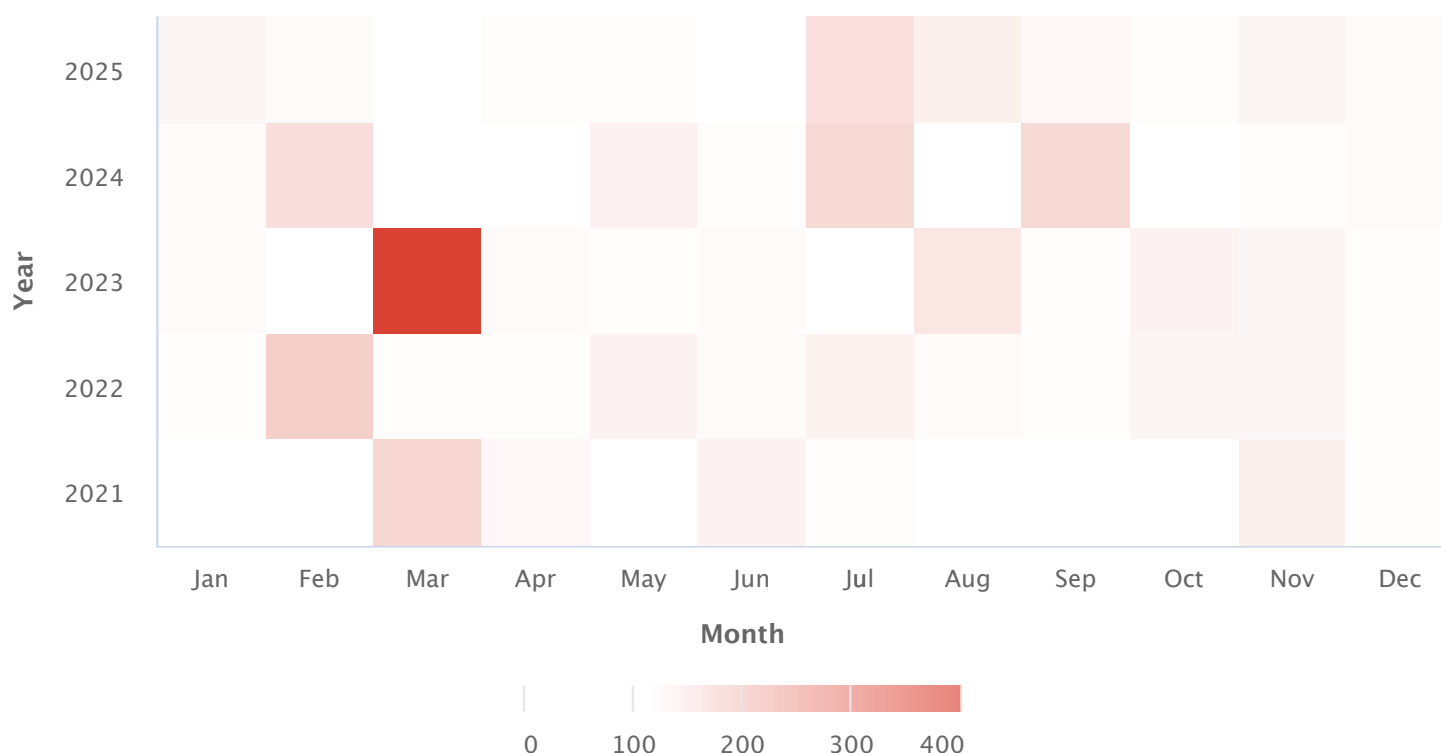


Figure 4: Calendar heat map of reported anthrax cases in the disease explorer page of the dashboard

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# Next steps and opportunities for scale-up

To strengthen and sustain the seasonal disease calendar approach, several next steps are recommended:

**Institutionalisation within KNPHI/MoH systems:** Transfer ownership of the GitHub repository and analytical workflows to the KNPHI/MoH data analytics platform, with clear governance, version control, and update schedules.

