# Life Stages of Maternal and Child Healthcare in Sierra Leone

## Biomedical Analytics B585 - Group 5 Project

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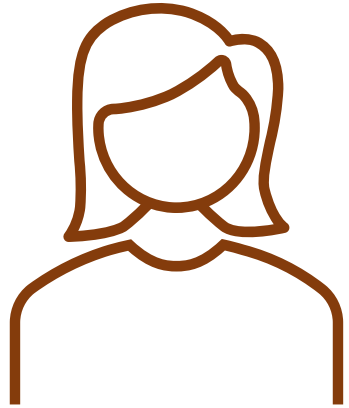
# Section 1: Introduction
# Exploring Reproductive Health Trends

Describe the trends of Reporting rates for the Reproductive Health dataset by all the districts in Sierra Leone for all the months in 2023. Can you describe the four components of this time series? Using an appropriate time series modeling approach, identify challenges and opportunities in this reporting rate data.

Along with topic and sentiment analysis.

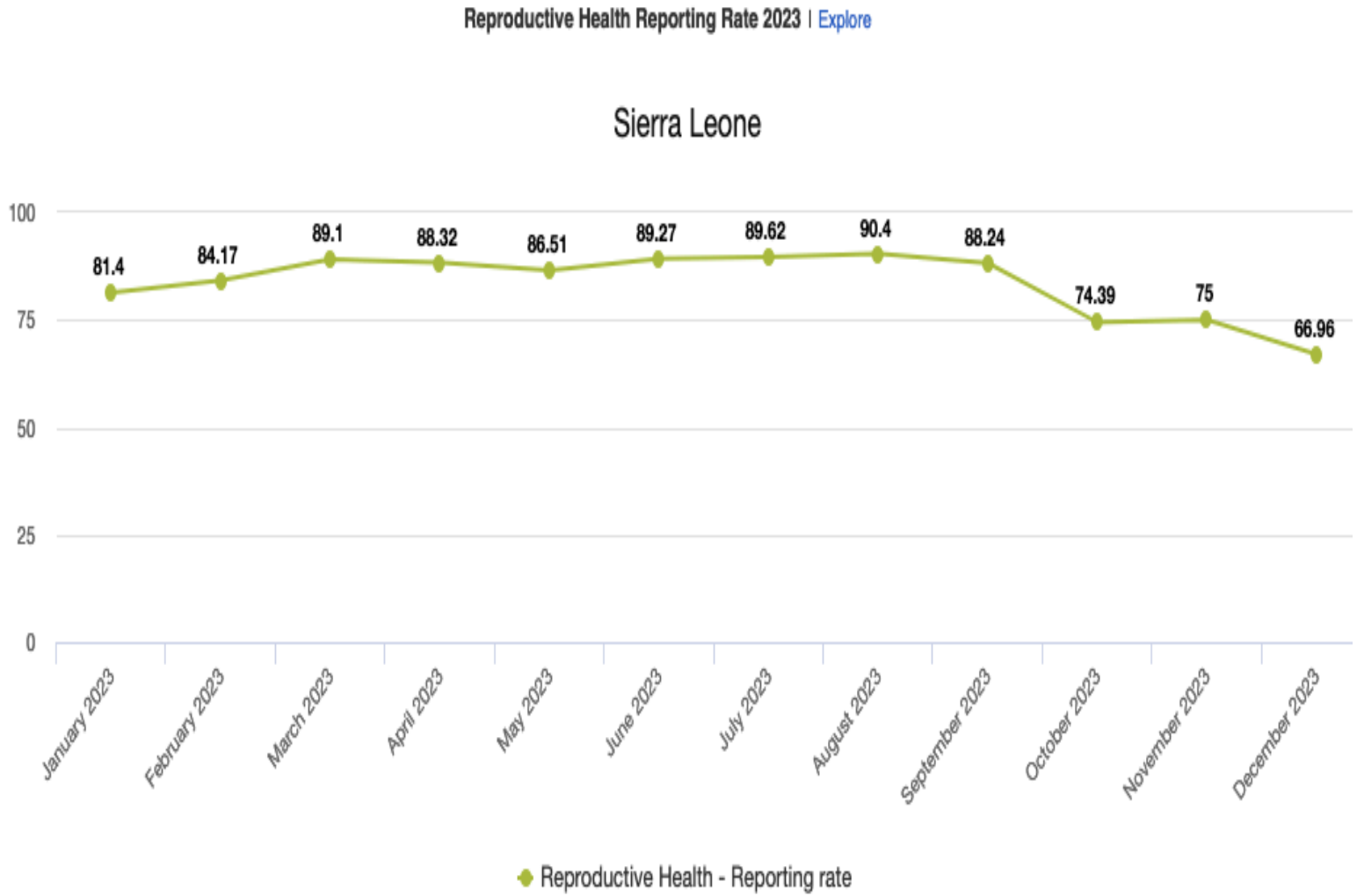


Question 2 and 9

# Question 2

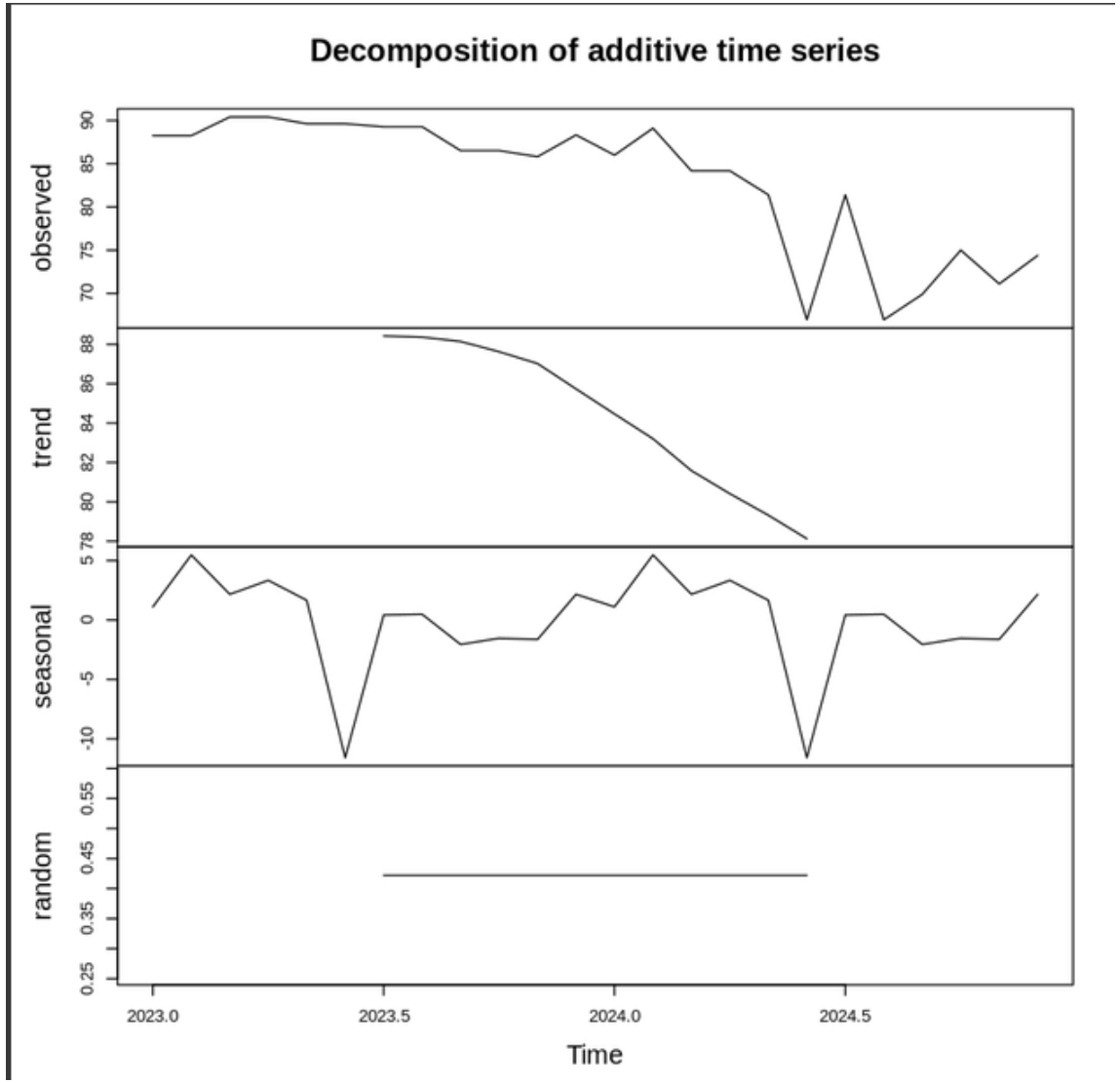
Describe the trends of reporting rates for the Reproductive Health dataset by all the districts in Sierra Leone for all the months in 2023.

Describe the four components of this time series.



# Components of this Series

- Trend – There appears to be a slight downward trend over the life of the data.
- Seasonality – While the statistical tests show no seasonality (due to short duration of data). The decomposition shows there may be annual seasonality
- Cycles – With only 2 years of data available (24 points) it is difficult to determine the long-term swings.
- Random – There is no sign of random variations.



# Question 2

Using an appropriate time series modeling approach, identify challenges and opportunities in the reporting rates for the Reproductive Health dataset by all the districts in Sierra Leone for all the months in 2023.

- Friedman, Kruskall-Wallis, F-test on seasonal summaries, and Welch test all return False for seasonality.
- Reporting does appear to go down during the months of October, November, and December.
    - This does not appear to be weather related as October is the peak of the rainy season, but November and December are mostly dry and pleasant.
- The overall downtrend in reporting between 2023 and 2024 should cause concern for local health officials.
- Incentivizing reporting may be one way to increase reporting rates.
- Making reporting easier (more places to report and less administrative hurdles) may also help increase reporting rates.

# Topic Analysis—Reproductive Health

Coherence Score for the final model (9 topics): **0.4118 (low interpretability)**

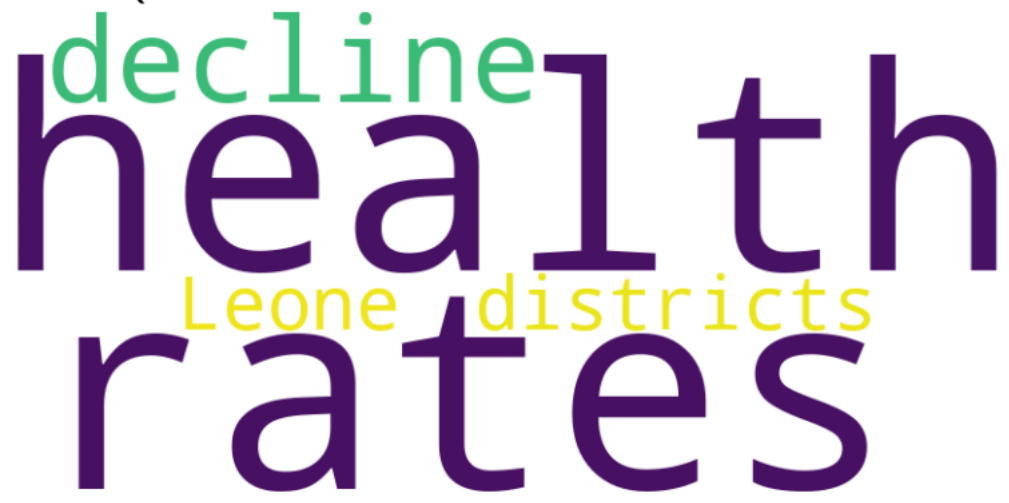
Interactive Topic Map

| Topic 1 | Topic 2 | Topic 3 | Topic 4 | Topic 5 | Topic 6 | Topic 7 | Topic 8 | Topic 9 |
|---|---|---|---|---|---|---|---|---|
| reporting | reporting | reporting | reporting | reporting | seasonality | data | reporting | reporting |
| rates | data | rates | data | data | data | reporting | data | rates |
| data | rates | health | 2023 | 2024 | years | resource | rates | year |
| trend | health | data | rates | 2023 | 2023 | rates | decline | decline |
| 2023 | trend | districts | year | years | November | year | health | monthly |
| year | seasonal | like | months | significant | reporting | patterns | collection | highlights |
| health | year | year | decline | patterns | months | health | trend | Leone |
| decline | analysis | reproductive | seasonality | However | rates | decline | year | quarter |
| could | like | might | seasonal | rates | December | collection | Leone | sharp |
| seasonality | time | Leone | years | steady | decline | gaps | system | Sierra |

Question 2: Seasonality and Trends

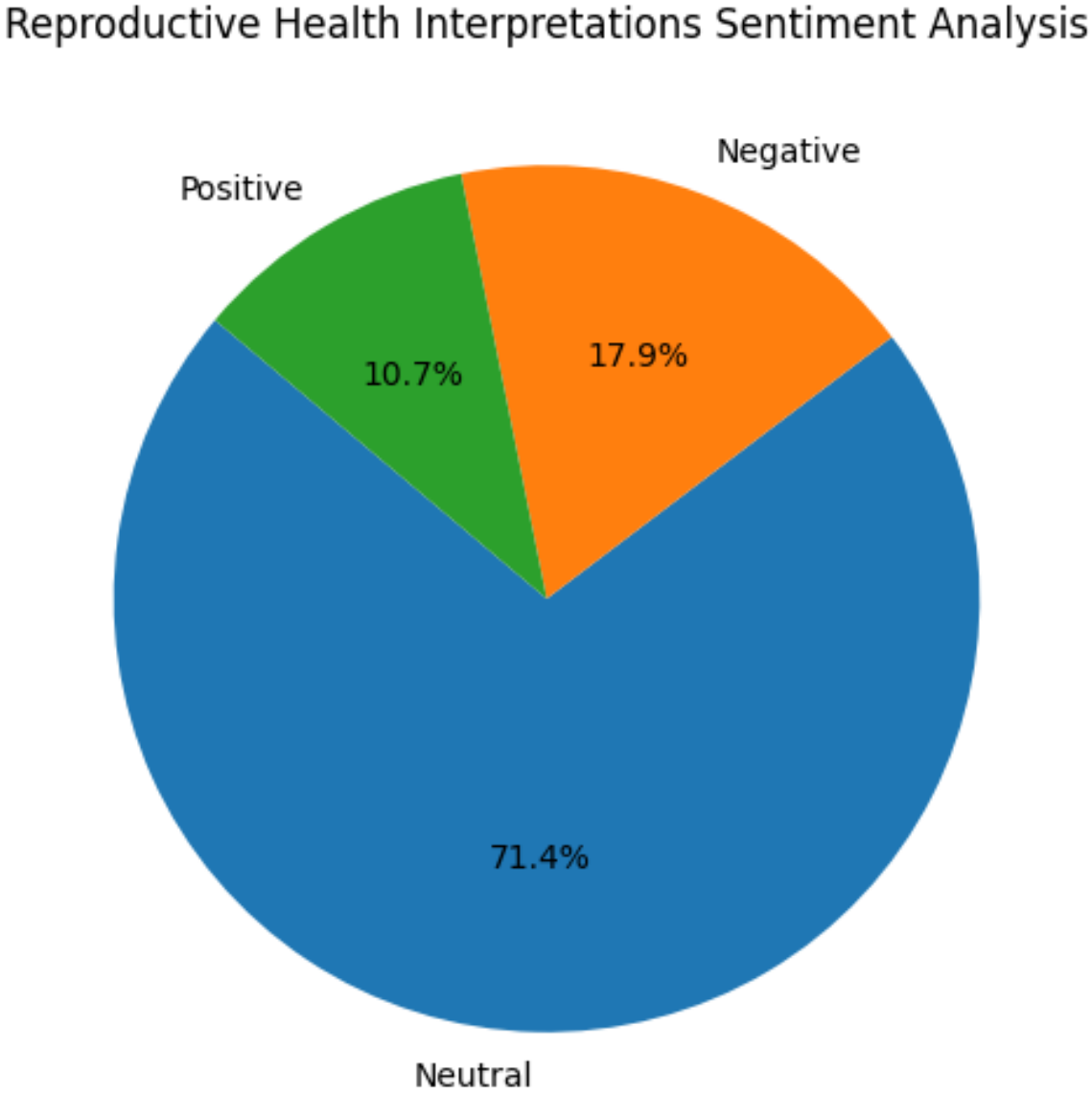

Question 2: Future Projections


Question 2: Health Metrics and Outcomes

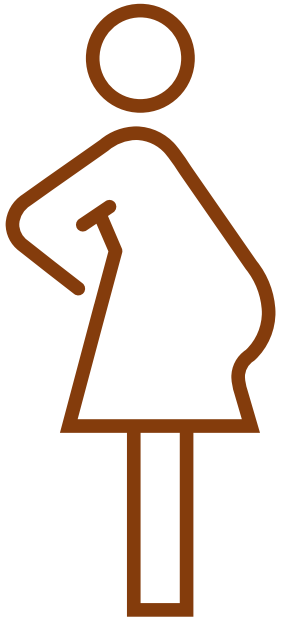



Question 2: Data Reporting and Analysis

# Sentiment Analysis—Reproductive Health



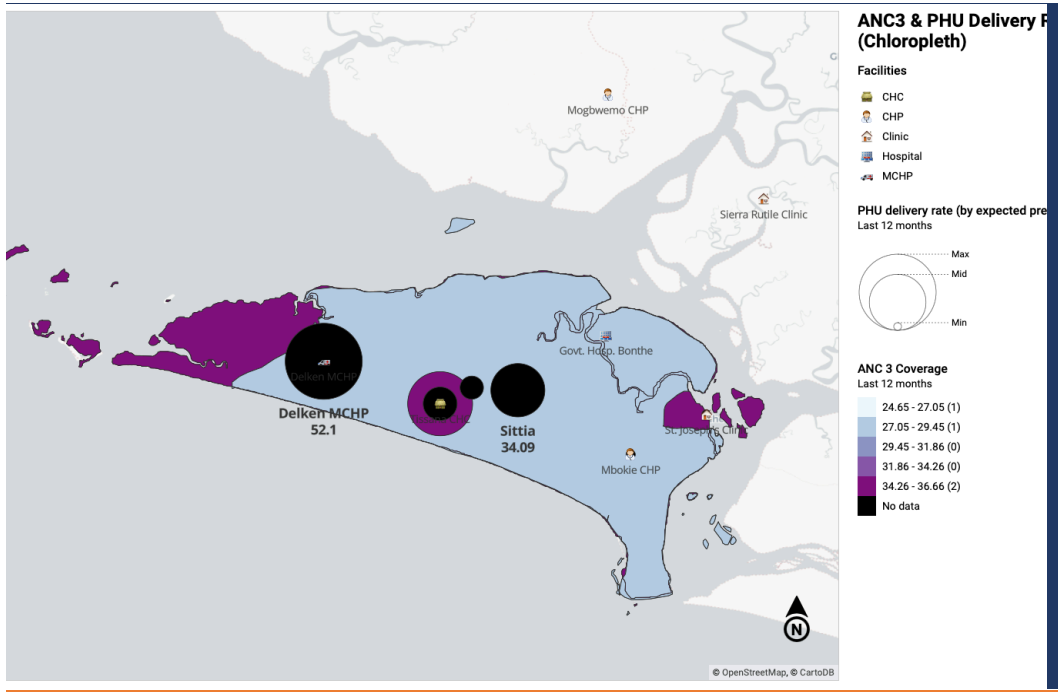
# Section 2:
# Antenatal care and Pregnancies



Compare the facilities on Sherbro Island on how they do on - ANC 3 Coverage, and PHU delivery rate. Please select the appropriate visualization to represent this comparison.

Along with topic and sentiment analysis.

Question 8 and 9




## Antenatal Care (3 visits) and Peripheral Health Unit Delivery Rate

Higher ANC3 Coverage: Tissana CHP and St. Joseph's Clinic (purple areas); likely due to better accessibility and infrastructure.

Tissana CHP: Moderate delivery rate.

Delken MCHP: Highest delivery rate (52.1%) despite no ANC3 coverage.

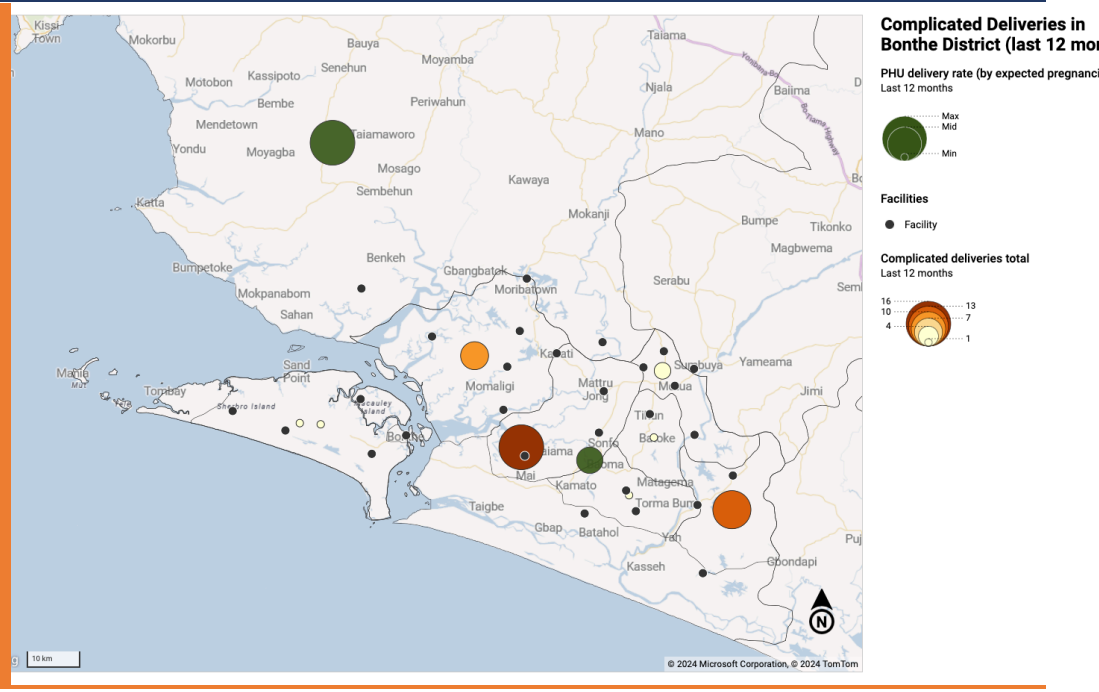
St. Joseph's Clinic and Mbokie CHP: No delivery rates, signaling infrastructure gaps.

