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Data quality assessment of maternal and newborn indicators from District Health Information Software 2 in five African countries for the period 2014–2023

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Background Tracking progress of sustainable development goal (SDG) targets requires robust monitoring systems, yet data quality remains challenging across sub-Saharan Africa. Most countries rely on aggregated data from District Health Information Software 2 (DHIS2) or surveys to track maternal, newborn and child health (MNCH) indicators. We evaluated MNCH data quality in DHIS2 across Ghana, Kenya, Tanzania, Uganda, and Zimbabwe (2014–2023).

Methods We analysed 16 ENAP-aligned indicators and their 29 corresponding data elements captured in DHIS2 across health facility levels. We applied the WHO Data Quality Review framework to assess availability, reporting completeness, internal consistency (ratio-based validation metrics and temporal trends), and external consistency (comparison with UN Inter-agency Group for Child Mortality Estimation (UN IGME), Maternal Mortality Estimation Inter-Agency Group (MMEIG), and World Health Organization Global Health Observatory data).

Results Of 29 data elements, Uganda had highest availability (72–76% during 2020–2023), followed by Kenya (62–66%), Tanzania (52%), and Ghana and Zimbabwe (41% each). Reporting completeness varied substantially: Tanzania achieved >95% facility reporting across all levels, while other countries showed disparities between hospitals and lower-level facilities. Internal consistency revealed problematic patterns for mortality-related ratios in Ghana (stillbirth-to-neonatal mortality ratios reaching 5.0–12.5) and Kenya (KMC-to-low birthweight ratios >2.0). After adjusting DHIS2 estimates for facility birth coverage, stillbirth rates generally exceeded or matched UN IGME estimates, whereas maternal mortality ratios showed substantial underreporting relative to MMEIG estimates. Ghana showed the closest MMR alignment and Kenya the largest discrepancy. Neonatal mortality was underreported in Ghana and Uganda but appeared higher than UN IGME estimates in Tanzania, a finding sensitive to aggregation method.

Conclusions DHIS2 data quality varies substantially across countries, with country-specific challenges in availability, completeness and consistency. Strengthening facility-level data capture and developing an MNCH data quality module are crucial for improving data reliability.

Keywords DHIS2; data quality; maternal, newborn and child health; Africa

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In 2015, the United Nations established the Sustainable Development Goals (SDGs), with targets 3.1 and 3.2 aiming to reduce maternal mortality ratio (MMR) to below 70 per 100,000 live births and end preventable

deaths of newborns and children under five by 2030 [1]. These targets are central to the Every Woman Every Newborn Everywhere (EWENE) initiative [2], which builds upon Every Newborn Action Plan (ENAP) and the Ending Preventable Maternal Mortality (EPMM) strategies [3–7]. The Every Newborn Action Plan (ENAP) indicators (14 core and 11 additional) are tracked using aggregated data, often compiled from surveys like demographic and health surveys (DHS) [8,9]. Despite progress, most countries remain off-track, particularly in sub-Saharan Africa, where only a few small states are approaching these targets and none is fully on track, highlighting the urgent need for improved monitoring [10–13].

Progress towards these goals depends on health information systems that can deliver timely, disaggregated, and sufficiently high-quality data at all levels of the health system [14,15]. The World Health Organization (WHO) has emphasised that effective progress tracking requires standardised measurement and reliable data collection [16]. However, many African countries face challenges in generating and utilising such data, often lacking electronic medical record systems for individual-level data capture and aggregation [17,18]. Inadequate infrastructure, limited resources and systemic barriers further hinder the adoption of digital health solutions [19–21].

The District Health Information Software version 2 (DHIS2), adopted across low- and middle-income countries since 2006 [22,23], collects various indicators monthly, supported by WHO and the Health Information Systems Programs (HISP) network [24,25]. However, its use for maternal, newborn and child health (MNCH) monitoring has been more limited [26]. DHIS2 is now operational across most of these countries, yet surprisingly little evidence exists on whether its MNCH data are good enough to inform clinical or policy decisions [18,27–30]. Reliable data are essential for tracking progress toward SDG targets, yet questions persist about completeness and consistency within the health systems [21,29–32].

