

AHEAD Integrated Data Quality Dashboard

Executive Brief for Country Programs

Purpose

This executive brief brings together key findings from the AHEAD Integrated Data Quality Analytics Pipeline and the Streamlit dashboard to help country teams interpret routine health and HIV data, identify root causes of data quality gaps, and implement targeted corrective actions. The analysis is grounded in outputs from the Excel-based data quality review tool and their interactive visualization through the Streamlit dashboard.

The findings presented in this brief are based on analysis of routine program data from Kenya, which served as the initial implementation context for the AHEAD Integrated Data Quality Analytics Pipeline. The pipeline and dashboard are modular by design and can be readily applied to other countries or operating units as data becomes accessible, enabling consistent data quality assessment and interpretation across settings.

Combining completeness, outlier diagnostics, trends, and geography allow country teams to prioritize follow-up efficiently and strengthen routine data use.

1. Overview of the Data Quality Assessment

The assessment examined 43 indicators across HIV, MNCAH, immunization, and nutrition, covering 1,453 subnational reporting units. Data quality was evaluated across four core dimensions:

- Reporting completeness
- Accuracy assessed through z-score based outlier detection
- Internal consistency and duplication
- Stability and interpretability of derived percentage indicators

Outputs from the validation pipeline were visualized through an interactive Streamlit dashboard, enabling rapid exploration of data quality patterns by indicator, geography, reporting unit, and time.

2. Key Findings Across Data Quality Domains

Figure 1. Multi-metric Data Quality Heatmap. Heatmap showing indicator-level proportions of missing values, negative values, duplicates, and outliers. The visualization demonstrates near-zero missing, negative, and duplicate values across indicators, with outliers concentrated within a limited subset. This pattern reflects strong system integrity alongside targeted accuracy issues rather than widespread data quality failure.

This section synthesizes evidence from the Excel-based validation outputs and the dashboard visualizations, including the multi-metric heatmap and derived indicator trend plots.