Bonthe Hospital Challenges: No ANC3 coverage or delivery rates, likely due to isolation or resource limitations.

## Comparison of Delivery Rates and Complicated Deliveries to Entire District

Delivery rate lower on the island, but fewer complicated deliveries.

Suggests high-risk pregnancies are managed on the mainland.

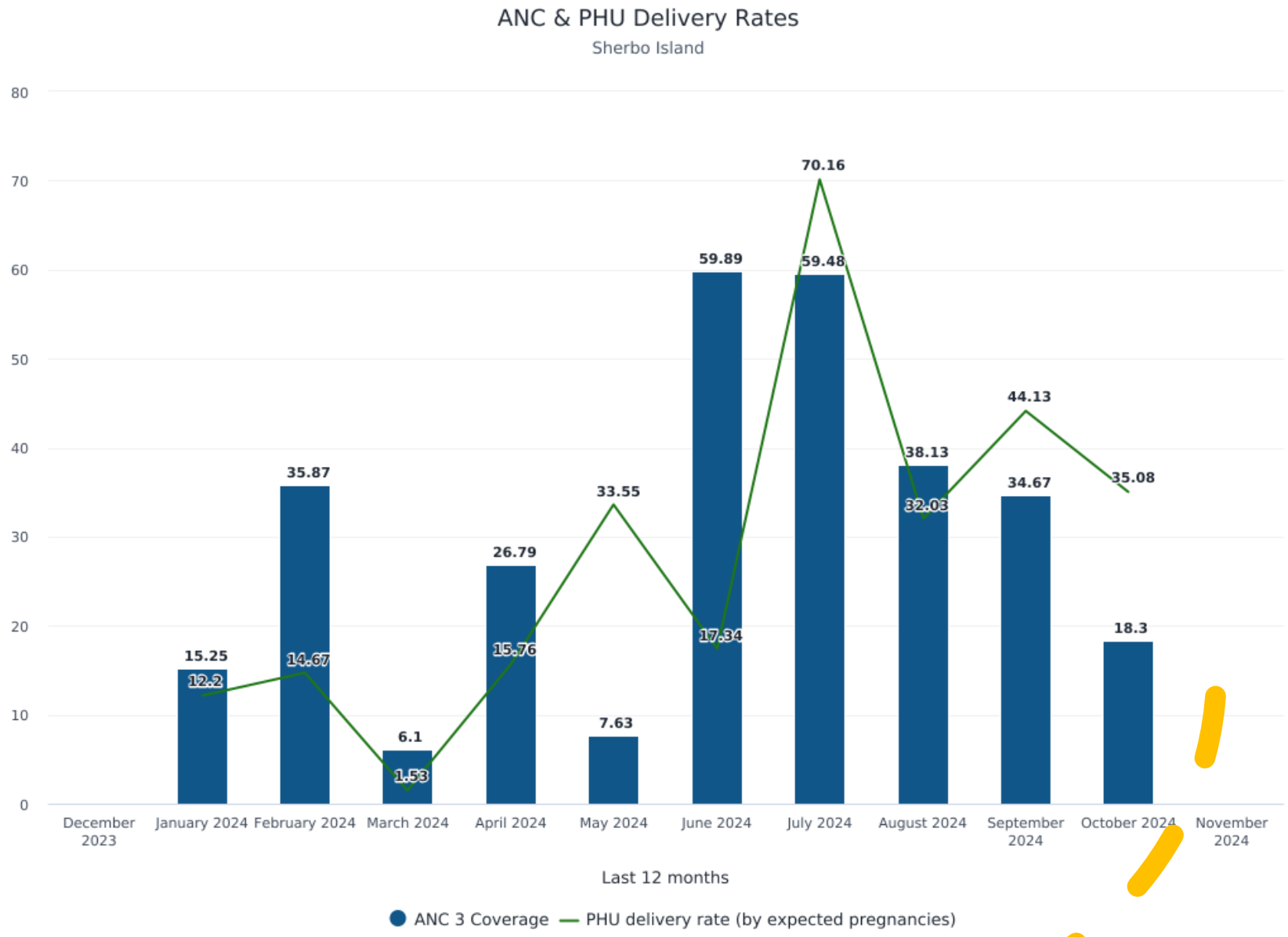


**12-Month Overview**: Displays ANC-3 coverage and PHU delivery rates on Sherbro Island.

**Highest Rates**: Both ANC-3 coverage (59.89%) and delivery rates (70.16%) peak in July 2024, hinting at a potential correlation.

**Lowest Rates**: May 2024 shows significant drops in ANC-3 coverage (7.63%) and delivery rates (17.84%), highlighting potential service gaps

**Key Insight**: Overall low rates suggest many maternal healthcare services are accessed off the island.



# Topic Analysis—Antenatal Care & Delivery Rates

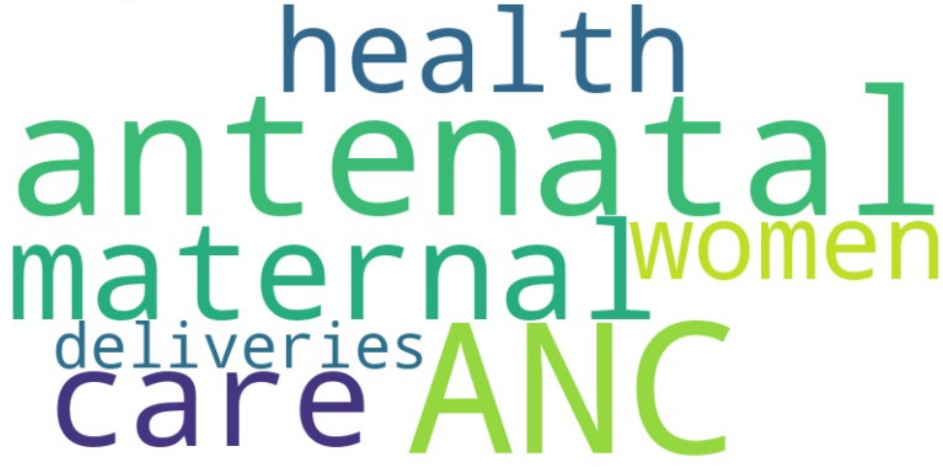
Coherence Score for the final model (4 topics): **0.5332** (high interpretability)

Interactive Topic Map

| Topic 1 | Topic 2 | Topic 3 | Topic 4 |
|---|---|---|---|
| ANC | delivery | delivery | coverage |
| delivery | PHU | PHU | delivery |
| health | facilities | ANC | PHU |
| PHU | rates | care | ANC |
| care | coverage | coverage | ANC3 |
| women | care | rates | Island |
| transportation | services | services | facilities |
| could | deliveries | facilities | rates |
| deliveries | Island | antenatal | care |
| maternal | ANC | maternal | rate |

Question 8: Data and Reporting

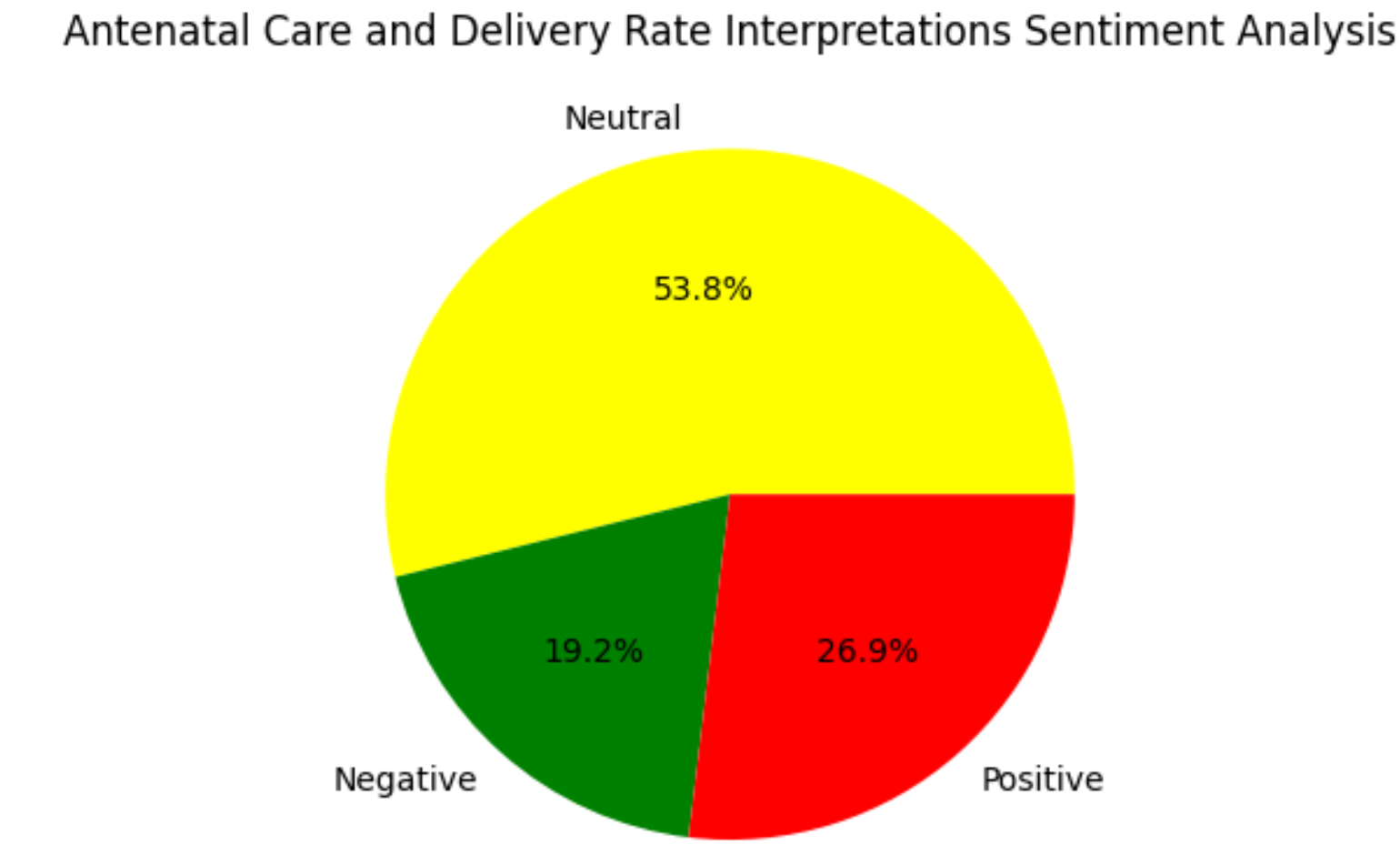

Question 8: Maternal and Child Healthcare




Question 8: Service Delivery and Coverage


Question 8: Infrastructure and Accessibility

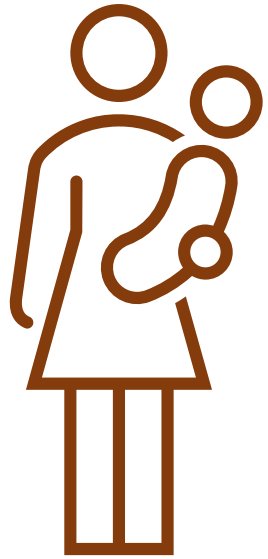
# Sentiment Analysis— Antenatal Care & Delivery Rate



# Section 3:
# Inter-dataset Reporting Comparisons

Among the following datasets, which of the reporting rates are the closest across the last 12 months for all of Sierra Leone, and provide a line chart comparison of these

- Reproductive Health
- Child Health
- PMTCT monthly summary

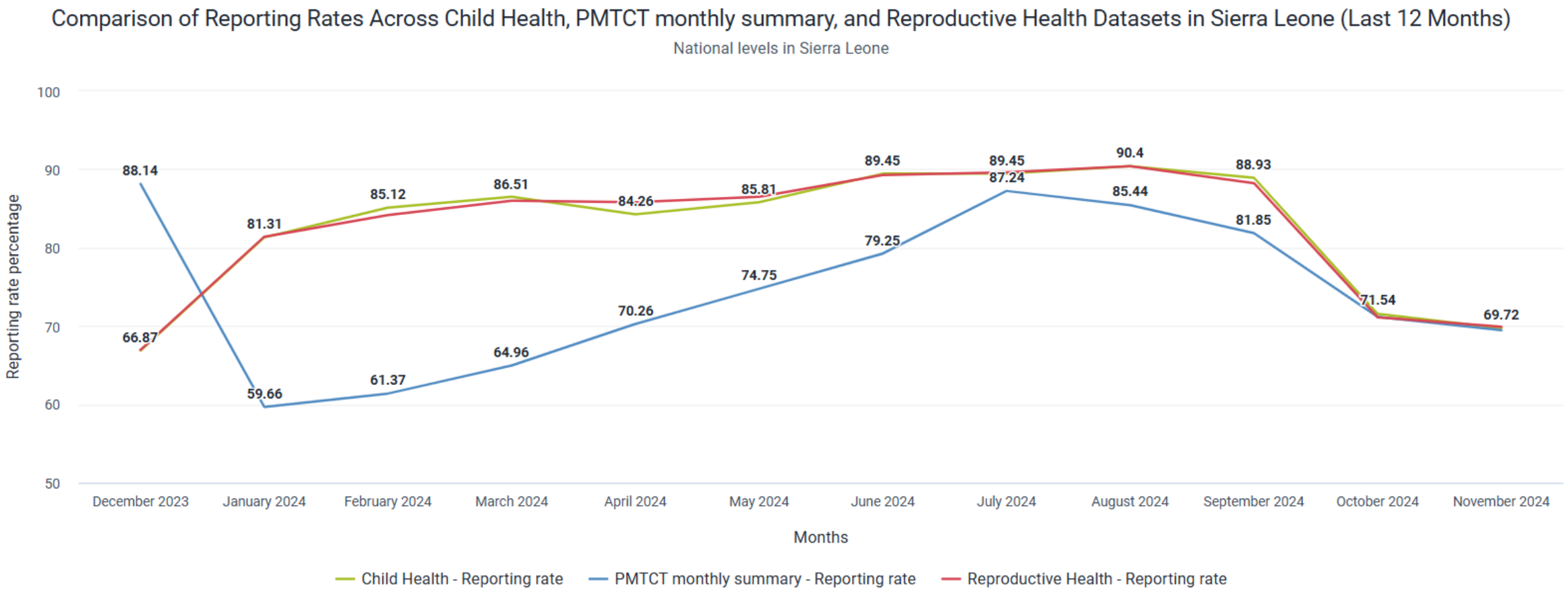


Question 3

The pivot table shows the reporting rates for Child Health, PMTCT monthly summary (Prevention of Mother-to-Child Transmission), and Reproductive Health at the national level in Sierra Leone over the past 12 months (between December 2023 and November 2024).

| Reporting rates comparison | | | |
|---|---|---|---|
| National levels in Sierra Leone | | | |
| | Child Health - Reporting rate | PMTCT monthly summary - Reporting rate | Reproductive Health - Reporting rate |
| December 2023 | 66.87 | 88.14 | 66.96 |
| January 2024 | 81.31 | 59.66 | 81.4 |
| February 2024 | 85.12 | 61.37 | 84.17 |
| March 2024 | 86.51 | 64.96 | 85.99 |
| April 2024 | 84.26 | 70.26 | 85.81 |
| May 2024 | 85.81 | 74.75 | 86.51 |
| June 2024 | 89.45 | 79.25 | 89.27 |
| July 2024 | 89.45 | 87.24 | 89.62 |
| August 2024 | 90.4 | 85.44 | 90.4 |
| September 2024 | 88.93 | 81.85 | 88.24 |
| October 2024 | 71.54 | 71.16 | 71.11 |
| November 2024 | 69.72 | 69.45 | 69.9 |

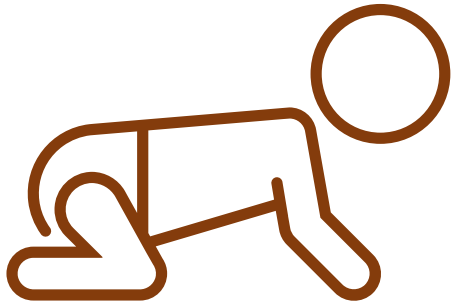
Data Visualizer




- **Reproductive Health and Child Health reporting rates are consistently closest.**
- PMTCT reporting rates show variability, especially in the first half of the year.
- By October–November 2024, all three datasets converge, indicating improved alignment.

# Section 4:
# Vaccination Coverage

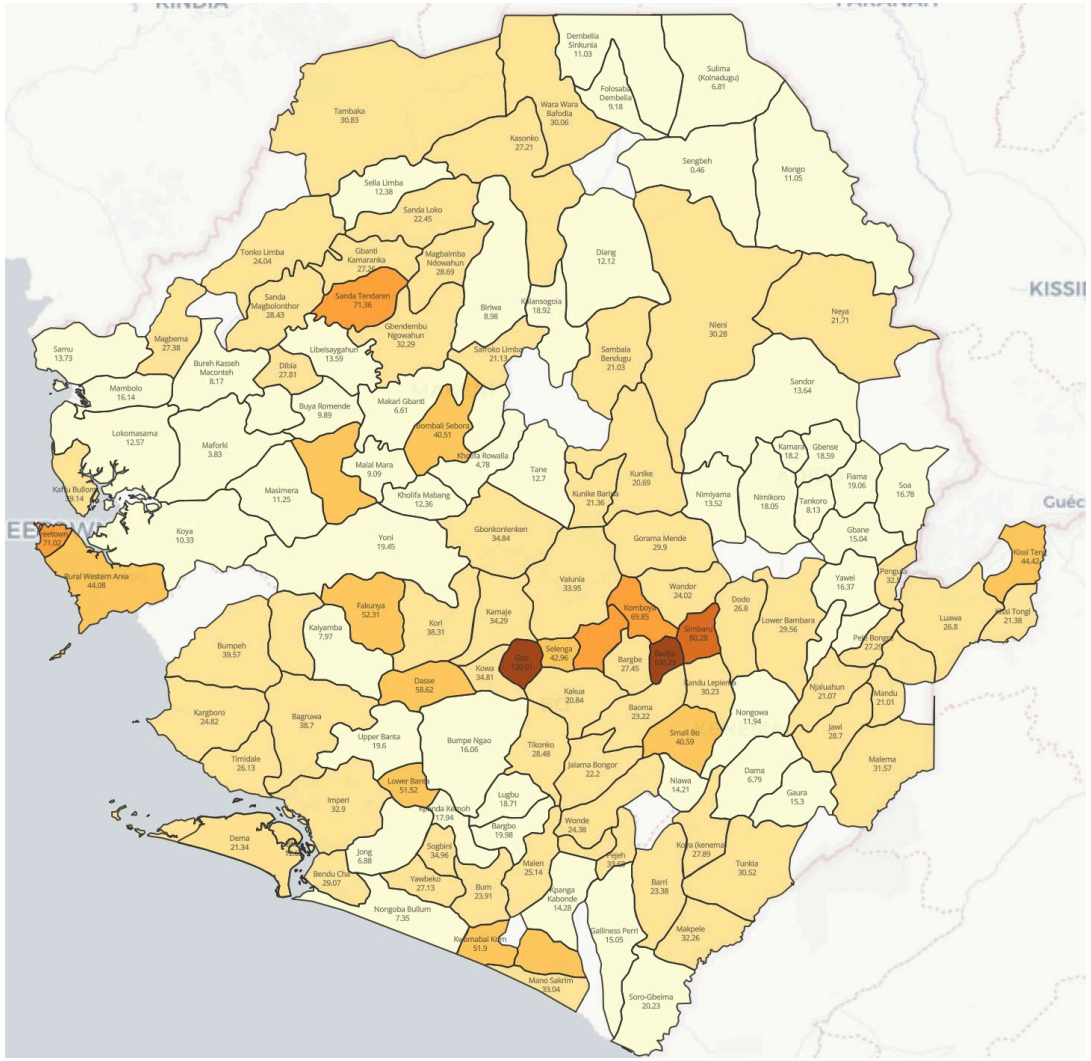
- For the last 12 months, which chiefdoms of Sierra Leone have a high OPV1 coverage for kids less than 1 year old.
- Compare the facilities in the geographical region of Sherbro Island and its surrounding coastal region for OPV1 coverage <1 yr.
- Describe the type of facilities in the geographical region of Sherbro Island that has the highest OPV1 coverage and the lowest OPV1 coverage <1yr



Question 5, 6, 7

| OPV1 coverage < 1yr of chiefdoms for past 12 months | |
|---|---|
| December 2023, January 2024, February 2024, March 2024, April 2024, May 2024, June 2024, July 2024, August 2024, September 2024, October 2024, November 2024 | |
| | OPV 1 Coverage <1y |
| Gbo | 120.01 |
| Badjia | 100.23 |
| Simbaru | 80.28 |
| Niawa Lenga | 78.35 |
| Sanda Tendaren | 71.36 |
| Freetown | 71.02 |
| Komboya | 69.85 |
| Dasse | 58.62 |
| Fakunya | 52.31 |
| Kwamabai Krim | 51.9 |
| Lower Banta | 51.52 |
| Ya Kpukumu Krim | 51.18 |

Created a Pivot table to show the chiefdoms with highest OPV 1 coverage




## OPV 1 Coverage <1y

Last 12 months

- 0.46 - 20.39 (54)
- 20.39 - 40.31 (63)
- 40.31 - 60.24 (11)
- 60.24 - 80.16 (4)
- 80.16 - 100.09 (1)
- 100.09 - 120.01 (2)

# Interpretation:

- **Top Performing Chiefdoms**:
  - **Simbaru**: Highest OPV1 coverage at **80.28%**.
  - **Niawa Lenga**: Second highest OPV1 coverage at **78.35%**.

- **Gbo and Badija Chiefdom**:
  - Has the highest reported OPV1 coverage with a value of **120% and 100.23%**, which is invalid as percentages above 100 are not possible.
  - This value indicates a possible data entry error.