We set out to examine how well DHIS2 captures MNCH indicators across five African countries (Ghana, Kenya, Tanzania, Uganda and Zimbabwe) from 2014 to 2023. These countries were selected based on their early adoption of DHIS2, varied health system structures, and commitment to improving MNCH outcomes [19,33]. These five countries were selected purposively and are not intended to be statistically representative of sub-Saharan Africa. Additionally, our existing partnerships with Ministry of Health representatives in these countries facilitated data access and validation.

We addressed four objectives:

1. availability and definitions of ENAP indicators and their data elements within DHIS2,
2. reporting completeness across facility levels,
3. internal consistency of reported indicators, and
4. external consistency with global reference estimates.

We also consider how far these data meet the FAIR principles of findability, accessibility, interoperability and reusability.

METHODS

This study is a secondary analysis of routine aggregated data held in national DHIS2 repositories. In line with the Journal of Global Health's GRABDROP [34], we declare our adherence to the five GRABDROP items, with full details provided in Table S1 in the **Online Supplementary Document**.

Data elements for these indicators were extracted from DHIS2 in Ghana, Kenya, Tanzania, Uganda, and Zimbabwe. Data elements were reported monthly from health facilities (hospitals, health centres, clinics and dispensaries) covering 2014 to 2023. We focussed on 16 of the 25 indicators aligned with ENAP framework (14 core and 11 additional) for which both numerator and denominator were available in at least one country. The remaining indicators were not assessed because their numerator or denominator data elements were largely absent from DHIS2. Birth

and death registration, although recorded in Uganda from 2021, was still being piloted and was therefore excluded [35].

Data sources and requisition

The research question was developed in consultation with Ministry of Health representatives to ensure alignment with national health information priorities. We developed a standardised data template to map the ENAP indicator data elements in DHIS2. Ministry of Health (MOH) representatives in each country extracted and shared the available data elements.

Health facility types and reporting periods varied across countries (Table S2 in the **Online Supplementary Document**). Ghana's data included only hospitals (2017–2022), limiting direct comparability with the other four countries which included lower-level facilities.

All five countries adopted DHIS2 between 2010 and 2013 as their primary health information management platform; country-specific DHIS2 adaptation and implementation history are provided in Appendix S1 in the **Online Supplementary Document** [23,27,28,31,32,36–39].

Data management and processing

Data underwent cleaning and validation including removing duplicate monthly entries, addressing missing values, and verifying outliers through enquiries to MOH representatives and during the data validation workshop (Nairobi, May 2025). We retained only facility-months where both numerator and denominator were non-missing and the denominator exceeded zero; zero values for mortality numerators were treated as valid data. Extreme outliers (exceeding three standard deviations from the country-year mean) were flagged for verification rather than removed and were retained where confirmed as genuine; no mortality numerator was excluded solely on a statistical threshold. Cleaned data were aggregated by country, month, year, and health facility levels. Variable names and formats were standardised across countries.

Statistical analyses

Our analyses followed the WHO guidelines for analysing and using health facility data [40]. We evaluated three out of the four data quality dimensions recommended by the WHO Data Quality Review framework. We could not assess the fourth dimension, timeliness of reporting, as submission dates were not consistently available across countries. Availability was assessed through both indicator coverage (Objective 1) and facility reporting completeness (Objective 2), internal consistency (Objective 3) and external comparison (Objective 4).

Alongside these dimensions, we interpreted the findings against the FAIR data principles. We used descriptive statistical methods conducted in Stata, version 18.5 (StataCorp LLC, College Station, TX, USA) and Python. As the analyses are descriptive and did not involve inferential hypothesis testing across multiple comparisons, no multiple-testing correction or significance threshold was applied. Using these 16 indicators and their 29 data elements, we calculated annual ENAP estimates and trends to assess their performance over time.