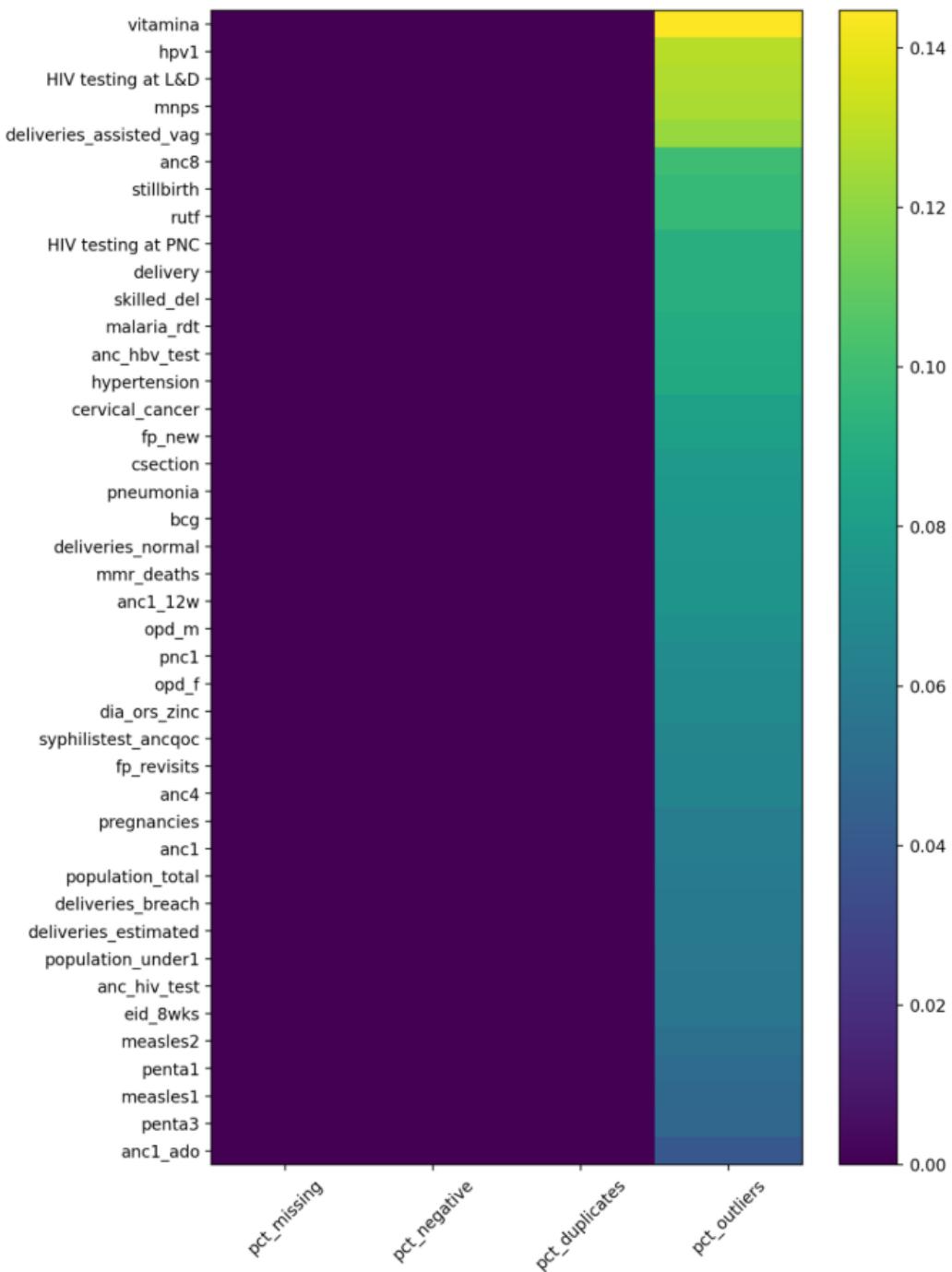


Figure 1. Multi-metric Indicator Data Quality Patterns

Source: AHEAD Integrated Data Quality Analytics Pipeline and Streamlit Dashboard.

2.1 Reporting Completeness: The Primary Constraint

Average reporting completeness across units was 41.4 percent, with all reporting units falling below the commonly referenced 80 percent completeness benchmark. The lowest-performing wards consistently reported completeness levels between 35 percent and 45 percent.

Interpretation

Low reporting completeness represents the primary operational constraint to effective data use, reflecting system-level reporting challenges rather than isolated facility-level failures. Inconsistent submission across indicators within the same units suggests workflow and capacity constraints rather than intentional data manipulation.

Programmatic Implication

Improvements in reporting completeness are likely to yield the largest and most immediate gains in data usability, trend stability, and confidence in program performance metrics.

2.2 Outlier Detection and Accuracy Assessment

Outliers were detected using z-scores to flag values that deviate from expected distributions. Outliers were statistically defined using the conventional threshold of $|z| > 3$; a tiered verification approach was applied operationally to prioritize review effort.

Statistical summary of outliers

- Total flagged outlier records: 272,162
- Median absolute z-score: approximately 1.7
- 75th percentile: approximately 2.6
- 90th percentile: approximately 4.0
- 95th percentile: approximately 5.1
- Approximately 19 percent of flagged records had $|z| > 3$
- Approximately 10 percent had $|z| > 4$

Interpretation

Most flagged values reflect mild to moderate deviations rather than extreme anomalies. Only a relatively small subset of records exhibits highly implausible values that are consistent with common data entry issues such as extra zeros, cumulative reporting, or indicator misclassification.

Overall, this pattern suggests that data accuracy is generally strong where reporting occurs, and that outlier-related issues are selective rather than systemic.

2.3 Indicator-Level Patterns

Indicator-level analysis shows that a limited group of indicators consistently contributes a disproportionate share of anomalies, including:

- Vitamin A supplementation
- HPV1 immunization
- HIV testing during labor, delivery, and postnatal care
- MNPS and selected delivery-related indicators

Despite their prominence among the worst-performing indicators, median outlier proportions remain low at 0.07 percent, reinforcing that data quality challenges are concentrated within specific indicators rather than widespread across the system.