- **Importance of a Choropleth Map**:

  **Geographic Insights**: Highlights regional trends and chiefdom performance at a glance.

  **Clear Flagging**: Invalid values like Gbo and Badija are visually distinguished, aiding in error detection.

- **Pivot Table** :

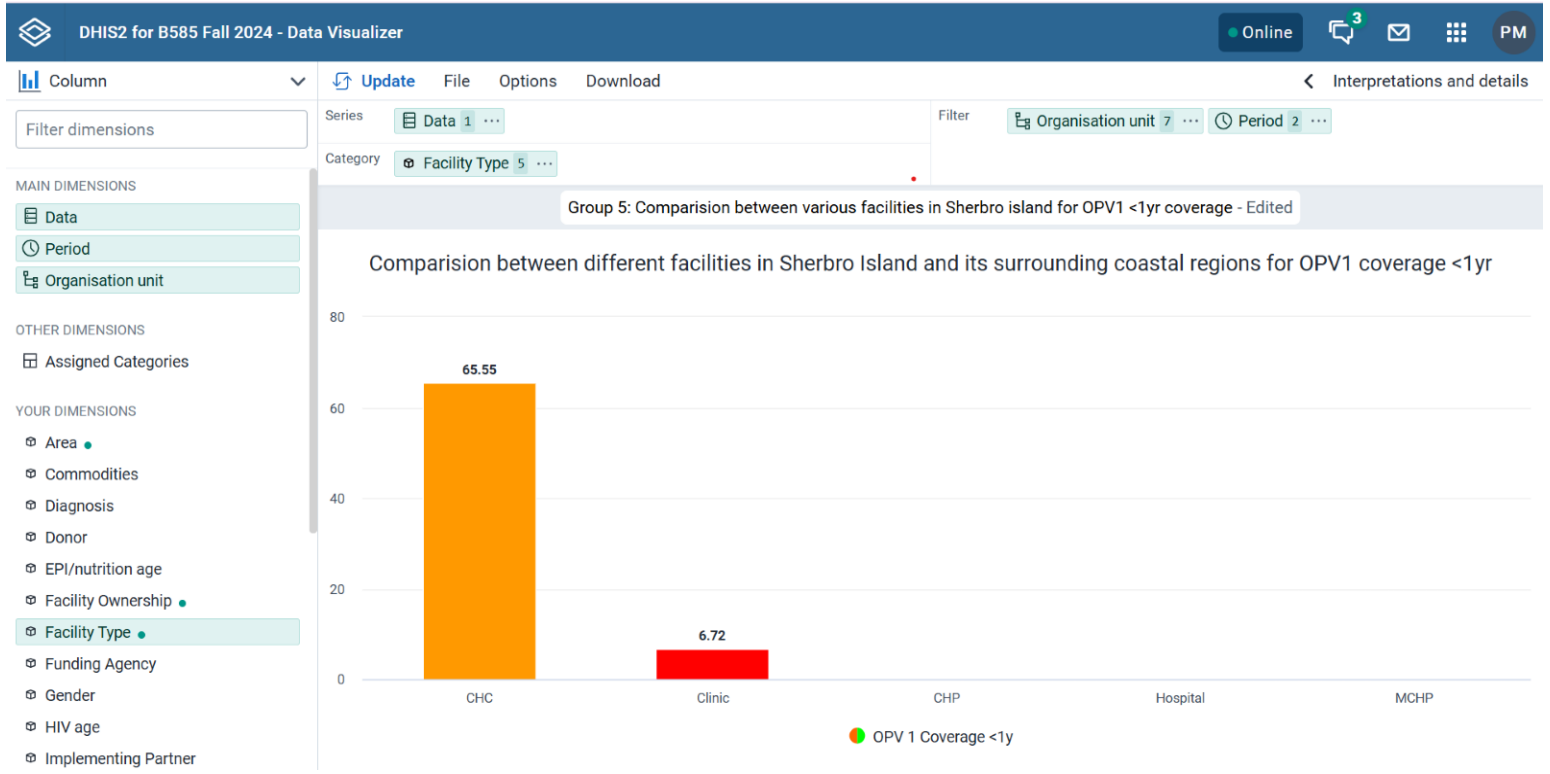
  Provides a detailed breakdown of chiefdoms and their exact OPV1 coverage values.

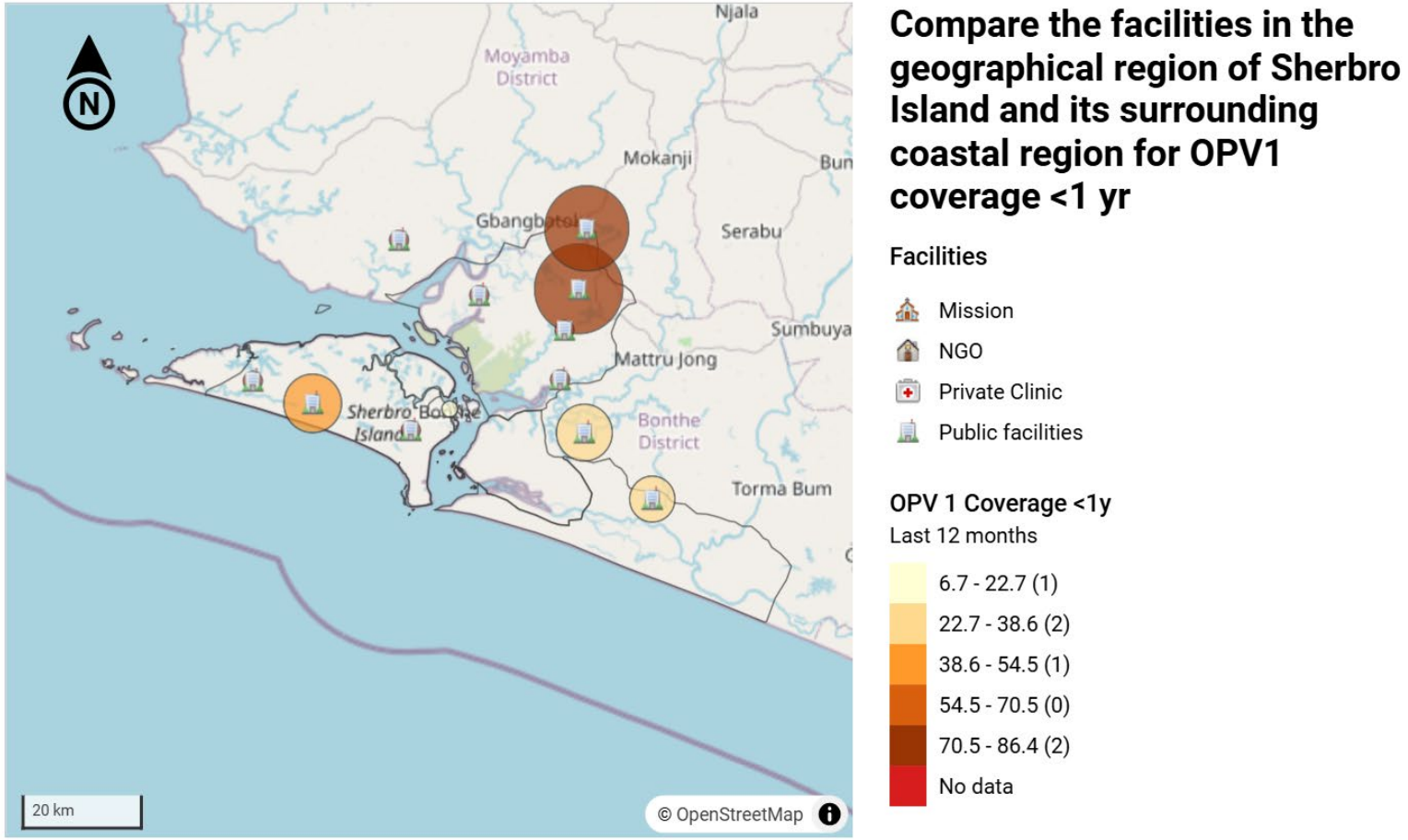
  Ensures precise data interpretation alongside the geographic visualization.

# Question 6

Compare the facilities in the geographical region of Sherbro Island and its surrounding coastal region for OPV1 coverage <1 yr.

- The geographical region of Sherbro Island and its surrounding coastal region are formed by the Sittia, Nongobabullum, Dema, Benducha and Imperi. The facilities in this region where OPV1 coverage was seen are majorly the CHCs and one clinic. All the other facilities do not have any contribution to OPV1 <1yr comparison.
- The bar chart below shows the comparison between various facilities in the OPV 1 coverage <1 yr in the geographical region of Sherbro Island and its surrounding coastal region:



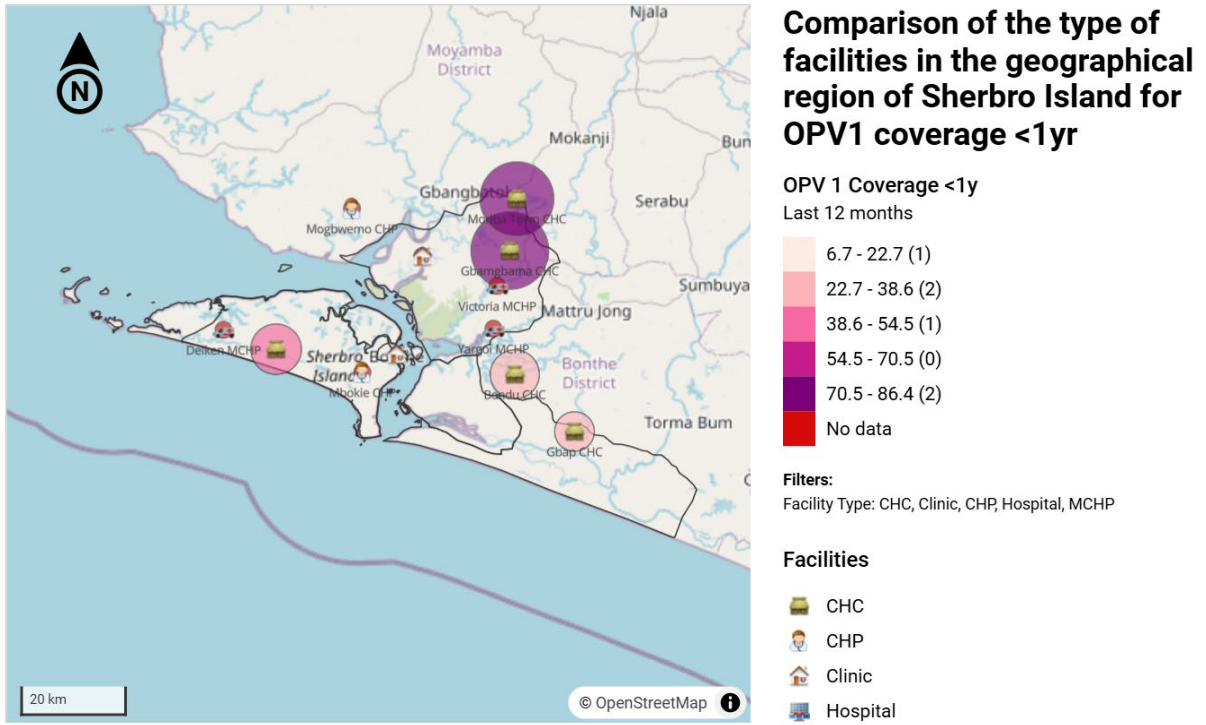



The facilities in this region where OPV1 coverage was seen, were all public facilities , this shows the need for fund allocation for development of health infrastructure in this area.

# Question 7

Describe the type of facilities in the geographical region of Sherbro Island that has the highest OPV1 coverage and the lowest OPV1 coverage <1yr

The highest coverage for OPV1 is seen in GbamGbama CHC with a coverage of 79. 29 in the region and lowest is seen in St. Joseph clinic at 6.71.




**Comparison of the type of facilities in the geographical region of Sherbro Island for OPV1 coverage <1yr**

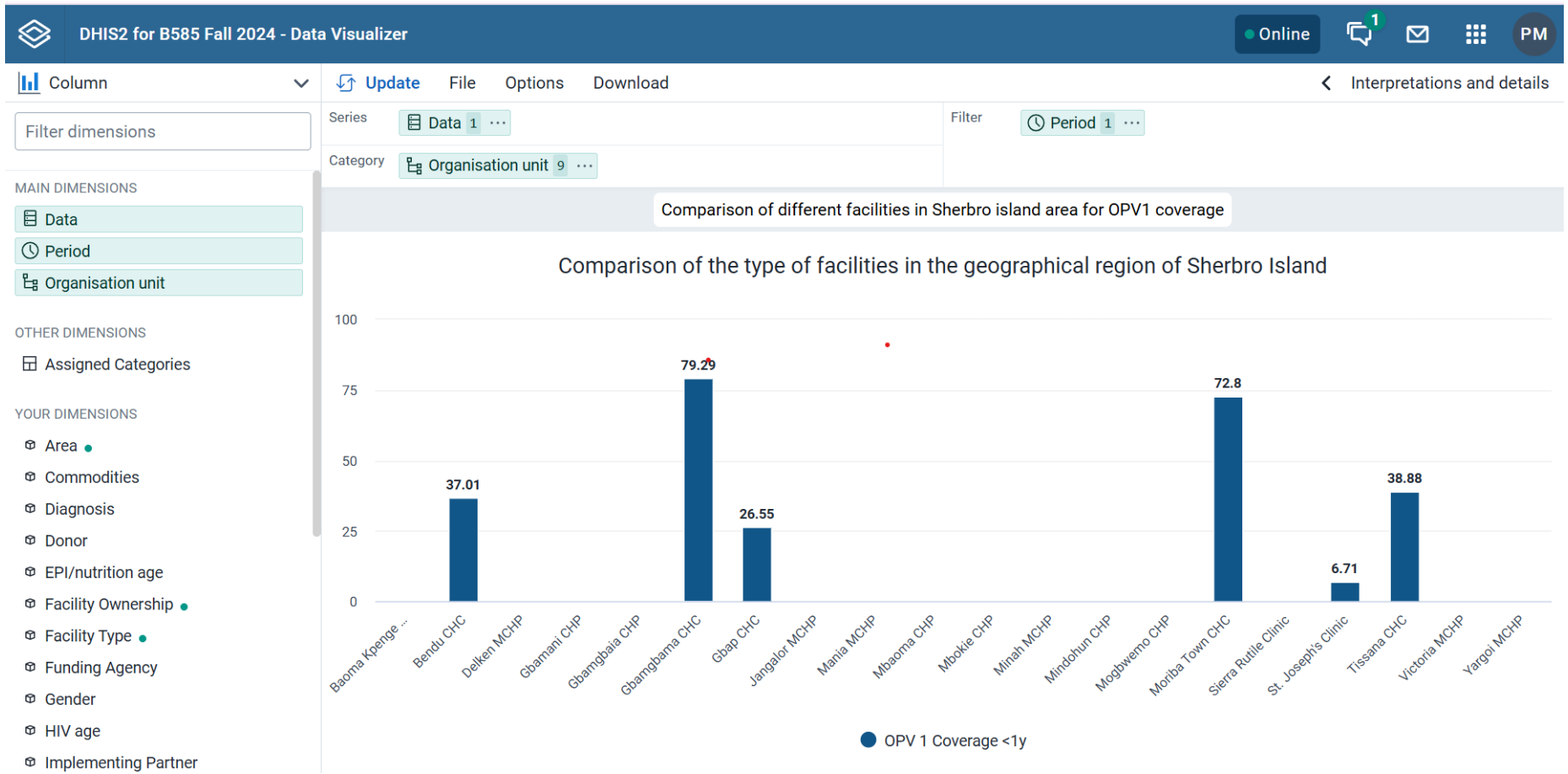
OPV 1 Coverage <1y
Last 12 months

- 6.7 - 22.7 (1)
- 22.7 - 38.6 (2)
- 38.6 - 54.5 (1)
- 54.5 - 70.5 (0)
- 70.5 - 86.4 (2)
- No data

**Filters:**
Facility Type: CHC, Clinic, CHP, Hospital, MCHP

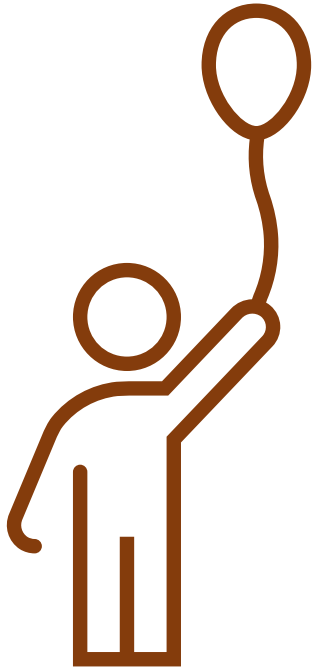
**Facilities**

- CHC
- CHP
- Clinic
- Hospital


DHIS2 for B585 Fall 2024 - Data Visualizer
Online
PM
Column
Update
File
Options
Download
Interpretations and details
Filter dimensions
MAIN DIMENSIONS
Data
Period
Organisation unit
OTHER DIMENSIONS
Assigned Categories
YOUR DIMENSIONS
Area
Commodities
Diagnosis
Donor
EPI/nutrition age
Facility Ownership
Facility Type
Funding Agency
Gender
HIV age
Implementing Partner
Series
Data 1
Category
Organisation unit 9
Filter
Period 1
Comparison of different facilities in Sherbro island area for OPV1 coverage
Comparison of the type of facilities in the geographical region of Sherbro Island
100
75
50
25
0
37.01
79.29
26.55
72.8
6.71
38.88
Baoma Kpenge ...
Bendu CHC
Delken MCHP
Gbamani CHP
Gbamgbaia CHP
Gbamgbama CHC
Gbap CHC
Jangalor MCHP
Mania MCHP
Mbaoma CHP
Mbokie CHP
Minah MCHP
Mindohun CHP
Mogbwemo CHP
Moriba Town CHC
Sierra Rutile Clinic
St. Joseph's Clinic
Tissana CHC
Victoria MCHP
Yargoi MCHP
OPV 1 Coverage <1y

# Section 5:
# Childhood Illnesses & Intervention

- Describe the underlying data elements, categories, and category combinations by which you calculate the "Diarrhea <5 y incidence rate". Create a table that gives underlying data values for every district, along with the indicator value for the last 12 months.
- Can you predict the minimum stock for Oral Rehydration Solution (ORS) that should be maintained in the district with the highest average rate of diarrhea < 5y if we know that these children need to be given 3 packets each day for 5-14 days of an episode. (Question 4b)




Question 4a & 4b

Here, we are working with the Indicator "Diarrhea <5 yr incidence rate", we went into the meta data to check what data elements this indicator is composed of-

Data Elements:

- Diarrhea with blood (Dysentry) new: New cases of diarrhea with blood (dysentery) in children <5 years. It is the highest in Western Area (3,668), lowest in Bonthe (234).
- Diarrhea with severe dehydration follow-up: Cases of severe dehydration due to diarrhea requiring follow-up care. These cases are the highest in Western Area (1,093), lowest in Pujehun (217).
- Total population <5 years: Total number of children under 5 in each district. The districts where the population of children <5 years is highest in Western Area (147,438) & lowest in Pujehun (44,164).

Categories:

This indicator categorizes data by age (<5 years), severity (e.g., dysentery, severe dehydration), and case type (new, follow-up, referral) to track critical diarrhea cases.

Category Combinations: The category combination for both the numerator values is Morbidity cases, which means the total count of individuals experiencing illness or disease within a specified population, the illness here being Diarrhea.

Incidence of diarrhea over the past 12 Months

| Incidence of Diarrhea and its components in Seirra Leone | | | | |
|---|---|---|---|---|
| December 2023, January 2024, February 2024, March 2024, April 2024, May 2024, June 2024, July 2024, August 2024, September 2024, ... | | | | |
| | Diarrhoea <5 y incidence rate (%) | Diarrhoea with blood (Dysentery) new | Diarrhoea with severe dehydration follow-up | Total population < 5 years |
| Bo | 5.21 | 3 899 | 600 | 86 101.66 |
| Bombali | 3.95 | 2 662 | 345 | 76 006.53 |
| Bonthe | 1.82 | 234 | 265 | 27 317.37 |
| Kailahun | 4.63 | 2 875 | 288 | 68 105.92 |
| Kambia | 4.75 | 1 942 | 490 | 51 079.19 |
| Kenema | 4.37 | 3 687 | 458 | 94 594.28 |
| Koinadugu | 4.02 | 1 753 | 252 | 49 753.18 |
| Kono | 2.26 | 1 203 | 255 | 64 322.87 |
| Moyamba | 3.06 | 1 435 | 104 | 50 091.18 |
| Port Loko | 3.01 | 1 962 | 683 | 87 638.69 |
| Pujehun | 3.09 | 1 151 | 217 | 44 164.6 |
| Tonkolili | 6.56 | 3 683 | 670 | 66 214.4 |
| Western Area | 3.22 | 3 668 | 1 093 | 147 438 |

This pivot table shows the incidence rate of diarrhea in children under 5 across districts, highlighting that districts with the highest number of diarrhea cases (e.g., Western Area) may not necessarily have the highest incidence rate, as this depends on the total population of children under 5 in each district. The higest incidence rate was in the district of Tonkolli with an incidence of 6.56 and the lowest is in Bonthe with 1.82

Question 4a & 4b

We approached the 2nd problem of calculating the ORS stock this way-

**Identify Data Elements:** Narrow down data elements contributing to the average.

**Find District with Highest Average Cases:** Locate the district with the highest average diarrhea cases.

**Analyze 2-Year Data:** Extract 2-year data from chiefdoms in the identified district.

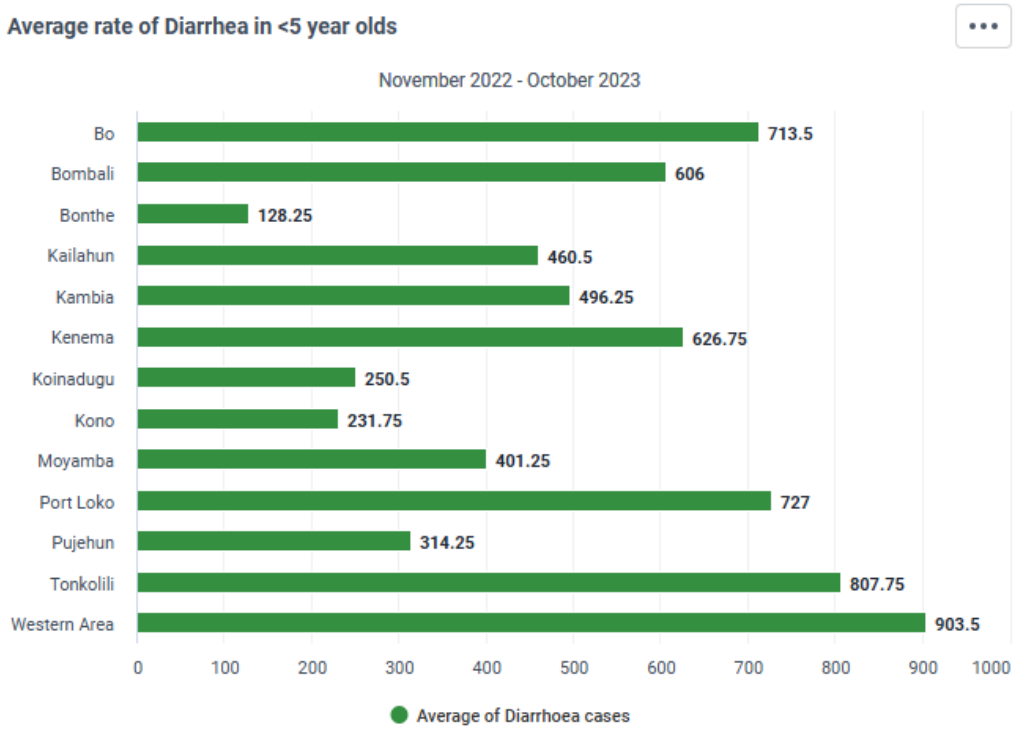
**Forecast in R:** Import data into R and forecast cases for the next year.