Objective 1: availability and mapping of indicators and their data elements within DHIS2 platform

We reviewed ENAP indicators' availability across five countries' DHIS2 systems from 2014–2023, identifying data elements required to calculate the 25 WHO-defined ENAP indicators (**Table 1**) [41,42]. We mapped 29 distinct data elements within each country's DHIS2 instance and cross-referenced these elements with WHO definitions to ensure conceptual alignment. Cross-referencing identified where country implementations departed from the WHO-standard definitions, and these departures are reported as findings rather than resolved by mapping. We distinguished structural availability, meaning a data element exists in a country's DHIS2 instance, from func-

tional availability, meaning the element is actively and completely populated. Our assessment is based on structural availability; therefore, it may overstate functional capture where elements are present but unused.

Data element availability was categorised for each country and year as:

1. complete availability (both numerator and denominator present),
2. partial availability (only numerator or denominator present), or
3. unavailable (neither present).

For each indicator with complete availability, we identified the first year of reporting to establish the temporal patterns in data system maturation. Results were compiled in comprehensive availability matrices showing the presence or absence of each data element (denoted by ✓ or X) by country and year. Annual Total Fertility Rates were obtained from World Population Prospects 2024 (Table S3 in the **Online Supplementary Document**).

Table 1. Every Newborn Action Plan Indicators set in 2014

Current status	Level	Core indicators	Additional indicators
Definitions clear but quantity & consistency of data lacking	Impact	1. Maternal mortality ratio	
		2. Stillbirth rate*	15. Intrapartum stillbirth rate*
		3. Neonatal mortality rate	16. Low birth weight rate
			17. Preterm birth rate*
			18. Small for gestational age*
			19. Neonatal morbidity rates*†
			20. Disability after neonatal conditions*†
Contact point definitions clear but data on content of care are lacking	Coverage Care for all mothers and newborns	4. Skilled attendant at birth	21. Antenatal care
		5. Early postnatal care for mothers & babies	22. Exclusive breastfeeding to six months
		6. Essential newborn care (early breastfeeding)	
Gaps in definitions, requiring validation and feasibility testing for HMIS use	Coverage	7. Neonatal resuscitation*†	23. Caesarean section rate
		8. Kangaroo mother care*†	24. Chlorhexidine cord cleansing*†
	Complications and extra care	9. Treatment of serious neonatal infections*†	
		10. Antenatal corticosteroid use*†	
	Input	11. Emergency obstetric care	
	Service readiness for quality of care	12. Care of small and sick newborns*†	
		13. Quality of care with measurable norms and standards*†	
	Counting	14. Birth registration	25. Death registration, cause of death

*Indicators not routinely tracked at a global level.
†Indicators requiring additional testing to inform consistent measurement. Adapted from [41,42].

Objective 2: reporting completeness of indicators

We evaluated reporting completeness by assessing the proportion of health facilities that submitted ENAP indicator data each month through their respective DHIS2 systems. Facilities were stratified into three levels: hospitals, higher-level health centres, and lower-level facilities (including clinics and dispensaries). For each facility level, we calculated the annual reporting rate as the percentage of registered facilities that submitted any ENAP indicator data at least once during the year. This is a permissive, structural measure of whether a facility reported at all, distinct from monthly completeness; a stricter monthly-submission definition would yield lower rates, and occasional reporting does not by itself indicate reliable surveillance. To quantify this stricter dimension, we additionally calculated, for each facility, the percentage of months in which it

reported a positive count for at least one ENAP data element, using as the denominator the number of months from the facility's first reported month to the end of the country's analysis period. Facilities were categorised as reporting 100%, 75 < 100%, 50 < 75% or <50% of expected months.

We distinguished between missing data (no report submitted) and zero values (report submitted with zero cases), considering only submitted reports in our completeness calculation. Reporting trends were analysed over time (2014–2023) to identify changes across facility levels and countries.