2.4 Consistency and Duplication

The multi-metric heatmap demonstrates near-zero levels of:

- Duplicate records
- Negative or structurally invalid values

Interpretation

System-level controls and validation rules appear to be functioning effectively. Data integrity challenges are not driven by duplication or invalid values, supporting continued reliance on routine reporting systems once completeness gaps are addressed.

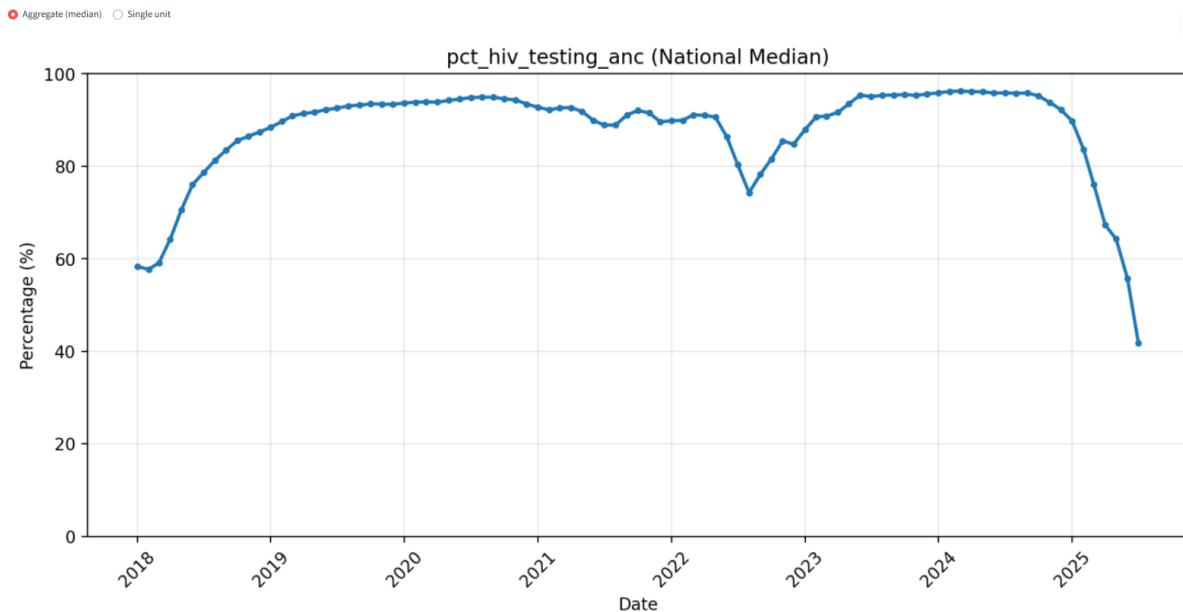
2.5 Derived Indicator Trends

Derived percentage indicators were analyzed at the national median level to assess performance stability, sensitivity to reporting completeness, and overall interpretability over time. Figures referenced in this section include the data quality KPI heatmap and selected trend plots, such as pct_hiv_testing_anc.

Comparative Review of Key Derived Indicators

Figure 2. National Median Trend for pct_hiv_testing_anc. Time-series plot showing the national median percentage of HIV testing during antenatal care. The plot illustrates gradual improvement over time, followed by sharp declines in recent periods that align with reporting completeness gaps, highlighting the sensitivity of indicators derived to data availability and the

importance of validating completeness before interpreting performance changes. (Note: pct denotes percentage).



Source: AHEAD Integrated Data Quality Analytics Pipeline and Streamlit Dashboard.