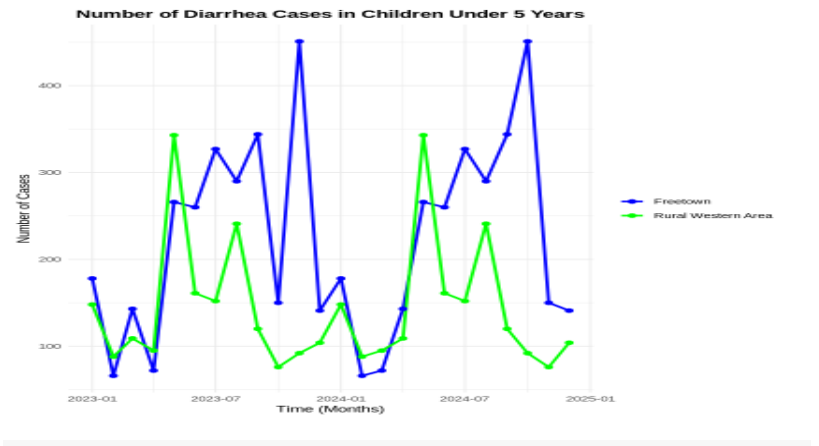
**Calculate ORS Stock:** Determine minimum ORS stock needed for 5 days

- Data elements which we selected for average are- New diarrhea cases with blood (dysentery) and severe dehydration in children under 5 years were chosen, as all cases, including referrals, require ORS as the first line of treatment. The district with highest average diarrhea cases was Western Area, as shown in the bar chart here.

- We took the last 24 months data of Chiefdoms Freetown & Western area to colab, which both had no missing values or many outliers to do a forecast for next year case count.

- We divided the dataset into training (first 18 months) and testing set (last 6 months) and performed forecasting methods like Auto-ARIMA, ETS, SES Holt Winters, and used MAPE to calcuate the efficiency of the model.




Colab link- https://colab.research.google.com/drive/1uJU6T-kG4uvTIa2_JSfj83I0s9Pzxug1?usp=sharing

# Results of the Forecasting process-

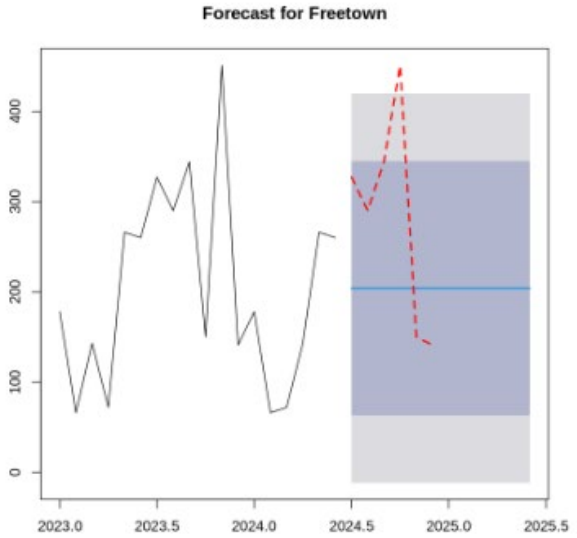
Auto- Arima was the better performing model for our data out of all the models we tried, we got a MAPE value of 40.57123 % and 44.0051 % for Rural Western Area, which is reasonable, but not the best or good.

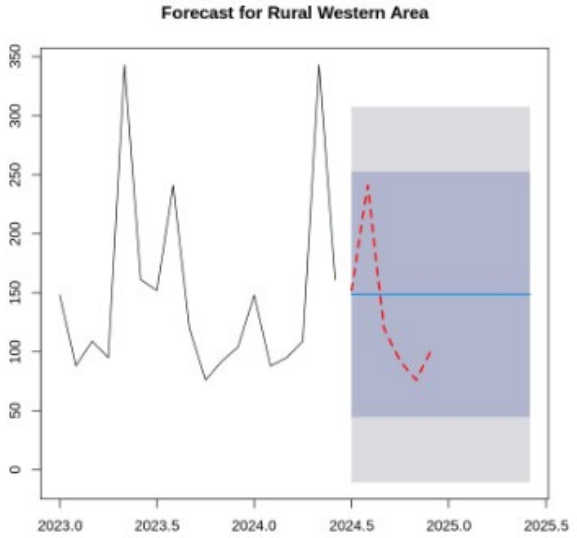
Some of the reasons why we think our forecasting was not optimum was-
irregular peaks in the data, non-stationarity and inconsistent seasonal trends across the two years of data.

Based on forecasted diarrhea cases for the next year, we calculated the minimum stock required for 5 days, prescribing 3 ORS packets per day. This resulted in **36,730 packets for Freetown** and **26,730 packets for the Rural Western Area**, leading to a total of **63,460 packets for the Western Area District.**

**Why Chiefdom-Level Calculation is Enough?**

Facilities within these chiefdoms are located 20–30 km apart, ensuring feasible transportation during dire conditions.

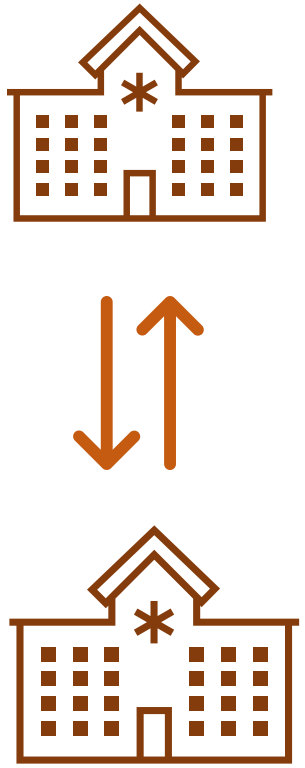


# Section 6:
# Referral trends and Forecasting

Questions we are answering-

1. Compare the two health facilities of Bo district - Ngelehun CHC in Badija and Jembe CHC in Baoma on the following: number of patients who have been referred and the cause of the referral for those who have been referred for the last 12 months. Also, could you identify the patient characteristics of those referred from these facilities compared to those not referred?
2. Can you build a model to predict the number of patients referred in each month of next year from these facilities? Please discuss some considerations when doing predictive modeling for this?

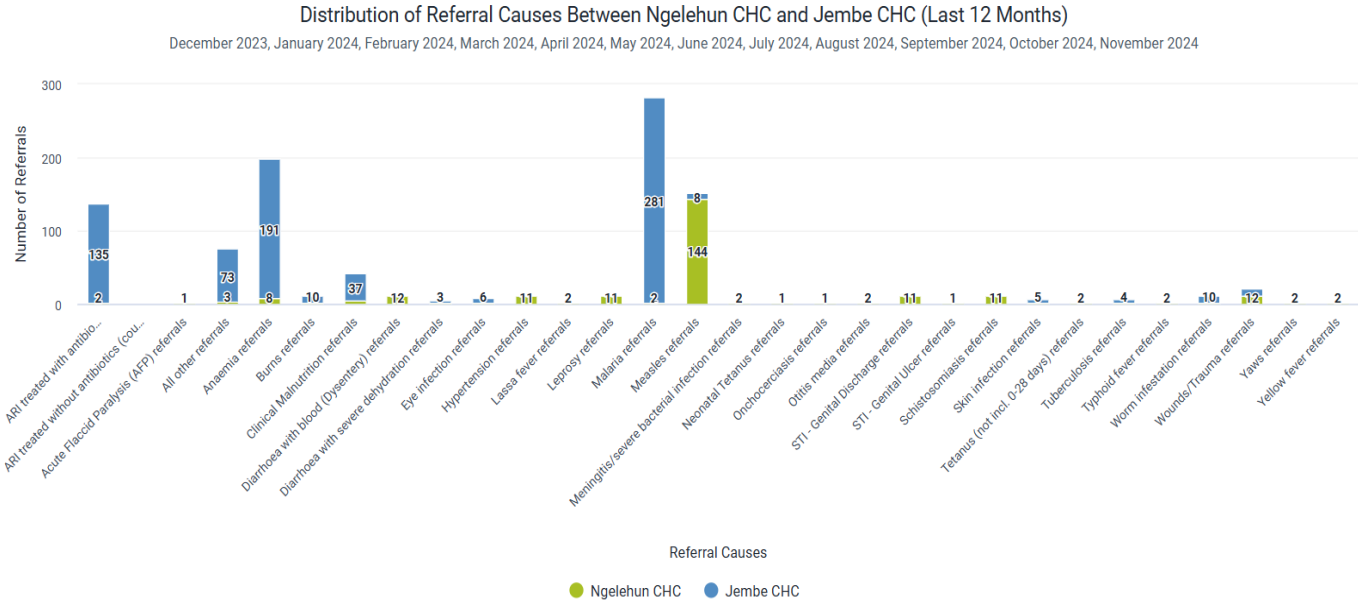


Question 1a & 1b

# Comparison of Patient Referrals from Ngelehun CHC and Jembe CHC (Last 12 Months)

| Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Last 12 Months)<br>ARI treated with antibiotics (pneumonia) referrals, ARI treated without antibiotics (cough) referrals, Acute Flaccid Paralysis (AFP) referrals, All other referrals, Anaemia referrals, Burns referrals, Clinical Malnutrition referrals, Diarrhoea with blood (Dysentery) referrals, Diarrhoea with severe dehydration referrals, Eye infection referrals, Hypertension referrals, Lassa fever referrals, Leprosy referrals, Malaria referrals, Measles referrals, Meningitis/severe bacterial infection referrals, Neonatal Tetanus referrals, Onchocerciasis referrals, Otitis media referrals, STI - Genital Discharge referrals, STI - Genital Ulcer referrals, Schistosomiasis referrals, Skin infection referrals, Tetanus (not incl. 0-28 days) referrals, Tuberculosis referrals, Typhoid fever referrals, Worm infestation referrals, Wounds/Trauma referrals, Yaws referrals, Yellow fever referrals | | |
|---|---|---|
| | Ngelehun CHC | Jembe CHC |
| December 2023 | | 52 |
| January 2024 | 119 | 48 |
| February 2024 | 6 | 48 |
| March 2024 | 17 | 49 |
| April 2024 | 7 | 89 |
| May 2024 | 13 | 42 |
| June 2024 | 14 | 71 |
| July 2024 | 13 | 101 |
| August 2024 | 7 | 64 |
| September 2024 | 14 | 87 |
| October 2024 | 51 | 66 |
| November 2024 | | 55 |
| Total | 261 | 772 |

# Comparison of Cause of Referrals at Ngelehun CHC and Jembe CHC (Last 12 Months)



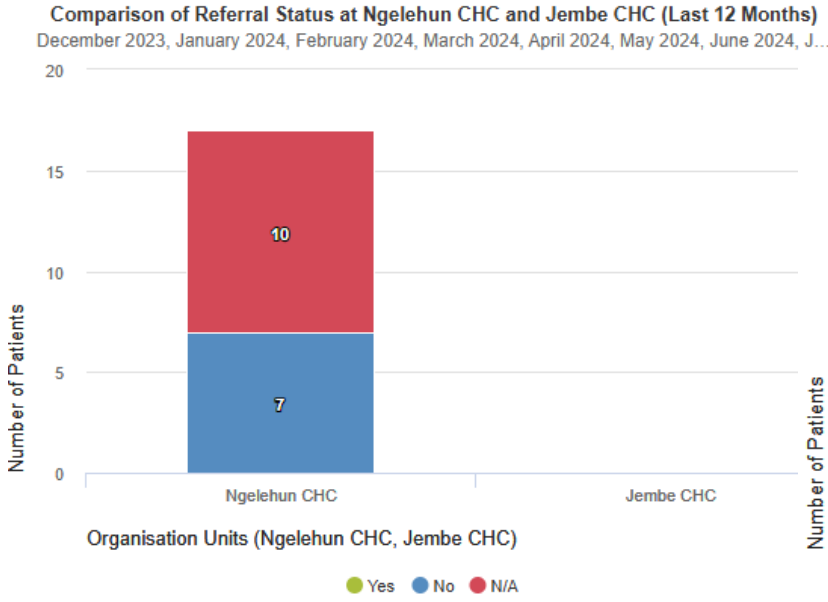

**Limitation:** Missing data observed for some months at **Ngelehun CHC**, impacting direct comparisons.

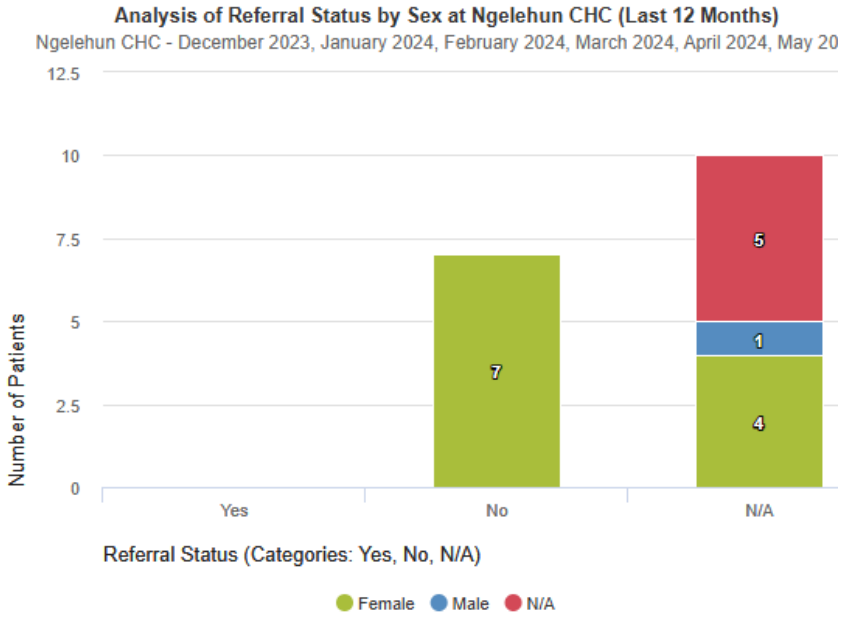
**Interpretation:** Over the last 12 months, **Jembe CHC referred had 772 referrals**, significantly more than **Ngelehun CHC's 261 referrals**.

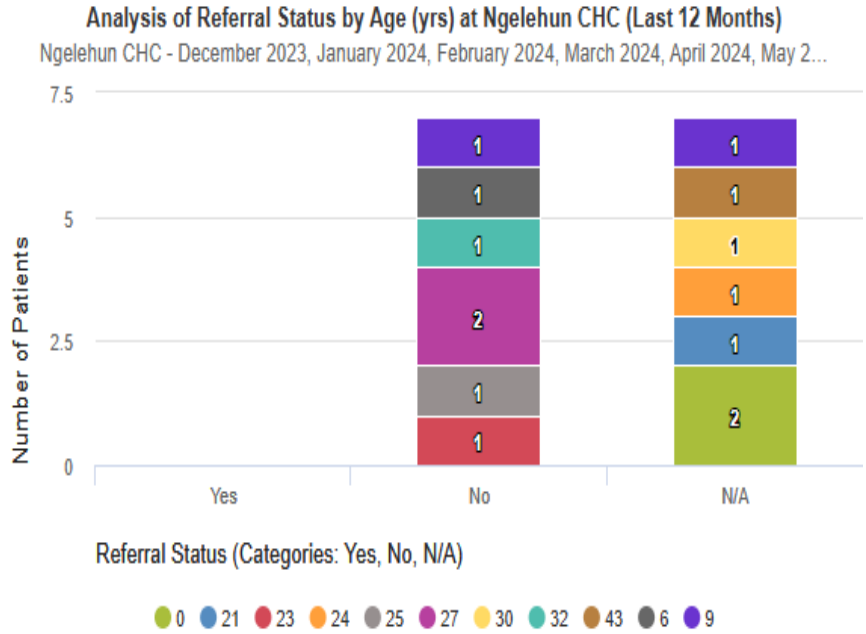
**Jembe CHC:** High referrals for **malaria (281 cases)**, **anaemia (191 cases)**, and **pneumonia (135 cases)**. Referrals for diverse conditions like clinical malnutrition and acute flaccid paralysis suggest a broader healthcare burden.

**Ngelehun CHC:** Higher referrals for **measles (144 cases)** and **dysentery (12 cases)**. Indicates possible outbreaks or a specific disease burden in the catchment area.

# Patient Characteristics and Referral Patterns at Ngelehun CHC and Jembe CHC (Last 12 Months)



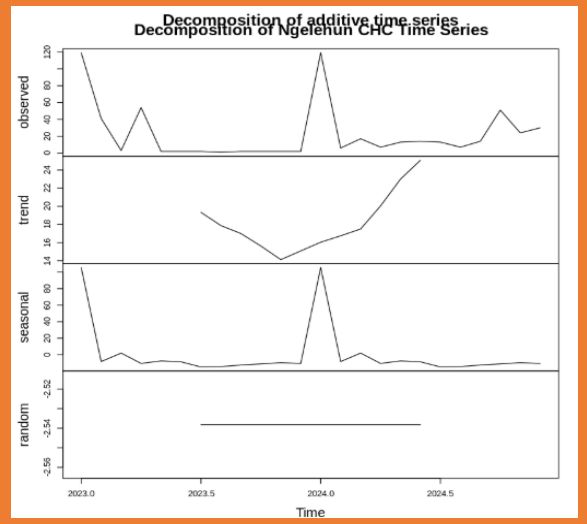



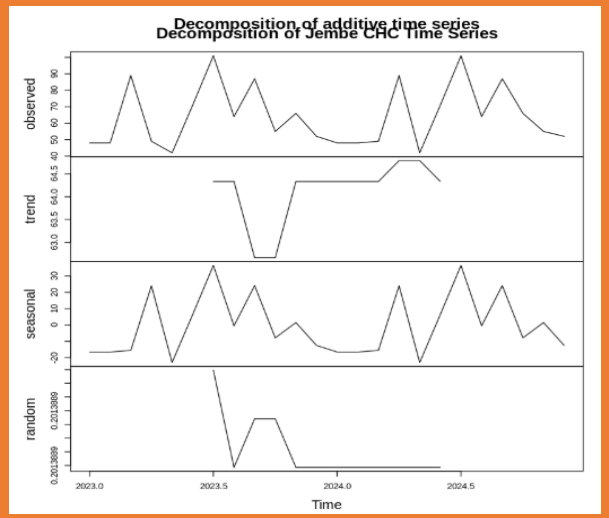

**Interpretation:**

- The stacked column chart shows that the majority of patient records from Ngelehun CHC had missing referral status marked as "N/A" (10 cases), followed by "No" referrals (7 cases). No "Yes" referrals were recorded for this period. Data from Jembe CHC is absent, preventing comparative analysis.