Objective 3: internal consistency

We assessed the internal consistency of computed indicators using ratio-based validation metrics and compared rates and ratios against expected ranges for each country using thresholds established in maternal and newborn health literature (**Table 2**) [43–55]. These are desirable reference ranges drawn from the literature, expected to vary with case-mix and context, and used to flag values for closer inspection rather than as universal cut-offs. For each metric, we plotted monthly values over time by country to identify periods when indicators fell outside expected ranges, suggesting potential data quality issues. We also examined temporal trends for unexpected fluctuations or patterns that might indicate systemic reporting problems rather than true epidemiological changes. In some countries, the perinatal deaths data element (version 18) captures early neonatal deaths only, excluding stillbirths, which affects interpretation of SBR:PNMR ratios.

Table 2. ENAP data consistency check indicators and thresholds

Indicator	Definition	Evidence	Thresholds*	References
Kangaroo Mother Care (KMC) to Low Birthweight (LBW) coverage ratio	Proportion of low-birth-weight newborns who received KMC	LBW newborns are the target population for KMC. Not all LBW babies are clinically eligible, and programme implementation varies according to settings.	0.4–0.8	[43,44]
Perinatal mortality rate (PNMR) to neonatal mortality rate (NMR) ratio	Ratio of perinatal mortality rate (stillbirths plus early neonatal deaths) to neonatal mortality rate	PNMR includes stillbirths plus early neonatal deaths (0–7 days), while NMR includes all neonatal deaths (0–28 days). PNMR is expected to be higher than NMR.	1.2–2.0	[45,46]
Stillbirth rate (SBR) to perinatal mortality rate (PNMR) ratio	Ratio of stillbirth rate to perinatal mortality rate	Stillbirths typically constitute 60%-80% of all perinatal deaths in most settings.	0.6–0.8	[47,48]
Stillbirth rate (SBR) to neonatal mortality rate (NMR) ratio	Ratio of stillbirth rate to neonatal mortality rate	In most settings, stillbirth rates and neonatal mortality rates tend to be similar, with SBR slightly lower than NMR in many countries.	0.7–1.0	[8,48,49]
Caesarean section rate	Percentage of births delivered by caesarean section	Both too low and too high rates can indicate poor quality of care. WHO states rates above 10% are not associated with reduced mortality.	5%–15%	[50,51]
Maternal mortality ratio	Maternal deaths per 100,000 live births in LMICs	Varies significantly by income level, with higher rates in low-income settings. SDG target is <70 by 2030.	20–400	[52,53]
Mother to newborn PNC ratio	Ratio of mothers receiving postnatal care to newborns receiving postnatal care	Both mother and newborn should receive postnatal care, ideally as a pair. Ratios significantly different from 1 suggest data quality issues or programme gaps.	0.9–1.1	[54,55]

WHO – World Health Organization, LMICs – low- and middle-income countries, SDG – sustainable development goal
*The thresholds refer to the desirable thresholds used in this study and are expected to vary with case-mix and context.

Objective 4: external consistency

We evaluated the external consistency of four key ENAP indicators derived from DHIS2 by comparing them with global reference estimates:

1. Caesarean section rate: compared with WHO Global Health Observatory estimates
2. Maternal mortality ratio: compared with estimates from the Maternal Mortality Estimation Inter-Agency Group (MMEIG)

3. Stillbirth rate: compared with UN Inter-agency Group for Child Mortality Estimation (UN IGME) estimates
4. Neonatal mortality rate: compared with UN IGME estimates

For each indicator, we computed annual country-level DHIS2 estimates as the mean of facility-level monthly rates (ratio-of-means), including only facility-months where both numerator and denominator were non-missing and the denominator exceeded zero. This approach weights each facility equally regardless of delivery volume, ensuring that signals from smaller facilities, often most affected by reporting challenges, are not diluted by high-volume hospitals. Equal weighting can, however, amplify instability in small facilities with sparse reporting. As a sensitivity analysis, we computed indicators using ratio-of-sums aggregation for both higher-level facilities only (Figure S4, Panels A–D in the **Online Supplementary Document**) and all facility levels (Figure S5, Panels A–D in the **Online Supplementary Document**), weighting facilities proportionally to delivery volume, consistent with approaches used in single-country DHIS2 assessments in Tanzania [56] and Nigeria [57]. We plotted DHIS2 estimates alongside reference estimates and their 95% confidence intervals by country and year to assess alignment.