**Routine updating and automation:** Automate data extraction from KHIS and updating of seasonal calendars on an annual or rolling basis, allowing recalibration as reporting improves or disease patterns shift over time.

**Integration of additional data sources:** Explore direct linkage with hospital electronic medical records (EMRs) to improve data quality and enable analyses based on aggregates of patient records that provide the:

- Date of illness onset
- Confirmed diagnosis
- Patient sub-county of residence
- Sub-county of reporting facility

**Development of decision-support tools:** Translate seasonal calendars into actionable decision-support products, such as trigger matrices that link seasonal phase (e.g. peak, high) to recommended preparedness and response actions.

**Work flow integration:** Incorporate seasonal calendars into IDSR technical guidelines, preparedness frameworks, and outbreak investigation SOPs, formalising their role in routine surveillance decision-making.

## Supplementary table 1: List of IDSR diseases detailing whether included in analysis and source of data

Infectious Disease	Included in analysis (Y/N)	Notes	Source of data
Anthrax	Yes		KHIS
Bacterial Meningitis	Yes		KHIS
Chikungunya	Yes		
Cholera	Yes		KHIS
Crimean Congo Haemorrhagic Fever	No	No data in KHIS	NA
Dengue fever	Yes		KHIS
Dracunculiasis	Yes		KHIS
Dysentery (Shigella)	Yes		KHIS
Ebola	No	No recent detection of acute disease or community transmission in Kenya	NA
HIV/AIDS	No	Long incubation period	NA
Influenza	No	No data in KHIS	NIC
Influenza due to a new sub type	No	No recent detection of acute disease or community transmission in Kenya	NA
Lassa Fever	No	No recent detection of acute disease or community transmission in Kenya	NA
Leishmaniasis	No	Long incubation period	KHIS
Leprosy	No	long incubation period	KHIS
Lymphatic filariasis	No	Long incubation period	NA
Malaria	Yes		KHIS
Marburg	No	No documented community transmission in Kenya	NA
Measles	Yes		KHIS
Mpox	No	Insufficient time period to detect seasonality	NA

Infectious Disease	Included in analysis (Y/N)	Notes	Source of data
Neonatal tetanus	Yes		KHIS
Non neonatal tetanus	Yes		KHIS
Onchocerciasis	No	Long incubation period	NA
Plague	Yes		KHIS
Polio	Yes		KHIS
Rabies	Yes		KHIS
Rift Valley Fever	Yes		KHIS
SARS	No	No data available for SARS in general	NA
SARS-CoV-2	No	No data in KHIS	KHIS
Schistosomiasis	Yes		KHIS
Sexually transmitted infections	Yes		KHIS
Small pox	No	No recent detection of acute disease or community transmission in Kenya	NA
Soil transmitted helminths	No	No data in KHIS	NA
TB	No	Long incubation period	NA
Trachoma	Yes		KHIS
Trypanosomiasis	No	No data in KHIS	NA
Typhoid fever	Yes		KHIS
West Nile Fever	No	No data in KHIS	NA
Yellow fever	Yes		
Zika	No	No recent detection of acute disease or community transmission in Kenya	NA

## Supplementary table 2: List of indicators and data elements in KHIS showcasing variability reports

Indicator/data element	No. of sub counties reporting monthly over the period 2021-2025	Reporting completeness (%)	Total number of cases reported over the period 2021-2025
IDSR Anthrax Cases	158	0.8	1,127
MOH 505 Rev 2020_IDSR Anthrax	169	0.9	1,332
Meningitis	-	0	-
Meningococcal Meningitis	3,569	18	16,009
MOH 505 Rev 2020_IDSR Meningococcal Meningitis	338	1.7	1,952
MOH 705A Rev 2020_Chikungunya	495	2.5	10,123
MOH 758 NTD Chikungunya	11	0.1	44
Cholera	588	3	4,827
Cholera Inpatient	29	0.1	213
IDSR Cholera Cases	545	2.8	9,319
MOH 505 Rev 2020_IDSR Cholera	563	2.8	9,657
IDSR Dengue Total	977	4.9	59,282
MOH 505 Rev 2020_IDSR Dengue	994	5	59,836
MOH 758 NTD Dengue	54	0.3	626
Dracunculosis Guinea Worm	-	0	-
MOH 505 Rev 2020_IDSR Guinea Worm Disease Dracunculiasis	335	1.7	12,968
MOH 505 Rev 2020_Shigella Dysentery Positive	844	4.3	5,490
Confirmed malaria cases MOH 505	16,439	83	13,029,152
Confirmed malaria cases MOH 705 A B	18,523	93.6	19,678,125
Confirmed Malaria only Positive cases	18,523	93.6	19,678,125