Four derived percentage indicators were reviewed side by side to demonstrate the diagnostic value of the dashboard:

- pct_anc4 – Antenatal care (4 or more visits)
- pct_penta3 – Immunization completion
- pct_skilled_del – Skilled birth attendance
- pct_hiv_testing_anc – HIV testing during antenatal care

pct_penta3 consistently shows high national median values, typically between 95 percent and 100 percent, with minimal volatility. This pattern reflects strong reporting alignment and stable numerator–denominator relationships, making it a useful reference benchmark when interpreting other service domains.

pct_skilled_del remains persistently near 100 percent, suggesting either very high coverage or a ceiling effect driven by aggregation and reporting conventions. While encouraging from a programmatic perspective, this pattern warrants cross-validation with delivery counts and completeness metrics to rule out default or over-aggregated reporting.

pct_hiv_testing_anc demonstrates steady improvement from approximately 60 percent to above 90 percent over time, followed by pronounced declines in recent periods. These declines coincide with documented completeness gaps and are therefore more consistent with data availability issues than with true program regression.

pct_anc4 fluctuates between approximately 50 percent and 65 percent, with sharp dips corresponding to periods of reduced reporting completeness. This confirms that antenatal

care (4 or more visits) coverage is highly sensitive to reporting participation and should not be interpreted in isolation.

Interpretation

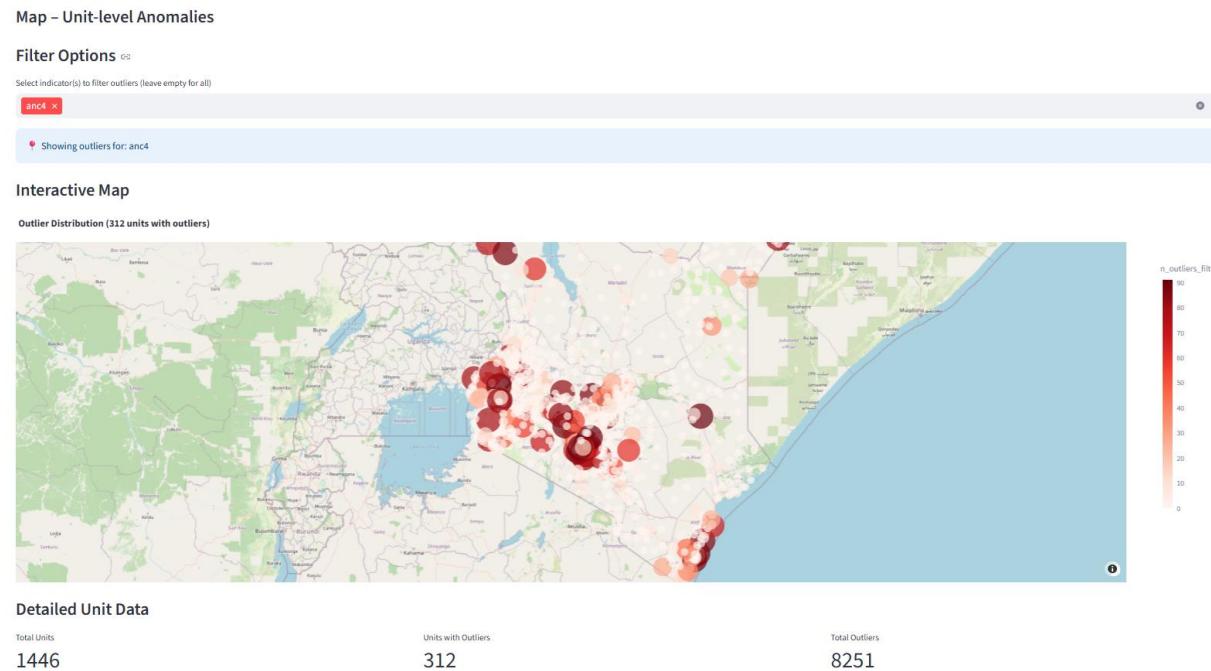
Reviewing these indicators concurrently allows country teams to distinguish true performance changes from reporting artifacts. Stable indicators provide interpretive anchors, while volatile indicators serve as early warning signals for data quality challenges. As a result, derived indicators should be interpreted jointly with completeness diagnostics during routine performance reviews.