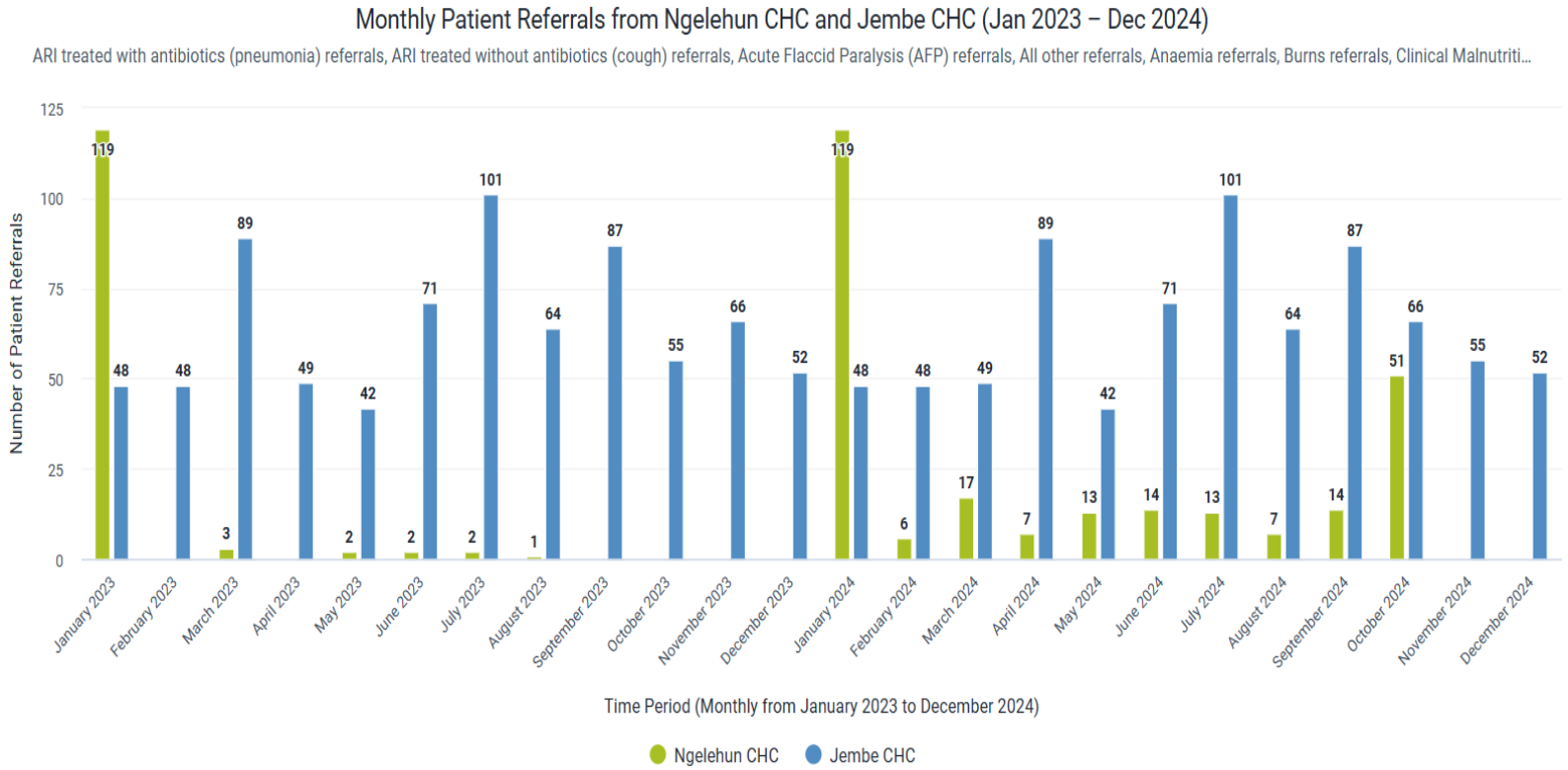
- At Ngelehun CHC, most patients who were not referred are female (7 cases). Among patients with missing referral status ("N/A"), there is a mix of female (4 cases), male (1 case), and unspecified sex (5 cases). No patients of any sex were recorded as referred ("Yes") during this period.

- At Ngelehun CHC, most age groups have missing referral status marked as "N/A". Among the "No" referrals, patients are distributed across a range of ages, but no referrals ("Yes") are observed.




# Referral Data From January 2023 To December 2024 (24 Months)



# 12-Month Referral Forecast for Jembe CHC and Ngelehun CHC (2025)

**Data Preparation and Modeling Steps:**

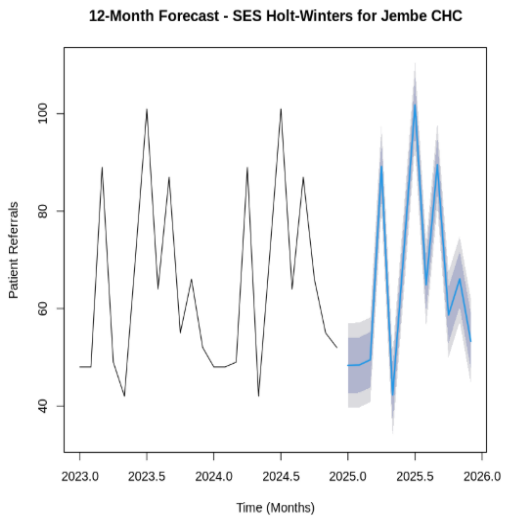
- Monthly referral data (Jan 2023–Dec 2024) from DHIS2.
- Missing data handled via 3-period Simple Moving Average (SMA).
- Converted to time series, split into training (Jan 2023–Jun 2024) and validation (Jul–Dec 2024).
- Identified trends, seasonality, and random components.
- Tested Auto ARIMA, ETS, and SES Holt-Winters. Selected SES Holt-Winters for forecasting.

Yes, we were able to build a model to predict the number of patients referred in each month of next year from these facilities.

# Considerations When Doing Predictive Modeling

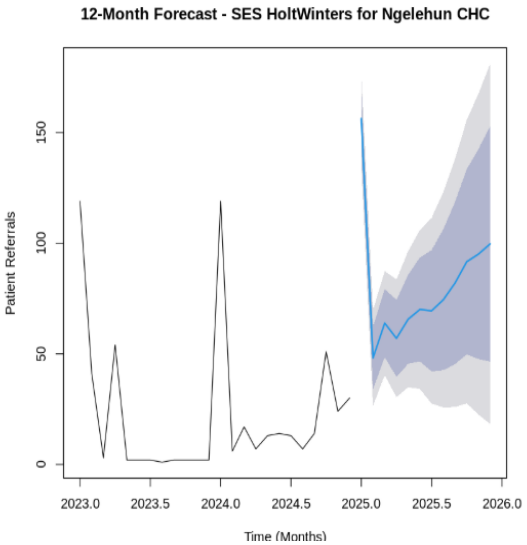
- **Data Quality:** Addressed missing data using a 3-period Simple Moving Average (SMA).
- **Feature Engineering:** Decomposed time series into trends, seasonality, and random components for better insights.
- **Model Selection:** Tested Auto ARIMA, ETS, and SES Holt-Winters; selected SES Holt-Winters for best performance
- **Model Evaluation:** Assessed using MAPE to ensure models captured seasonal variations effectively.
- **Seasonality & Trends:** SES Holt-Winters modeled seasonality and trends critical for accurate forecasting.
- **Uncertainty & Confidence:** Used 80% and 95% confidence intervals to quantify prediction variability and guide planning.

| | Point Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|---|---|---|---|---|---|
| Jan 2025 | 48.31128 | 42.62587 | 53.99668 | 39.61620 | 57.00636 |
| Feb 2025 | 48.39729 | 42.71188 | 54.08270 | 39.70221 | 57.09237 |
| Mar 2025 | 49.48330 | 43.79790 | 55.16871 | 40.78822 | 58.17838 |
| Apr 2025 | 89.15682 | 83.47141 | 94.84223 | 80.46174 | 97.85190 |
| May 2025 | 42.24283 | 36.55743 | 47.92824 | 33.54775 | 50.93791 |
| Jun 2025 | 71.74135 | 66.05594 | 77.42675 | 63.04627 | 80.43643 |
| Jul 2025 | 101.82736 | 96.14195 | 107.51277 | 93.13228 | 110.52244 |
| Aug 2025 | 64.91337 | 59.22797 | 70.59878 | 56.21829 | 73.60845 |
| Sep 2025 | 89.49939 | 83.81398 | 95.18480 | 80.80431 | 98.19447 |
| Oct 2025 | 58.68540 | 53.00000 | 64.37081 | 49.99032 | 67.38048 |
| Nov 2025 | 66.07142 | 60.38601 | 71.75682 | 57.37634 | 74.76650 |
| Dec 2025 | 53.25743 | 47.57202 | 58.94284 | 44.56235 | 61.95251 |




**Jembe CHC - 12-Month Referral Forecast for 2025**

| | Point Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|---|---|---|---|---|---|
| Jan 2025 | 156.35199 | 142.81715 | 169.88682 | 135.65224 | 177.05173 |
| Feb 2025 | 48.13766 | 34.01145 | 62.26386 | 26.53349 | 69.74182 |
| Mar 2025 | 63.88940 | 48.51556 | 79.26324 | 40.37714 | 87.40166 |
| Apr 2025 | 56.99471 | 39.62270 | 74.36672 | 30.42652 | 83.56291 |
| May 2025 | 65.65802 | 45.55768 | 85.75837 | 34.91720 | 96.39884 |
| Jun 2025 | 70.03680 | 46.55819 | 93.51541 | 34.12937 | 105.94423 |
| Jul 2025 | 69.45270 | 42.03684 | 96.86857 | 27.52376 | 111.38165 |
| Aug 2025 | 74.45029 | 42.61703 | 106.28355 | 25.76552 | 123.13506 |
| Sep 2025 | 82.02100 | 45.35215 | 118.68984 | 25.94084 | 138.10116 |
| Oct 2025 | 91.64521 | 49.76977 | 133.52065 | 27.60226 | 155.68817 |
| Nov 2025 | 95.09700 | 47.67992 | 142.51408 | 22.57883 | 167.61517 |
| Dec 2025 | 99.72458 | 46.45859 | 152.99056 | 18.26129 | 181.18786 |




**Ngelehun CHC - 12-Month Referral Forecast for 2025**

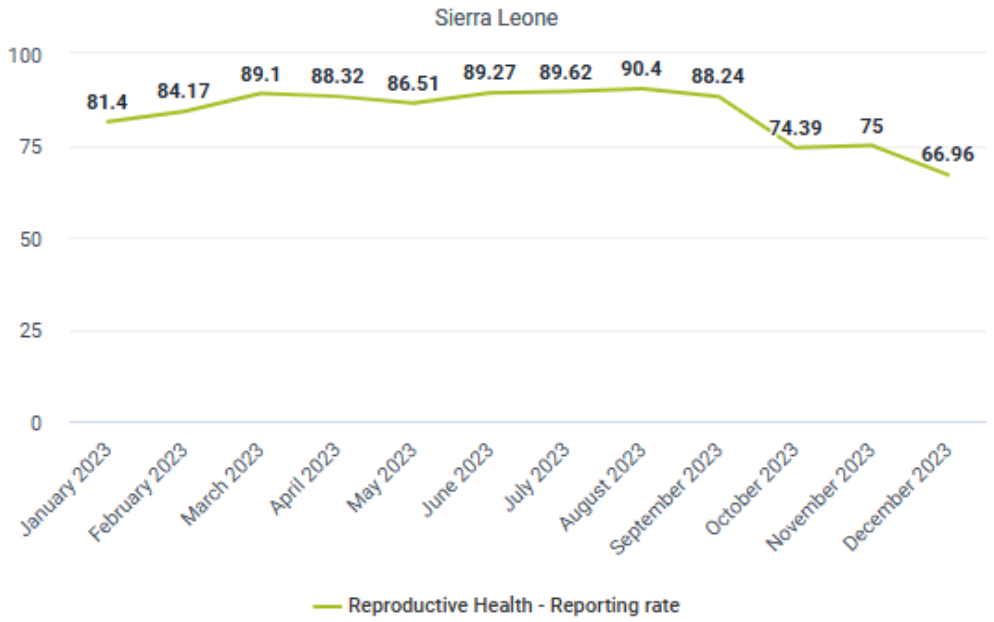
# Question 10 Dashboard

Create a new dashboard of the visualization, table, report that you have created for answering all the questions in this project.

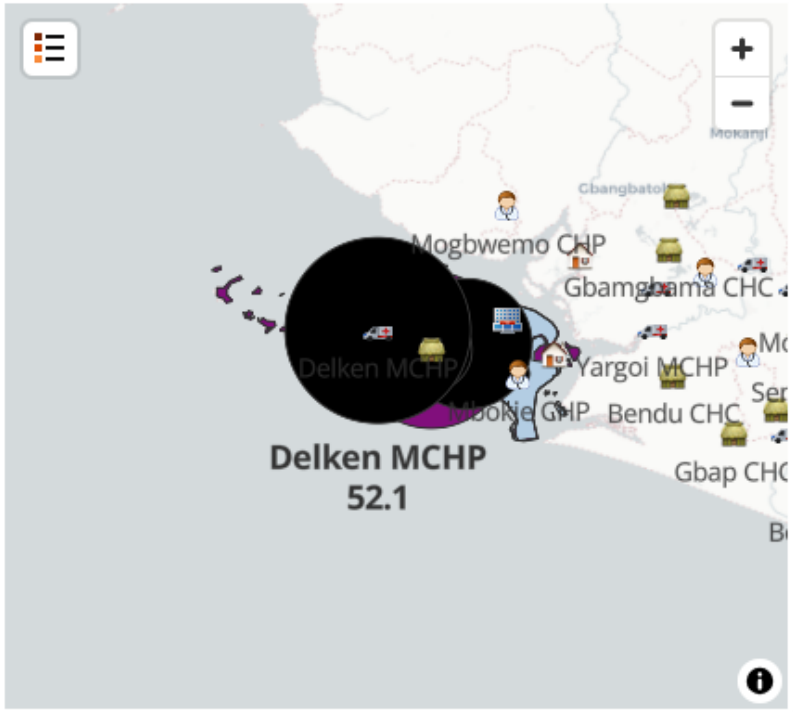
**Section-1: Exploring Reproductive Health Trends**
Here, we analyze reproductive health reporting rates across Sierra Leone in 2023, highlighting seasonal trends, challenges, and their impact on maternal health data.
https://colab.research.google.com/drive/1TQAAB6_d7NM5eCdNsv7Eo6TKjyBOvjJk?usp=sharing

**Section-2: Antenatal Care and Maternal Health**
Through a choropleth map and bar-line chart, we observe higher ANC 3 Coverage but comparatively lower PHU delivery rates on Sherbro Island, highlighting gaps in translating antenatal care into facility-based deliveries and the need for targeted interventions.

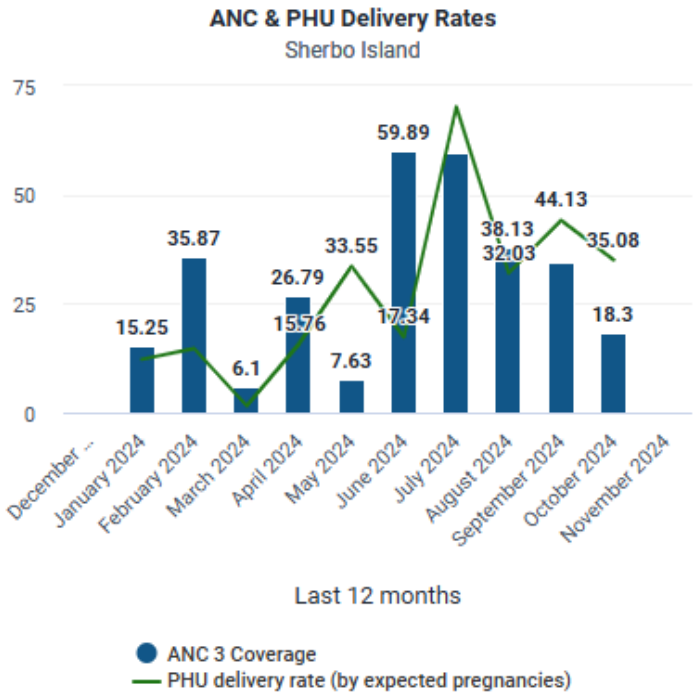
## Reproductive Health Reporting Rate 2023




## ANC3 & PHU Delivery Rates (Chloropleth)




## ANC-3 & PHU Delivery Rates on Sherbo Island (last 12 months)



**Section-3: Connecting Maternal and Infant Health**

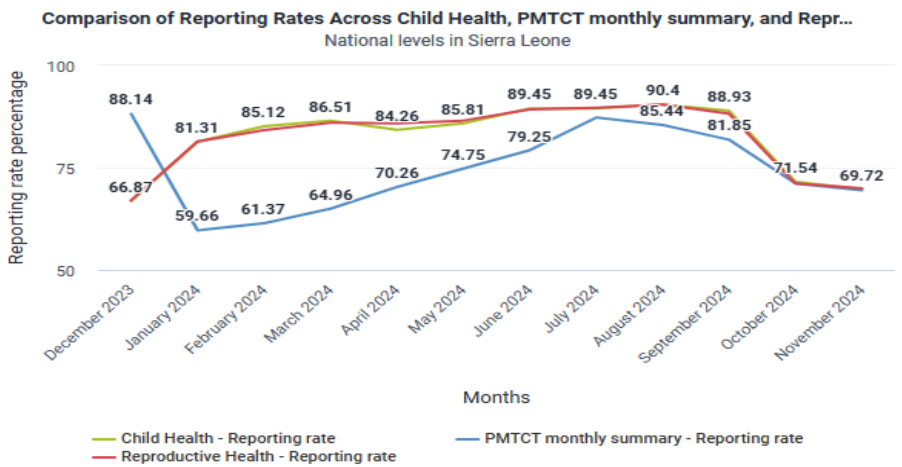
Here in this line graph comparing comparing reporting rates for Reproductive Health, Child Health, and PMTCT monthly summaries. This analysis bridges maternal health insights with PMTCT efforts, emphasizing the role of maternal care in preventing mother-to-child HIV transmission and safeguarding infant health.

**Section-4: Vaccination Coverage (Focus on Infants <1 Year Old)**

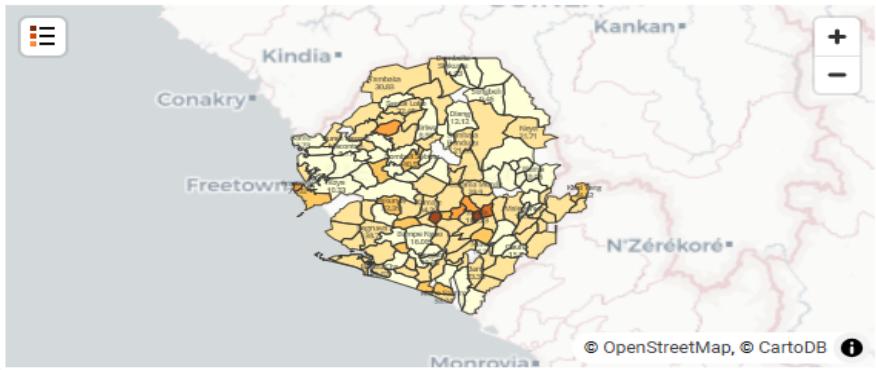
As part of our exploration of child health, this visualization highlights OPV1 vaccination coverage across Sierra Leone's chiefdoms for infants under 1 year, showcasing regions with high immunization rates over the past 12 months and identifying areas that may require targeted support.

As we delve deeper into child health, this visualization compares OPV1 coverage for infants under 1 year across facilities in Sherbro Island and its surrounding coastal region, highlighting significant disparities in immunization rates between facility types.

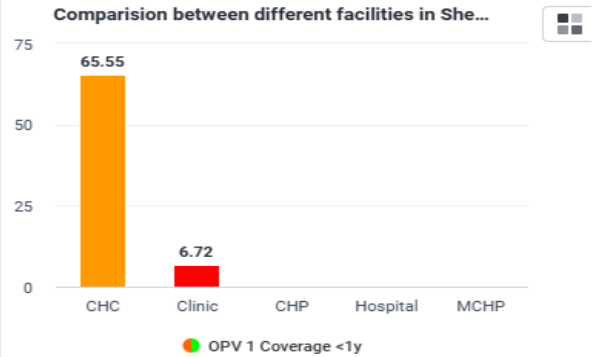
## Reporting Rates Comparison (Last 12 Months)



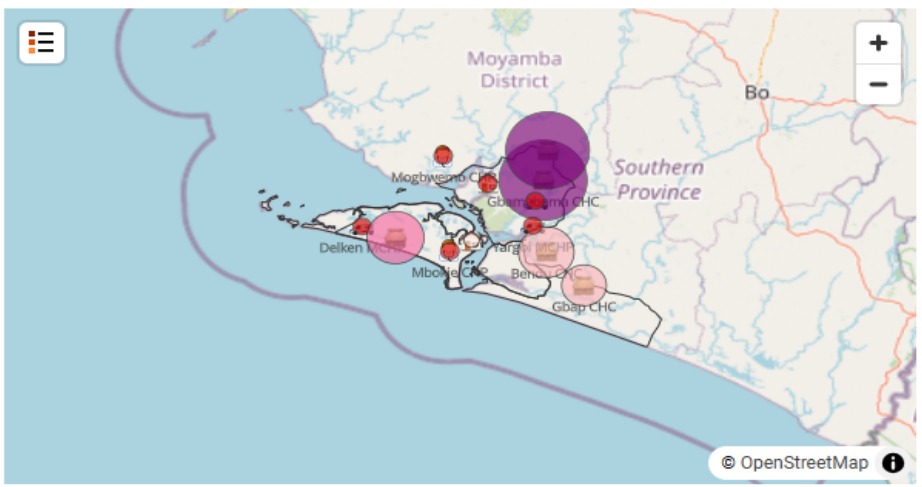

## OPV1 coverage(<1y) in Sierra Leone over the past 12 months




## Comparison between various facility types in Sherbro island for OPV1(<1yr) coverage

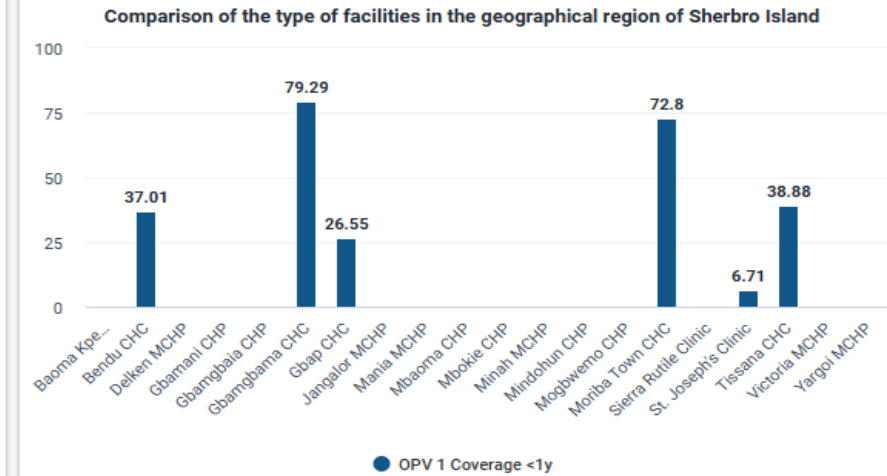



## Comparison of the type of facilities in the geographical region of Sherbro Island for OPV1 coverage <1yr




As we delve into infant health and vaccination, we focus on Sherbro Island, an isolated region, comparing facility-level OPV1 coverage. Using a choropleth map and bar chart, we identify the types of facilities with the highest and lowest vaccination rates for infants under 1 year. Notably, the facility with the lowest coverage is near the mainland, which works out as families may still access healthcare services more easily on the mainland, highlighting the interplay between geography and service utilization in this unique area.