Indicator/data element	No. of sub counties reporting monthly over the period 2021-2025	Reporting completeness (%)	Total number of cases reported over the period 2021-2025
IDSR Malaria Cases	13,339	67.4	31,830,549
IDSR Positive malaria	-	0	-
IDSR Total Malaria Cases	13,339	67.4	31,830,549
Malaria Inpatient	595	3	22,782
Total malaria Case IDSR MOH 505	13,339	67.4	31,830,549
Total Confirmed malaria cases 5Years MoH 705A 5Years MoH 705B	18,523	93.6	19,678,125
Total Number of Confirmed Malaria cases IDSR	1	0	65
IDSR Measles Total	1,715	8.7	16,311
Measles	6,403	32.3	50,116
MOH 505 Rev 2020_IDSR Measles	1,744	8.8	16,642
IDSR Neonatal Tetanus Total	47	0.2	254
MOH 505 Rev 2020_IDSR Neonatal Tetanus	71	0.4	373
Neonatal Tetanus	1,483	7.5	4,839
Tetanus	2,488	12.6	19,130
Tetanus Inpatient	18	0.1	38
IDSR Plague Total	8	0	50
MOH 505 Rev 2020_IDSR Plague	19	0.1	277
Plague	1	0	1
Plague Inpatient	35	0.2	124

Indicator/data element	No. of sub counties reporting monthly over the period 2021-2025	Reporting completeness (%)	Total number of cases reported over the period 2021-2025
IDSR Acute Flaccid Paralysis AFP for Poliomyelitis Cases	894	4.5	1,818
MOH 505 Rev 2020_IDSR Acute Flaccid Paralysis AFP for Poliomyelitis	932	4.7	11,104
Poliomyelitis AFP	1,046	5.3	3,963
IDSR Rabies Total	485	2.4	1,500
MOH 505 Rev 2020_IDSR Rabies	505	2.6	1,737
MOH 705A Rev 2020_ Rift valley fever	121	0.6	1,094
MOH 505 Rev 2020_IDSR Rift Valley Fever	42	0.2	288
Bilharzia Schistosomiasis	7,441	37.6	201,443
Schistosomiasis	4	0	5
Sexually Transmitted Infections	19,060	96.3	1,467,812
MoH_735_2023 Trachoma follicles TF	34	0.2	90
MoH_735_2023 Trachoma intense inflammation T1	76	0.4	209
MoH_735_2023 Trachoma trichiasis TT	330	1.7	1,491
MoH_735 Active Trachoma T1 TF	329	1.7	1,627
Trypanosomiasis	16	0.1	39
MOH 758 NTD Human African Trypanosomiasis sleeping sickness	5	0	6
IDSR Typhoid Total	6,313	31.9	326,581
MOH 505 Rev 2020_IDSR Typhoid	6,332	32	328,070
Typhoid fever	17,690	89.3	1,434,111
IDSR Yellow Fever Total	61	0.3	460

<b>Indicator/data element</b>	<b>No. of sub counties reporting monthly over the period 2021-2025</b>	<b>Reporting completeness (%)</b>	<b>Total number of cases reported over the period 2021-2025</b>
MOH 505 Rev 2020_IDSR Yellow Fever	74	0.4	703
Yellow fever cases	162	0.8	1,596



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