3. Geographic Insights and Root Cause Identification

The dashboard's thematic and proportional symbol maps reveal spatial clustering of outliers. When filtering by specific indicators, anomalies are confined to a subset of reporting units; for example, when filtering ANC4, there are 312 units with outliers and 8,251 total outlier records associated with that indicator.

Figure 3. Geographic Distribution of Indicator-Specific Outliers Across Reporting Units.

Thematic and proportional symbol maps showing spatial clustering of outlier records for a selected indicator. Outliers are concentrated within a subset of reporting units, while the majority of units show no anomalies. This pattern demonstrates that data quality challenges are geographically localized and indicator-specific rather than systemic, enabling targeted supervision and review.



Source: AHEAD Integrated Data Quality Analytics Pipeline and Streamlit Dashboard.

Interpretation

Figure 3 shows that data quality anomalies are spatially clustered rather than uniformly distributed. Outliers are confined to specific reporting units and vary by indicator, suggesting that observed issues are driven by localized operational factors such as reporting workflows, service volume, supervision frequency, or indicator interpretation. This supports targeted supportive supervision and indicator-specific verification, rather than broad national corrective actions.

These spatial patterns enable rapid identification of priority supervision zones or subnational areas requiring targeted review, rather than broad nationwide corrective actions.

4. Value of the Streamlit Dashboard for Country Teams

The Streamlit Integrated Data Quality Dashboard translates complex validation outputs into an intuitive decision-support tool. By integrating indicator-level metrics, unit-level completeness, geographic visualization, heatmaps, and trend analysis into a single interface, the dashboard enables rapid diagnosis of data quality and performance issues.

The multi-metric heatmap shows that missing values, negative values, and duplicates are negligible across indicators, while outliers are concentrated within a limited subset. This shifts analytical focus away from concerns about system integrity toward targeted process improvement.

Trend plots such as pct_hiv_testing_anc at national median level provide clear visual evidence of how reporting completeness directly affects derived indicators. Sudden declines that coincide with low completeness can be quickly identified and contextualized during routine data review meetings.

Through interactive filtering by indicator, geography, and reporting unit, country teams can move efficiently from problem identification to root cause analysis, supporting timely and proportionate corrective action.

The Streamlit Integrated Data Quality Dashboard transforms validation outputs into actionable intelligence by:

- Enabling rapid filtering by indicator, geography, and reporting unit
- Linking completeness, accuracy, and trends within a single interface
- Supporting real-time exploration during data review meetings
- Reducing reliance on static reports and manual spreadsheet analysis

Country teams can therefore progress from identifying performance gaps to diagnosing root causes and planning corrective actions within a single review session.

5. Recommendations for Course Correction and Data Quality Improvement

The following recommendations are intended for national, subnational, and partner teams responsible for routine data reporting, supervision, and review.

5.1 Prioritize Reporting Completeness

- Focus supervisory efforts on persistently low-reporting wards
- Align reporting schedules with facility workflows
- Simplify indicator reporting for high-volume services

5.2 Apply Tiered Outlier Verification

- Immediately verify extreme outliers ($|z| > 4$)
- Contextually review moderate deviations ($|z|$ between 3 and 4)
- Monitor mild deviations without automatic correction

5.3 Validate Completeness Before Interpreting Trends

- Pair derived indicator trends with completeness diagnostics
- Avoid programmatic decisions based solely on unvalidated trend fluctuations

5.4 Institutionalize Dashboard Use

- Integrate dashboard reviews into routine monthly and quarterly data review forums
- Use geographic and indicator filters to guide targeted supportive supervision

6. Conclusion

The AHEAD Integrated Data Quality Analytics and Dashboard show that routine health data are largely accurate and internally consistent when reported. The primary constraint to effective data use remains incomplete reporting, compounded by localized and indicator-specific anomalies.

By enabling rapid, interactive exploration of multiple data quality dimensions, the dashboard empowers country teams to identify root causes, prioritize corrective actions, and strengthen data-informed decision-making. This executive brief supports adoption of a targeted, evidence-based approach to data quality improvement, with emphasis on strengthening reporting completeness, applying selective verification, and institutionalizing routine data use.