## Comparison of different facilities in Sherbro island area for OPV1 coverage



**Section-5: Childhood Illnesses and Interventions**

As we shift to childhood illnesses, this analysis focuses on the 'Diarrhea <5y Incidence Rate' indicator, which consists of three components: diarrhea cases with blood (dysentery), severe dehydration follow-ups, and the total population under 5 years. A pivot table provides district-level insights, showcasing how these components constitute the indicator over the past year.

Through a detailed pivot table and bar chart analysis, we identified the Western Area as having the highest average rate of diarrhea cases under 5 years. Using this insight, we forecasted the minimum ORS stock required to meet treatment needs effectively.
https://colab.research.google.com/drive/1uJU6T-kG4uvTIa2_JSfj83I0s9Pzxug1?usp=sharing
Minimum ORS stock required for Freetown for the next year (5 days per case): 36730
Minimum ORS stock required for Rural Western Area for the next year (5 days per case): 26730
Total minimum ORS stock required for the district for the next year (5 days per case): 63460

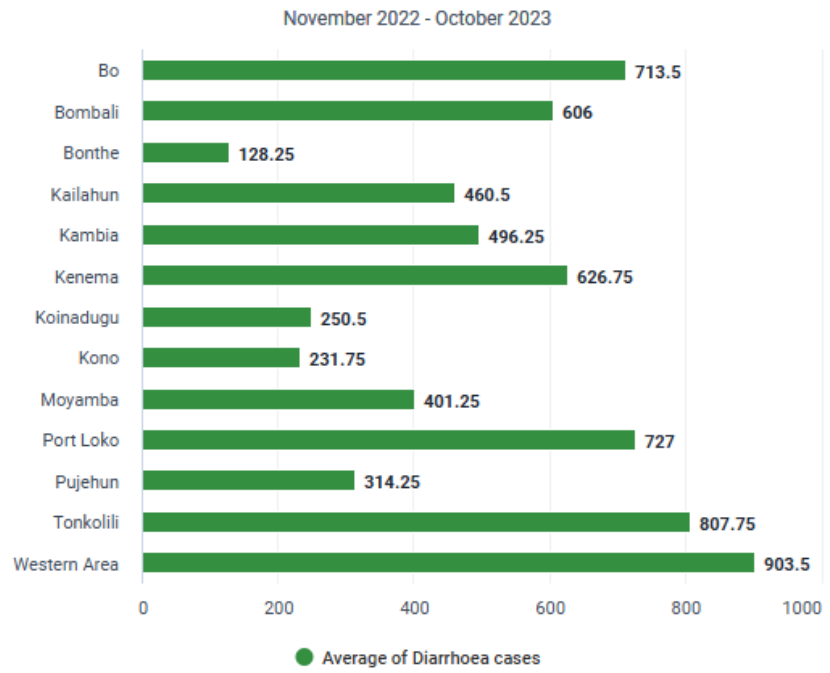
### Incidence of diarrhea over the past 12 Months

| Incidence of Diarrhea and its components in Seirra Leone | | | | |
|---|---|---|---|---|
| December 2023, January 2024, February 2024, March 2024, April 2024, May 2024, June 2024, July 2024, August ... | | | | |
| | Diarrhoea <5 y incidence rate (%) | Diarrhoea with blood (Dysentery) new | Diarrhoea with severe dehydration follow-up | Total population < 5 years |
| Bo | 5.21 | 3 899 | 600 | 86 101.66 |
| Bombali | 3.95 | 2 662 | 345 | 76 006.53 |
| Bonthe | 1.82 | 234 | 265 | 27 317.37 |
| Kailahun | 4.63 | 2 875 | 288 | 68 105.92 |
| Kambia | 4.75 | 1 942 | 490 | 51 079.19 |
| Kenema | 4.37 | 3 687 | 458 | 94 594.28 |
| Koinadugu | 4.02 | 1 753 | 252 | 49 753.18 |
| Kono | 2.26 | 1 203 | 255 | 64 322.87 |
| Moyamba | 3.06 | 1 435 | 104 | 50 091.18 |
| Port Loko | 3.01 | 1 962 | 683 | 87 638.69 |
| Pujehun | 3.09 | 1 151 | 217 | 44 164.6 |
| Tonkolili | 6.56 | 3 683 | 670 | 66 214.4 |
| Western Area | 3.22 | 3 668 | 1 093 | 147 438 |

### Average Rate of Diarrhea Cases in Children Under 5 by District

| November 2022 - October 2023 | | | | | |
|---|---|---|---|---|---|
| | Diarrhoea with blood (Dysentery) new 0-11m | Diarrhoea with blood (Dysentery) new 12-59m | Diarrhoea with severe dehydration new 0-11m | Diarrhoea with severe dehydration new 12-59m | Ave of Diar ca |
| Bo | 583 | 1 018 | 497 | 756 | |
| Bombali | 617 | 892 | 365 | 550 | |
| Bonthe | 52 | 77 | 189 | 195 | |
| Kailahun | 463 | 782 | 265 | 332 | |
| Kambia | 373 | 695 | 376 | 541 | |
| Kenema | 595 | 914 | 461 | 537 | |
| Koinadugu | 119 | 464 | 126 | 293 | |
| Kono | 201 | 408 | 147 | 171 | |
| Moyamba | 331 | 565 | 299 | 410 | |
| Port Loko | 231 | 725 | 709 | 1 243 | |
| Pujehun | 217 | 377 | 272 | 391 | |
| Tonkolili | 599 | 1 223 | 520 | 889 | |
| Western Area | 727 | 996 | 910 | 981 | |

### Average rate of Diarrhea in <5 year olds

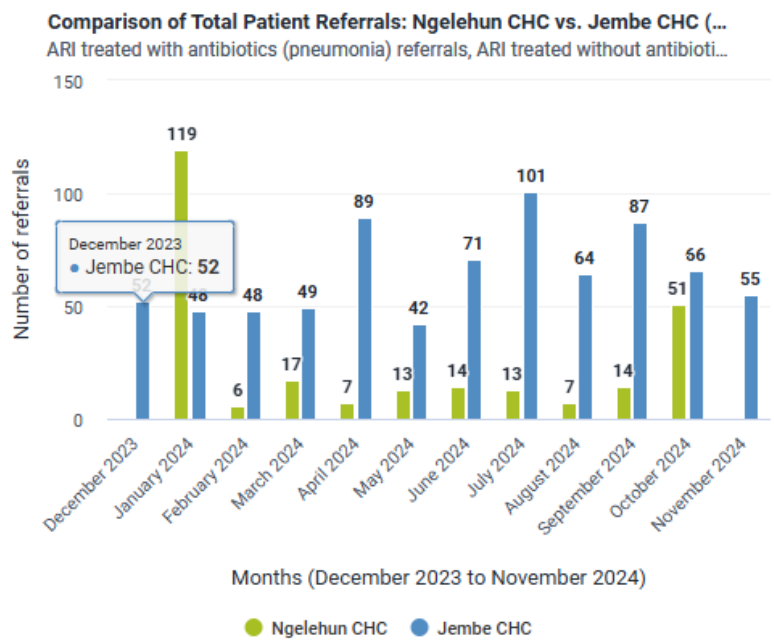


**Section-6: Referral Trends and Forecasting**
We began by creating a pivot table to summarize the referral trends and patient characteristics at Ngelehun CHC and Jembe CHC over 12 months. This was followed by side-by-side bar charts to compare the total referrals and delve into the causes behind these referrals, offering insights into disparities in patient care and resource allocation. Continuing our analysis, we began by using a bar chart to compare referral causes between Ngelehun CHC and Jembe CHC, identifying disparities in service needs. Building on this, we utilized stacked bar charts to explore patient demographics and referral statuses, uncovering patterns that reflect differences in healthcare access and outcomes across the facilities

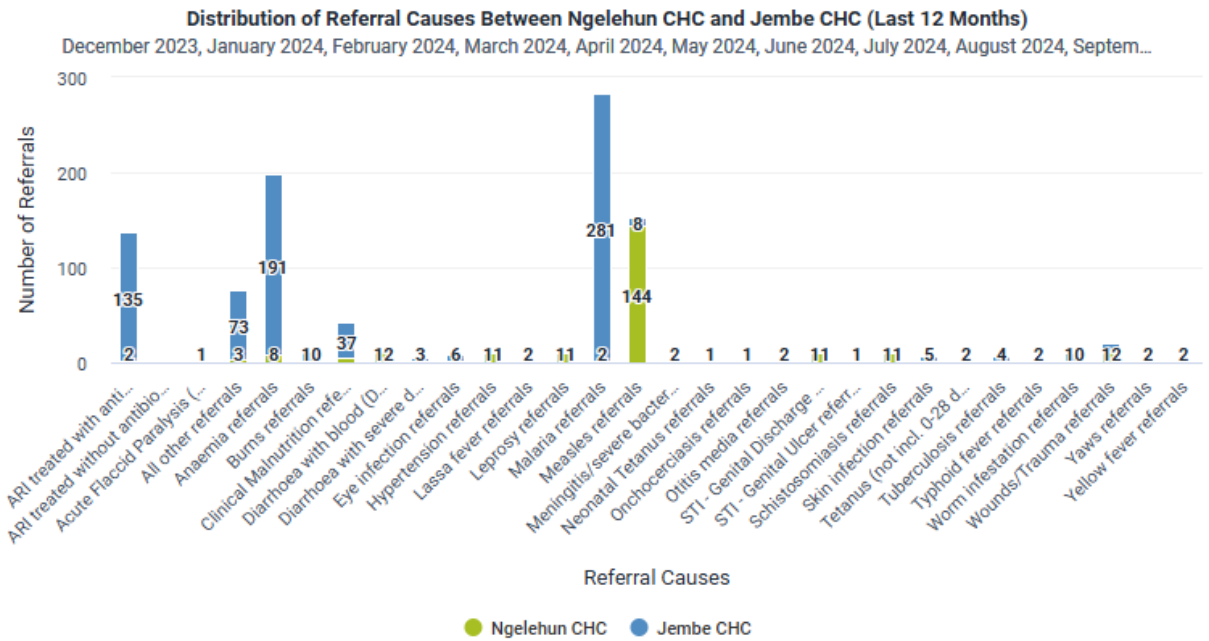
### Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Last 12 Months)

| Monthly Patient Referrals from Ngelehun CHC and Je... | | |
|---|---|---|
| ARI treated with antibiotics (pneumonia) referrals, ARI... | | |
| | Ngelehun CHC | Jembe CHC |
| December 2023 | | 52 |
| January 2024 | 119 | 48 |
| February 2024 | 6 | 48 |
| March 2024 | 17 | 49 |
| April 2024 | 7 | 89 |
| May 2024 | 13 | 42 |
| June 2024 | 14 | 71 |
| July 2024 | 13 | 101 |
| August 2024 | 7 | 64 |
| September 2024 | 14 | 87 |
| October 2024 | 51 | 66 |
| November 2024 | | 55 |
| Total | 261 | 772 |

### Comparison of Total Patient Referrals: Ngelehun CHC vs. Jembe CHC (Last 12 Months)



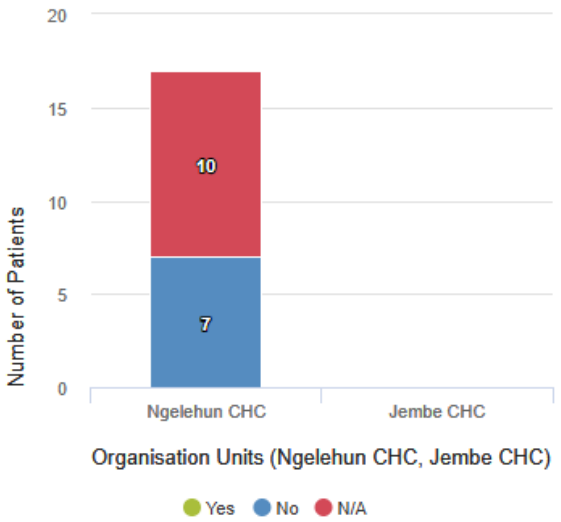

### Distribution of Referral Causes Between Ngelehun CHC and Jembe CHC (Last 12 Months)



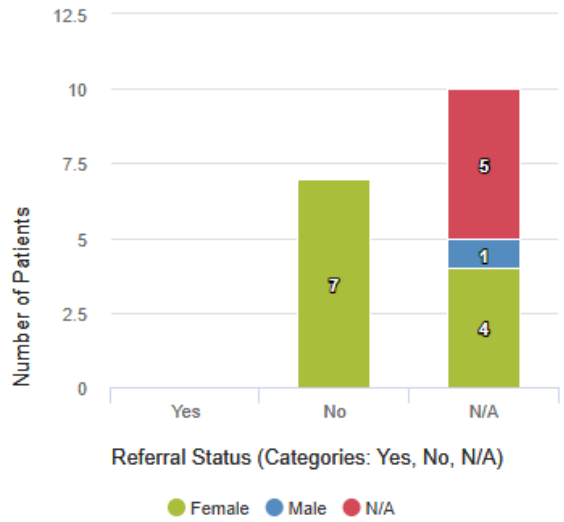
## Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Jan 2023 – Dec 2024)

| Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Jan 2023 – ... | | |
|---|---|---|
| ARI treated with antibiotics (pneumonia) referrals, ARI treated without antibi... | | |
| | Ngelehun CHC | Jembe CHC |
| January 2023 | 119 | 48 |
| February 2023 | | 48 |
| March 2023 | 3 | 89 |
| April 2023 | | 49 |
| May 2023 | 2 | 42 |
| June 2023 | 2 | 71 |
| July 2023 | 2 | 101 |
| August 2023 | 1 | 64 |
| September 2023 | | 87 |
| October 2023 | | 55 |
| November 2023 | | 66 |
| December 2023 | | 52 |
| January 2024 | 119 | 48 |
| February 2024 | 6 | 48 |
| March 2024 | 17 | 49 |
| April 2024 | 7 | 89 |
| May 2024 | 13 | 42 |
| June 2024 | 14 | 71 |
| July 2024 | 13 | 101 |
| August 2024 | 7 | 64 |
| September 2024 | 14 | 87 |
| October 2024 | 51 | 66 |
| November 2024 | | 55 |
| December 2024 | | 52 |

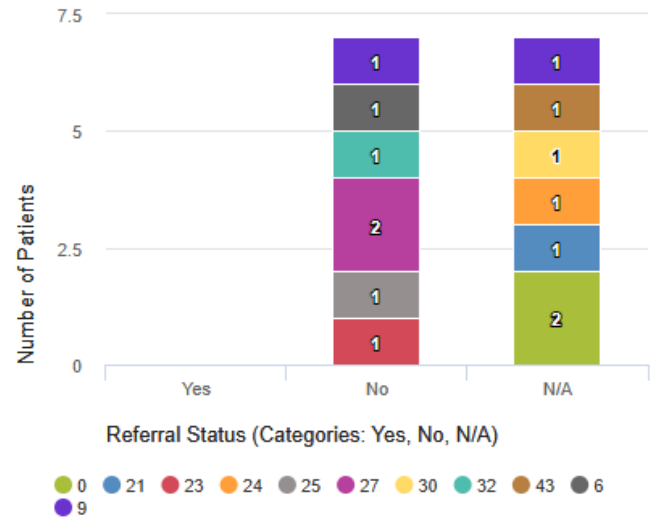
## Group5_1a_3rd_part_visualization_1




## Group5_1a_3rd_part_visualization_2




## Group5_1a_3rd_part_visualization_3




Building on our exploration of referrals, we expanded our analysis to forecast referral patterns using SES Holt-Winters predictive model. These forecasts, derived from referral data across Ngelehun and Jembe CHCs, provide actionable insights to enhance resource planning and service delivery. By predicting patient referral trends for the next 12 months, we enable health administrators to address critical gaps in maternal and child healthcare, ensuring timely interventions and resource allocation. This effort not only reinforces proactive healthcare delivery in the region but also sets a precedent for leveraging data to optimize maternal and child health outcomes on a broader scale.
https://colab.research.google.com/drive/1-XC5MgoX47xNJPCBoLO5BA72AkM3aal_?usp=sharing

## Resources

- group5 - question2 - Analysis of Reporting Rates in Reproductive Health Across Sierra Leone Districts: Trends and Time Series Components for 2023
- Forecasting Diarrhea cases under 5 yrs using Autoarima
- group5 - Question1b - decomposition of Jembe CHC and Ngelehun CHC time series.
- group5 - question1b - 12-Month Referral Forecast for Jembe CHC and Ngelehun CHC (2025)

**Topic and Sentiment Analysis:** https://colab.research.google.com/drive/1dUQ_duDEKGLUcw8OOjxdSiFBscog6ogU?usp=sharing

**Topic Analysis for question 2:**
http://jtay.me/question_2_topics_9.html

**Topic Analysis for question 8:**
http://jtay.me/question_8_topics.html

# Policy Decisions from Dashboard

The dashboard provides clear insights to guide health policy decisions. For maternal health, the gap between high ANC-3 coverage and low facility-based delivery rates on Sherbro Island shows a need for policies that promote safe deliveries through better access to services, such as transportation, or to community outreach programs. In child health, disparities in OPVI vaccination rates highlight areas that need targeted immunization campaigns. Referral trends from Ngelehun and Jembe CHCs help allocate resources like staff and supplies more effectively, while forecasting ensures readiness for high-demand periods. Data on diarrhea cases emphasizes the importance of distributing ORS supplies and improving hygiene education. The dashboard provides policymakers with consolidated information to guide them in making healthcare decisions.

# APPENDIX

# QUESTION 1a

## Comparison of Patient Referrals from Ngelehun CHC and Jembe CHC (Last 12 Months)

Data Visualizer

### Data Collection Steps:

- Selected **Ngelehun CHC** and **Jembe CHC** as the **Organization units**.
- Analyzed data for the **last 12 months**.
- Chose **"referrals"** as the data element group and visualized it.

### Visualization Tools:

- **Pivot Table** format for monthly breakdown.
- **Column chart** for total referrals comparison.

### Limitation:

- Missing data observed for some months at **Ngelehun CHC**, impacting direct comparisons.

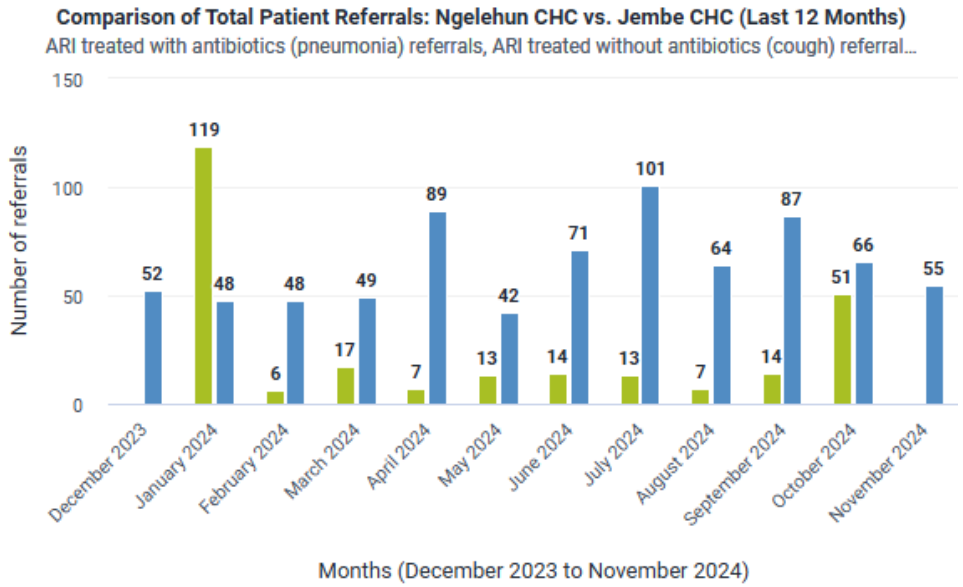
### Interpretation:

- Over the last 12 months, **Jembe CHC had 772 referrals**, significantly more than **Ngelehun CHC's 261 referrals.**

**Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Last 12 Months)**

**ARI treated with antibiotics (pneumonia) referrals, ARI treated without antibiotics (cough) referrals, Acute Flaccid Paralysis (AFP) referrals, All other referrals, Anaemia referrals, Burns referrals, Clinical Malnutrition referrals, Diarrhoea with blood (Dysentery) referrals, Diarrhoea with severe dehydration referrals, Eye infection referrals, Hypertension referrals, Lassa fever referrals, Leprosy referrals, Malaria referrals, Measles referrals, Meningitis/severe bacterial infection referrals, Neonatal Tetanus referrals, Onchocerciasis referrals, Otitis media referrals, STI - Genital Discharge referrals, STI - Genital Ulcer referrals, Schistosomiasis referrals, Skin infection referrals, Tetanus (not incl. 0-28 days) referrals, Tuberculosis referrals, Typhoid fever referrals, Worm infestation referrals, Wounds/Trauma referrals, Yaws referrals, Yellow fever referrals**

| | Ngelehun CHC | Jembe CHC |
|---|---|---|
| December 2023 | | 52 |
| January 2024 | 119 | 48 |
| February 2024 | 6 | 48 |
| March 2024 | 17 | 49 |
| April 2024 | 7 | 89 |
| May 2024 | 13 | 42 |
| June 2024 | 14 | 71 |
| July 2024 | 13 | 101 |
| August 2024 | 7 | 64 |
| September 2024 | 14 | 87 |
| October 2024 | 51 | 66 |
| November 2024 | | 55 |
| Total | 261 | 772 |



Data Visualizer

# Comparison of Cause of Referrals at Ngelehun CHC and Jembe CHC (Last 12 Months)

## Data Collection Steps:

- Selected **Ngelehun CHC** and **Jembe CHC** as the organization units.
- Chose **"referrals"** as the data element group for the last 12 months.

## Visualization Tools:

- The **pivot table of causes of referrals** for detailed reference.
- The **stacked bar chart** to highlight the significant differences visually.

## Key Findings:

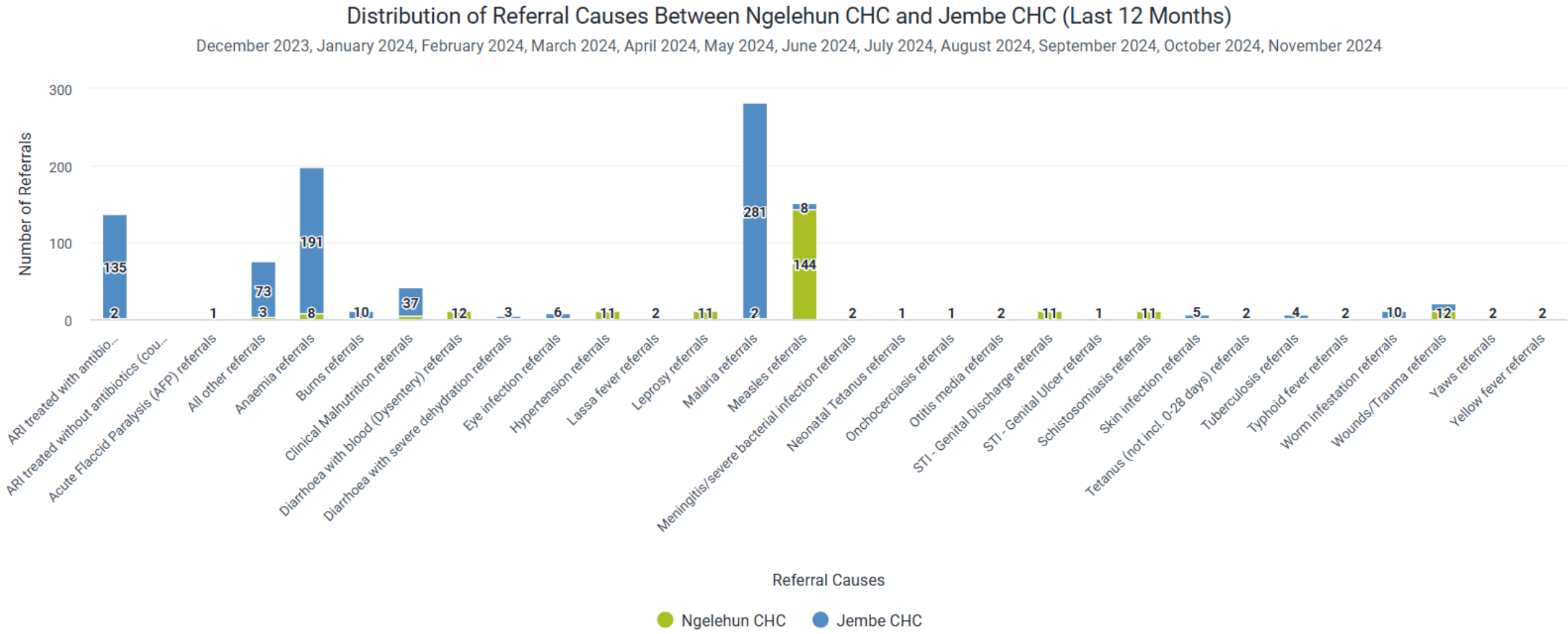
### Jembe CHC:

- High referrals for **malaria (281 cases)**, **anaemia (191 cases)**, and **pneumonia (135 cases)**.
- Referrals for diverse conditions like clinical malnutrition and acute flaccid paralysis suggest a broader healthcare burden.

### Ngelehun CHC:

- Higher referrals for **measles (144 cases)** and **dysentery (12 cases)**.
- Indicates possible outbreaks or a specific disease burden in the catchment area.

| Comparison of Referral Causes at Ngelehun CHC and Jembe CHC (Last 12 Months) | | |
|---|---|---|
| December 2023, January 2024, February 2024, March 2024, April 2024, May 2024, June 2024, July 2024, August 2024, September 2024, October 2024, November 2024 | | |
| | Ngelehun CHC | Jembe CHC |
| ARI treated with antibiotics (pneumonia) referrals | 2 | 135 |
| ARI treated without antibiotics (cough) referrals | | |
| Acute Flaccid Paralysis (AFP) referrals | 1 | |
| All other referrals | 3 | 73 |
| Anaemia referrals | 8 | 191 |
| Burns referrals | 2 | 10 |
| Clinical Malnutrition referrals | 5 | 37 |
| Diarrhoea with blood (Dysentery) referrals | 12 | |
| Diarrhoea with severe dehydration referrals | 2 | 3 |
| Eye infection referrals | 2 | 6 |
| Hypertension referrals | 11 | |
| Lassa fever referrals | 2 | |
| Leprosy referrals | 11 | |
| Malaria referrals | 2 | 281 |
| Measles referrals | 144 | 8 |
| Meningitis/severe bacterial infection referrals | 2 | |
| Neonatal Tetanus referrals | 1 | |
| Onchocerciasis referrals | 1 | |
| Otitis media referrals | 2 | |
| STI - Genital Discharge referrals | 11 | |
| STI - Genital Ulcer referrals | 1 | |
| Schistosomiasis referrals | 11 | |
| Skin infection referrals | 2 | 5 |
| Tetanus (not incl. 0-28 days) referrals | 2 | |
| Tuberculosis referrals | 2 | 4 |
| Typhoid fever referrals | 2 | |
| Worm infestation referrals | 1 | 10 |
| Wounds/Trauma referrals | 12 | 9 |
| Yaws referrals | 2 | |
| Yellow fever referrals | 2 | |
| Total | 261 | 772 |




**Implications:**

- The disparity in causes of referral reflects:
- Differences in **disease prevalence** between the regions.
- Variations in **healthcare resources and service availability**.
- **Jembe CHC** appears to handle a wider array of severe cases requiring specialized care.

# Patient Characteristics and Referral Patterns at Ngelehun CHC and Jembe CHC (Last 12 Months)

Event Reports

## Data Collection Steps:

- Selected **Ngelehun CHC** and **Jembe CHC** as organization units.
- Analyzed data from the **Malaria Case Diagnosis, Treatment, and Investigation program**.
- Included key data elements: **Referral status**, **Age (years)** and **Sex**

## Insights from Ngelehun CHC Data:

### Referral Patterns:

- Majority of patients were **not referred** ("No").
- A large portion of entries were marked as **"N/A"** for referral status, reflecting incomplete data.

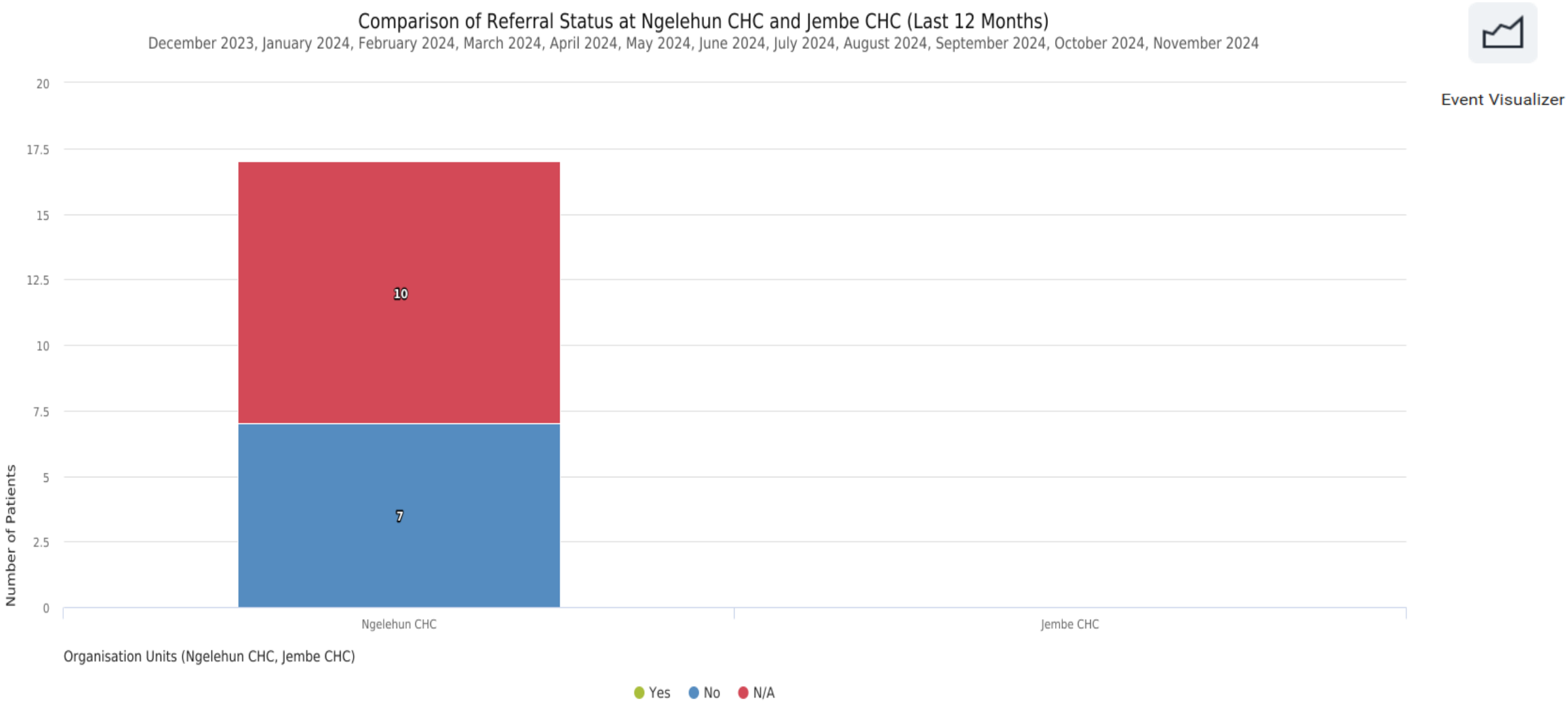
### Patient Characteristics:

- **Age Distribution:** Ages ranged from **infants (0 years)** to **43 years**. Notable number of **pediatric cases**.
- **Gender Distribution:** Majority of patients were **female**, though some entries lacked gender information ("N/A").

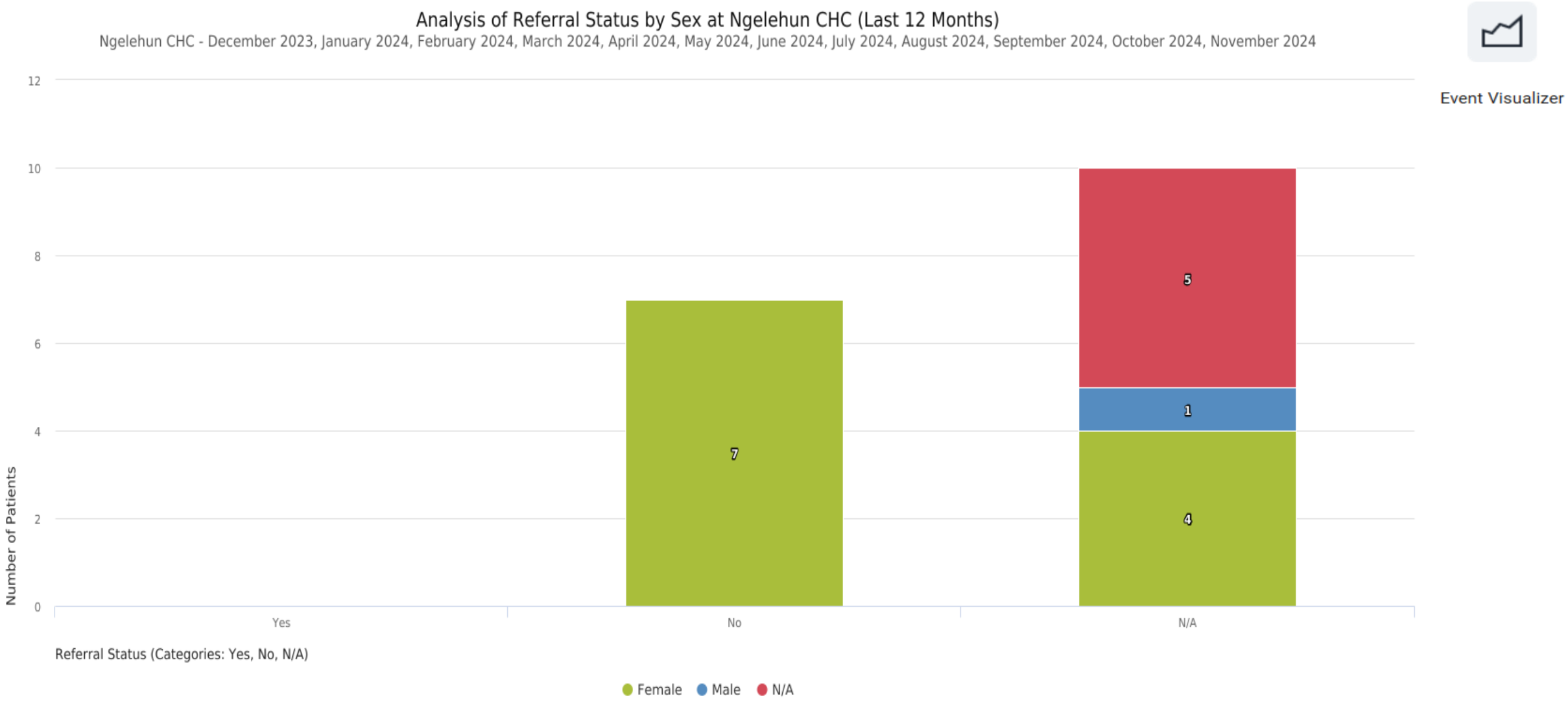
## Limitations:

- **Incomplete documentation** in Ngelehun CHC data, particularly in referral status and gender information.
- Lack of data for **Jembe CHC** restricts the ability to conduct a full comparative analysis.

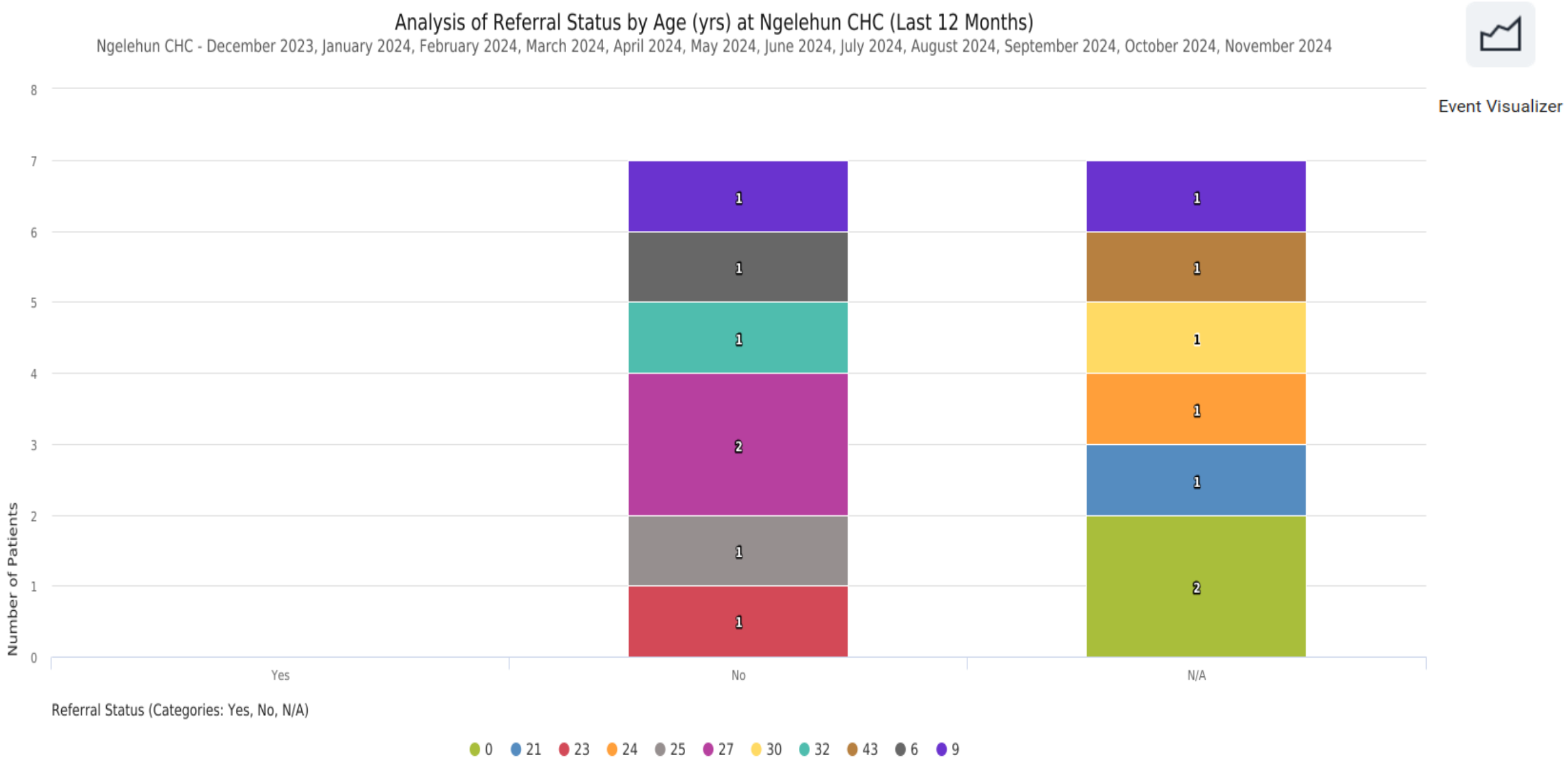
| # | Date of diagnosis | Enrollment date | Incident Date | Organisation unit | Age (years) | Sex | Referred |
|---|---|---|---|---|---|---|---|
| 1 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:45:18.845 | Ngelehun CHC | 9 | Female | No |
| 2 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:45:18.646 | Ngelehun CHC | 6 | Female | No |
| 3 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:58:57.416 | Ngelehun CHC | 9 | Female | N/A |
| 4 | 2024-03-08 00:00:00.0 | 2024-03-08 00:00:00.0 | 2024-03-09 09:59:24.142 | Ngelehun CHC | 32 | Female | No |
| 5 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:34:11.27 | Ngelehun CHC | 30 | Female | N/A |
| 6 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:59:04.167 | Ngelehun CHC | 23 | Female | No |
| 7 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:37:44.116 | Ngelehun CHC | 24 | Female | N/A |
| 8 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 20:44:26.234 | Ngelehun CHC | 27 | Female | No |
| 9 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:22:47.131 | Ngelehun CHC | 25 | Female | No |
| 10 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:28:40.461 | Ngelehun CHC | 27 | Female | No |
| 11 | 2024-02-04 00:00:00.0 | 2024-02-04 00:00:00.0 | 2024-02-04 16:57:53.897 | Ngelehun CHC | 21 | N/A | N/A |
| 12 | 2024-02-04 00:00:00.0 | 2024-02-04 00:00:00.0 | 2024-02-15 14:04:22.896 | Ngelehun CHC | 43 | Female | N/A |
| 13 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 10:23:00.355 | Ngelehun CHC | 0 | N/A | N/A |
| 14 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 08:40:09.971 | Ngelehun CHC | | N/A | N/A |
| 15 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | Ngelehun CHC | | N/A | N/A |
| 16 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 10:23:00.557 | Ngelehun CHC | 0 | Male | N/A |
| 17 | 2024-01-10 00:00:00.0 | 2024-01-10 00:00:00.0 | 2024-01-10 00:00:00.0 | Ngelehun CHC | | N/A | N/A |




**Interpretation:** The stacked column chart shows that the **majority** of patient records from **Ngelehun CHC** had **missing referral status** marked as **"N/A"** (10 cases), followed by **"No" referrals** (7 cases). **No "Yes" referrals** were recorded for this period. Data from **Jembe CHC** is **absent**, preventing **comparative analysis**.




**Interpretation:** At **Ngelehun CHC**, most patients who were **not referred** are **female** (7 cases). Among patients with **missing referral status ("N/A")**, there is a mix of **female (4 cases)**, **male (1 case)**, and **unspecified sex (5 cases)**. No patients of any sex were recorded as **referred ("Yes")** during this period.




**Interpretation:** At **Ngelehun CHC**, most **age groups** have missing referral status marked as **"N/A"**. Among the **"No" referrals**, patients are distributed across a range of **ages**, but no **referrals ("Yes")** are observed.

# Patient Characteristics and Referral Patterns at Ngelehun CHC and Jembe CHC (Nov 2023 – Nov 2024)

- The data from **Ngelehun CHC** indicates that most patients were **not referred**, with several entries marked as **"N/A"**, highlighting **incomplete documentation**.
- Patients ranged from **infants to 43 years**, with a focus on **pediatric cases**, and the majority were **female**, though some gender data was missing.
- Notably, **one male infant (age 0)** was explicitly **referred**, likely for specialized care.
- The absence of data for **Jembe CHC** limits the ability to compare **referral patterns** and **patient characteristics** between the two facilities.

Event Reports

| # | Date of diagnosis | Enrollment date | Incident Date | Organisation unit | Age (years) | Sex | Referred |
|---|---|---|---|---|---|---|---|
| 1 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:45:18.646 | Ngelehun CHC | 6 | Female | No |
| 2 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:45:18.845 | Ngelehun CHC | 9 | Female | No |
| 3 | 2024-03-10 00:00:00.0 | 2024-03-10 00:00:00.0 | 2024-03-10 15:58:57.416 | Ngelehun CHC | 9 | Female | N/A |
| 4 | 2024-03-08 00:00:00.0 | 2024-03-08 00:00:00.0 | 2024-03-09 09:59:24.142 | Ngelehun CHC | 32 | Female | No |
| 5 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:22:47.131 | Ngelehun CHC | 25 | Female | No |
| 6 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 20:44:26.234 | Ngelehun CHC | 27 | Female | No |
| 7 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:28:40.461 | Ngelehun CHC | 27 | Female | No |
| 8 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:34:11.27 | Ngelehun CHC | 30 | Female | N/A |
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| 10 | 2024-03-07 00:00:00.0 | 2024-03-07 00:00:00.0 | 2024-03-07 21:59:04.167 | Ngelehun CHC | 23 | Female | No |
| 11 | 2024-02-04 00:00:00.0 | 2024-02-04 00:00:00.0 | 2024-02-15 14:04:22.896 | Ngelehun CHC | 43 | Female | N/A |
| 12 | 2024-02-04 00:00:00.0 | 2024-02-04 00:00:00.0 | 2024-02-04 16:57:53.897 | Ngelehun CHC | 21 | N/A | N/A |
| 13 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 10:23:00.557 | Ngelehun CHC | 0 | Male | N/A |
| 14 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 08:40:09.971 | Ngelehun CHC |  | N/A | N/A |
| 15 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | Ngelehun CHC |  | N/A | N/A |
| 16 | 2024-01-31 00:00:00.0 | 2024-01-31 00:00:00.0 | 2024-01-31 10:23:00.355 | Ngelehun CHC | 0 | N/A | N/A |
| 17 | 2024-01-10 00:00:00.0 | 2024-01-10 00:00:00.0 | 2024-01-10 00:00:00.0 | Ngelehun CHC |  | N/A | N/A |
| 18 | 2023-11-27 00:00:00.0 | 2023-11-27 00:00:00.0 | 2023-11-27 00:00:00.0 | Ngelehun CHC | 0 | Male | Yes |
| 19 | 2023-11-13 00:00:00.0 | 2023-11-13 00:00:00.0 | 2023-11-13 00:00:00.0 | Ngelehun CHC | 29 | Female | N/A |
| 20 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | Ngelehun CHC | 15 | Female | N/A |
| 21 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | Ngelehun CHC | 33 | Female | N/A |
| 22 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | 2023-11-12 00:00:00.0 | Ngelehun CHC | 29 | Female | N/A |
| 23 | 2023-11-05 00:00:00.0 | 2023-11-05 00:00:00.0 | 2023-11-05 09:55:00.437 | Ngelehun CHC | 0 | N/A | N/A |

# QUESTION 1b

# 12-Month Referral Forecast for Jembe CHC and Ngelehun CHC (2025)

Data Visualizer

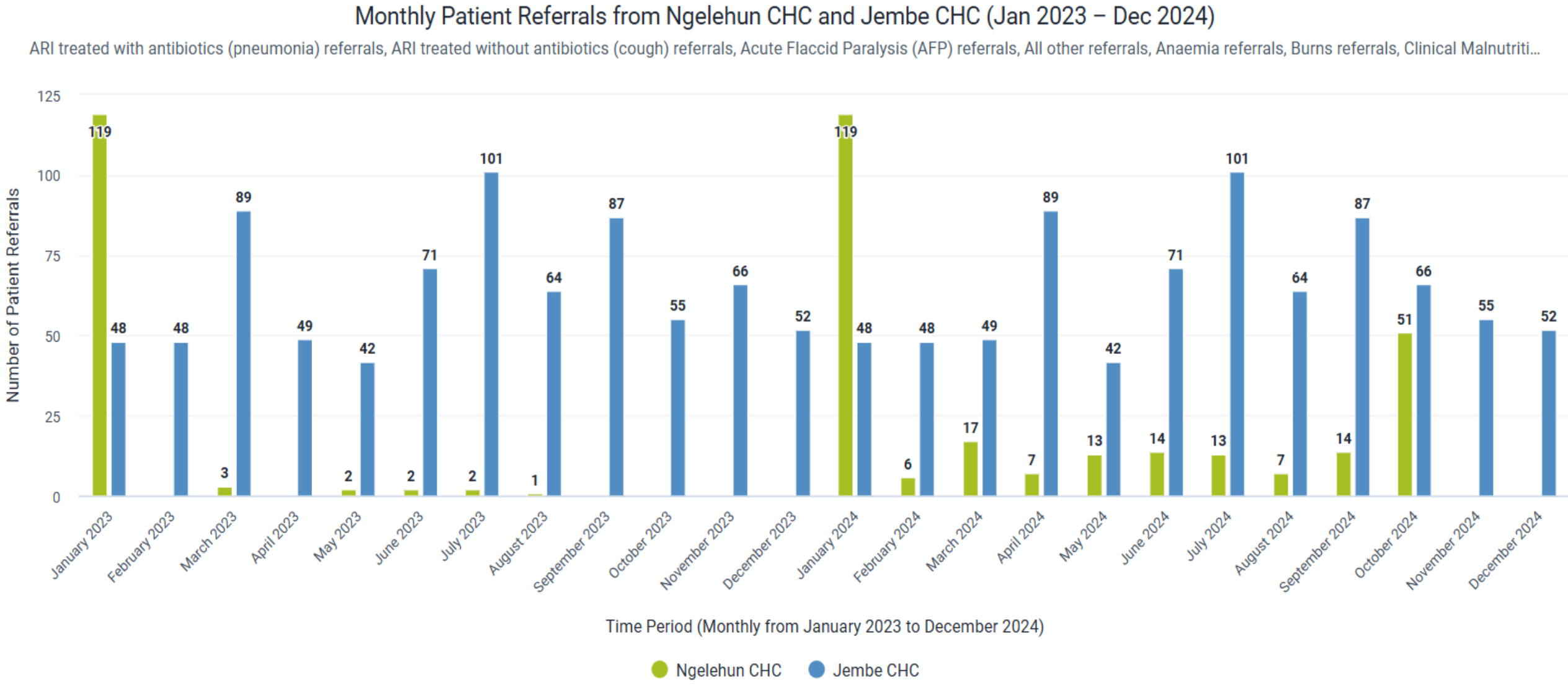
Data Preparation and Modeling Steps:

1. Data Collection:
   Extracted monthly referral data for Jembe CHC and Ngelehun CHC from DHIS2 (Jan 2023 – Dec 2024).
2. Data Preprocessing:
   Addressed missing values in Ngelehun CHC using a 3-period Simple Moving Average.
3. Time Series Conversion:
   Converted referral data into time series objects with monthly frequency.
4. Exploratory Analysis:
   Decomposed time series into trends, seasonal, and random components. Split data into training (Jan 2023–Jun 2024) and validation (Jul 2024–Dec 2024) sets.
5. Model Fitting and Forecasting:
   Tested multiple models: AUTO ARIMA, ETS, and SES Holt-Winters.
   Selected SES Holt-Winters as the best model based on Mean Absolute Percentage Error (MAPE).
6. 12-Month Forecast:
   Generated point forecasts and confidence intervals for 2025.

**Monthly Patient Referrals from Ngelehun CHC and Jembe CHC (Jan 2023 – Dec 2024)**

**ARI treated with antibiotics (pneumonia) referrals, ARI treated without antibiotics (cough) referrals, Acute Flaccid Paralysis (AFP) referrals, All other referrals, Anaemia referrals, Burns referrals, Clinical Malnutrition referrals, Diarrhoea with blood (Dysentery) referrals, Diarrhoea with severe dehydration referrals, Eye infection referrals, Hypertension referrals, Lassa fever referrals, Leprosy referrals, Malaria referrals, Measles referrals, Meningitis/severe bacterial infection referrals, Neonatal Tetanus referrals, Onchocerciasis referrals, Otitis media referrals, STI - Genital Discharge referrals, STI - Genital Ulcer referrals, Schistosomiasis referrals, Skin infection referrals, Tetanus (not incl. 0-28 days) referrals, Tuberculosis referrals, Typhoid fever referrals, Worm infestation referrals, Wounds/Trauma referrals, Yaws referrals, Yellow fever referrals**

| | Ngelehun CHC | Jembe CHC |
|---|---|---|
| January 2023 | 119 | 48 |
| February 2023 | | 48 |
| March 2023 | 3 | 89 |
| April 2023 | | 49 |
| May 2023 | 2 | 42 |
| June 2023 | 2 | 71 |
| July 2023 | 2 | 101 |
| August 2023 | 1 | 64 |
| September 2023 | | 87 |
| October 2023 | | 55 |
| November 2023 | | 66 |
| December 2023 | | 52 |
| January 2024 | 119 | 48 |
| February 2024 | 6 | 48 |
| March 2024 | 17 | 49 |
| April 2024 | 7 | 89 |
| May 2024 | 13 | 42 |
| June 2024 | 14 | 71 |
| July 2024 | 13 | 101 |
| August 2024 | 7 | 64 |
| September 2024 | 14 | 87 |
| October 2024 | 51 | 66 |
| November 2024 | | 55 |
| December 2024 | | 52 |




**Interpretation:** The chart shows that **Jembe CHC** consistently recorded higher monthly referrals compared to **Ngelehun CHC**, except for January 2023 and January 2024, where Ngelehun CHC had significant spikes. This indicates a stark difference in referral trends between the two facilities.

Data Visualizer

## Interpretation:

### Jembe CHC:

- The 12-month forecast for 2025 predicts **seasonal variations** in patient referrals.
- Referrals range from **48 in January to 53 in December**, with peaks in **April (89)** and **July (101)**.
- Seasonal patterns observed in historical data are effectively captured.

### Ngelehun CHC:

- Forecast predicts a **spike in January (156 referrals)**, tapering to **99 referrals by December**.
- Highlights seasonal fluctuations, with high-demand periods in **January and September**.
- Reflects trends observed in historical data, despite some variability.

## Uses of the Forecast Models:

- **Resource Planning:** Allocate staff, supplies, and budgets effectively for high-demand months like January and September (Ngelehun) and April and July (Jembe).
- **Seasonal Insights:** Identify recurring patterns in referral trends to prepare for seasonal peaks and manage variability.

**Jembe CHC - 12-Month Referral Forecast for 2025**

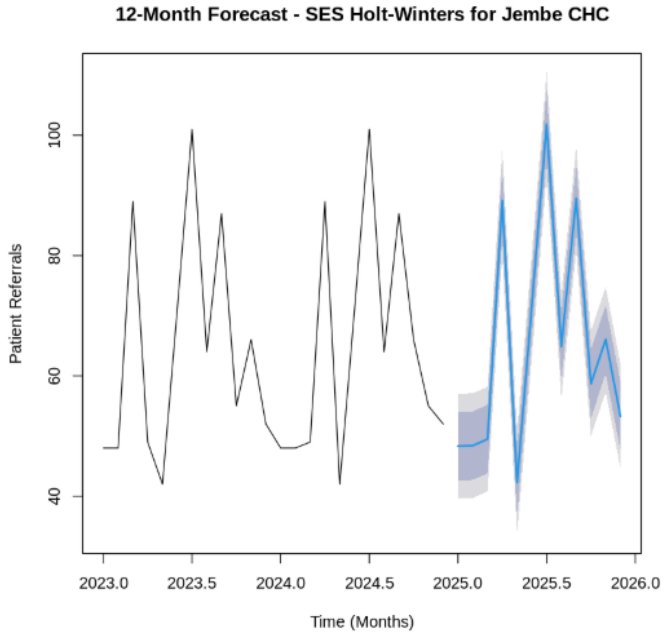
| | Point Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|---|---|---|---|---|---|
| Jan 2025 | 48.31128 | 42.62587 | 53.99668 | 39.61620 | 57.00636 |
| Feb 2025 | 48.39729 | 42.71188 | 54.08270 | 39.70221 | 57.09237 |
| Mar 2025 | 49.48330 | 43.79790 | 55.16871 | 40.78822 | 58.17838 |
| Apr 2025 | 89.15682 | 83.47141 | 94.84223 | 80.46174 | 97.85190 |
| May 2025 | 42.24283 | 36.55743 | 47.92824 | 33.54775 | 50.93791 |
| Jun 2025 | 71.74135 | 66.05594 | 77.42675 | 63.04627 | 80.43643 |
| Jul 2025 | 101.82736 | 96.14195 | 107.51277 | 93.13228 | 110.52244 |
| Aug 2025 | 64.91337 | 59.22797 | 70.59878 | 56.21829 | 73.60845 |
| Sep 2025 | 89.49939 | 83.81398 | 95.18480 | 80.80431 | 98.19447 |
| Oct 2025 | 58.68540 | 53.00000 | 64.37081 | 49.99032 | 67.38048 |
| Nov 2025 | 66.07142 | 60.38601 | 71.75682 | 57.37634 | 74.76650 |
| Dec 2025 | 53.25743 | 47.57202 | 58.94284 | 44.56235 | 61.95251 |

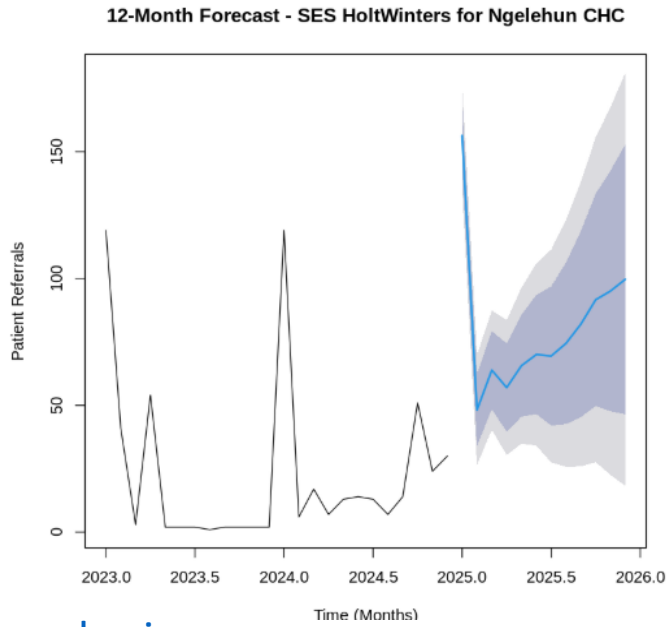
**Ngelehun CHC - 12-Month Referral Forecast for 2025**

| | Point Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|---|---|---|---|---|---|
| Jan 2025 | 156.35199 | 142.81715 | 169.88682 | 135.65224 | 177.05173 |
| Feb 2025 | 48.13766 | 34.01145 | 62.26386 | 26.53349 | 69.74182 |
| Mar 2025 | 63.88940 | 48.51556 | 79.26324 | 40.37714 | 87.40166 |
| Apr 2025 | 56.99471 | 39.62270 | 74.36672 | 30.42652 | 83.56291 |
| May 2025 | 65.65802 | 45.55768 | 85.75837 | 34.91720 | 96.39884 |
| Jun 2025 | 70.03680 | 46.55819 | 93.51541 | 34.12937 | 105.94423 |
| Jul 2025 | 69.45270 | 42.03684 | 96.86857 | 27.52376 | 111.38165 |
| Aug 2025 | 74.45029 | 42.61703 | 106.28355 | 25.76552 | 123.13506 |
| Sep 2025 | 82.02100 | 45.35215 | 118.68984 | 25.94084 | 138.10116 |
| Oct 2025 | 91.64521 | 49.76977 | 133.52065 | 27.60226 | 155.68817 |
| Nov 2025 | 95.09700 | 47.67992 | 142.51408 | 22.57883 | 167.61517 |
| Dec 2025 | 99.72458 | 46.45859 | 152.99056 | 18.26129 | 181.18786 |

# Considerations When Doing Predictive Modeling

- **Data Quality:**
  Missing data handled using a **3-period Simple Moving Average (SMA)** to ensure completeness.
- **Feature Engineering:**
  Decomposed time series to identify **seasonality, trends, and patterns** for accurate modeling.
- **Model Selection:**
  Tested multiple models (**Auto ARIMA, ETS, SES Holt-Winters**) and selected **SES Holt-Winters** for best performance and lowest MAPE (Jembe: **18.38%**, Ngelehun: **45.77%**).
- **Model Evaluation:**
  Evaluated models using **MAPE**, ensuring they captured seasonal variations effectively.
- **Seasonality and Trends:**
  **SES Holt-Winters** explicitly addressed seasonality and trends critical for time series forecasting.
- **Uncertainty and Confidence:**
  Included **confidence intervals (80% and 95%)** to quantify prediction variability and guide planning.



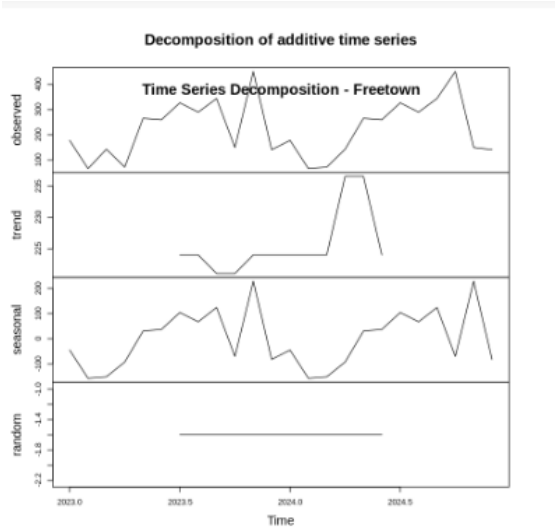



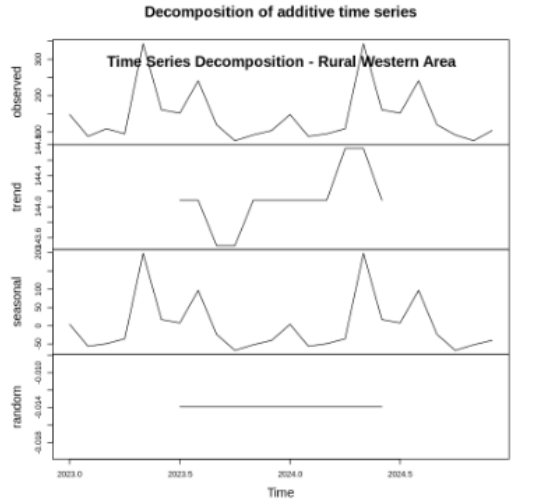

**Notebook Link:**
https://colab.research.google.com/drive/1-XC5MgoX47xNJPCBoLO5BA72AkM3aal_?usp=sharing

# Sourcing of Data and Data preparation for Question 4 from Section 5-

We created a pivot table using the case count in Western area district(It is the one with highest average cases of Diarrhea) and downloaded it in the form of CSV file.
Imported that CSV file into colab to do our forecasting, there were no missing data or outliers, there was only one outlier in the Rural western area which we felt was not so significant.
Decomposed the time series and found that there is weak seasonality in the data.
We forecasted the data for next year using Auto- Arima, ETS and Holt Winters, out of all these we found that Auto- Arima was the better performing model. This Auto- Arima used Non seasonal Arima with p,d,q being 0,0,0.
We chose **MAPE** because it provides an intuitive, percentage-based accuracy measure.

- The data has weak seasonality, no outliers, and no missing values, making MAPE reliable.
- With only 2 years of data, MAPE is simple to interpret for short time series.




```
Freetown Metrics:
MAPE: 40.56926 %
Forecasted values for next year (rounded): 204 204 204 204 204 204 204 204 204 204 204 204

Rural Western Area Metrics:
MAPE: 44.2655 %
Forecasted values for next year (rounded): 149 149 149 149 149 149 149 149 149 149 149 149
```

## Why we selected Auto ARIMA

We selected **Auto ARIMA** because it provided the lowest MAPE among all tested models for our dataset.

- Auto ARIMA efficiently handled the 2 years of monthly data, identifying weak seasonality and non-stationarity.
- It eliminated the need for manual parameter tuning (p,d,qp, d, qp,d,q), ensuring optimal performance for both Freetown and Rural Western Area.
- The absence of outliers and missing values in the data allowed Auto ARIMA to model the trends and patterns accurately.
- Its adaptability to short time series like ours ensured reliable forecasts without overfitting.

**Selected AutoArima due to MAPE value**

```
packets_per_day <- 3
days_per_case <- 5
total_packets_freetown <- sum(forecasted_cases_freetown) * packets_per_day * days_per_case
cat("Minimum ORS stock required for Freetown for the next year (5 days per case):", total_packets_freetown, "\n")


forecasted_cases_rural <- forecast_rural$mean
total_packets_rural <- sum(forecasted_cases_rural) * packets_per_day * days_per_case
cat("Minimum ORS stock required for Rural Western Area for the next year (5 days per case):", total_packets_rural, "\n")

total_packets_district <- total_packets_freetown + total_packets_rural
cat("Total minimum ORS stock required for the district for the next year (5 days per case):", total_packets_district, "\n")
```

```
Minimum ORS stock required for Freetown for the next year (5 days per case): 36730
Minimum ORS stock required for Rural Western Area for the next year (5 days per case): 26730
Total minimum ORS stock required for the district for the next year (5 days per case): 63460
```

# ANC-3 Coverage and Delivery Rates Analysis Methods

**Methods**

- Data visualizations created for ANC-3 coverage and PHU delivery rates using line charts and choropleth maps.
- Used spatial analysis to compare delivery rates and complicated deliveries across regions and facilities.

**Pros:**

- Highlighted patterns and correlations, such as peaks in ANC-3 coverage and delivery rates in specific months and locations.
- Maps provided spatial insights into accessibility and facility-level challenges.
- Helped identify facilities with high delivery rates or service gaps.

**Cons:**

- Imbalanced data made it difficult to capture trends for facilities with missing data (e.g., Bonthe Hospital).
- Static methods lack deeper insights into temporal trends and population-specific issues.
- Delivery rates and complications are influenced by external factors not captured in the data, such as patient behavior or transport challenges.

**Biases and Mitigation Strategies:**

- Bias: Lack of ANC-3 data at some facilities creates gaps in spatial analysis.
  Mitigation: Collect more comprehensive data from underserved areas.
- Bias: Neutral delivery trends might mask high-risk deliveries on the mainland.
  Mitigation: Analyze data with specific population subgroups (e.g., high-risk pregnancies).
- Bias: Seasonal or regional trends may skew delivery data.
  Mitigation: Use dynamic temporal models to analyze seasonal effects.

# Topic and Sentiment Analysis—Methods

**Sentiment Analysis:**

Used TextBlob to assign polarity scores, classifying text as Positive, Neutral, or Negative.

Most data was Neutral due to the scientific nature of the topics, limiting sentiment variability.

Imbalanced data made calculating metrics like F1-Score difficult and skewed overall results.

Future improvements include using domain-specific models and balanced datasets to handle such biases.

**Topic Modeling:**

Applied Latent Dirichlet Allocation (LDA) to extract scientific themes from the corpus.

Optimal topic count was selected using coherence scores to ensure meaningful topic separation.

Generated keyword tables and visual maps to interpret themes, such as healthcare delivery and accessibility.

Preprocessing, including stop word and punctuation removal, improved clarity