Since DHIS2 captures data only from health facilities and not from home births or deliveries outside the health system, direct comparison of facility-based rates with population-level global estimates would systematically underestimate the true burden. To enable more meaningful comparisons, we adjusted DHIS2 estimates to approximate population-level rates using country-specific institutional delivery proportions derived from the most recent Demographic and Health Surveys (DHS) and UNICEF data. Adjustment factors were calculated as the inverse of the proportion of births occurring in health facilities: 1.16 for Ghana (86% facility births; DHS 2022) [58], 1.14 for Kenya (88%; DHS 2022) [59], 1.23 for Tanzania (81%; DHS 2022) [60], 1.10 for Uganda (91%; DHS 2022) [61], and 1.18 for Zimbabwe (85%; Zimbabwe Countdown 2019 report) [62]. This adjustment assumes that the rate of complications and outcomes is similar among facility and non-facility births, which is a simplifying assumption, as non-facility births may carry higher risk. This approach is consistent with previous DHIS2 data quality assessments: Shabani *et al.* applied a uniform 20% adjustment for home births in Tanzania [56]. Caesarean section rates were not adjusted as the external comparator (WHO GHO) already reflects facility-based data. Unadjusted external comparisons are described in Appendix S2 in the **Online Supplementary Document**.

RESULTS

Patient and public involvement

This study used routine aggregated health facility data extracted from national DHIS2 platforms. No patients or members of the public were directly involved in the design, conduct, or reporting of this research. Ministry of Health representatives in each study country, who are co-authors, contributed to data extraction, validation, and interpretation of findings.

Objective 1: availability and mapping of indicators and data elements within DHIS2 platform

Of 29 data elements required to calculate 16 'study focus' ENAP indicators (**Table 3**; Table S4 in the **Online Supplementary Document**), Uganda demonstrated the highest coverage (72–76% during 2020-2023). Kenya maintained consistent availability of 62–66% elements from 2019–2023, while Tanzania showed stable coverage of 52% elements from 2015–2022. Ghana and Zimbabwe's implementation remained unchanged at 41% throughout 2017–2022 and 2015–2023 respectively (**Table 3**).

Coverage of the 16 indicators was more than 50%, notably Uganda (n = 15, 94%), Tanzania (n = 11, 69%), Kenya (n = 11, 69%), Ghana (n = 9, 56%) and Zimbabwe (n = 9, 56%).

Impact indicators: maternal mortality ratio (MMR) (indicator 1), stillbirth rate (indicator 2), and neonatal mortality rate (indicator 3) showed the highest availability across all countries. All five nations consistently captured data on deliveries, live births, stillbirths, and maternal deaths

Table 3. Mapping of DHIS2 data elements' availability by country and year

DATA ELEMENTS FOR ENAP INDICATORS	GHANA*						KENYA					TANZANIA								UGANDA									ZIMBABWE								
YEAR	2017	2018	2019	2020	2021	2022	2019	2020	2021	2022	2023	2015	2016	2017	2018	2019	2020	2021	2022	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2015	2016	2017	2018	2019	2020	2021	2022	2023
PERCENTAGE COVERAGE (%), n = 29	41	41	41	41	41	41	62	66	62	62	62	52	52	52	52	52	52	52	52	59	59	55	55	55	62	76	72	72	72	41	41	41	41	41	41	41	41	41
Deliveries (v0)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Deliveries with Traditional Birth Attendants (TBA) (v0a)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓
Born Before Arrival (v0d)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Live births (v1)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Stillbirths (v2)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Intrapartum stillbirths (v3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Antepartum stillbirths (v4)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Normal deliveries or spontaneous vaginal deliveries (v5)	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Breach Delivery (v6)	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Preterm births (v7)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Caesarean Section deliveries (v8)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Low birth weight (v9)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Breastfed within 1 h after birth (v10)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Mothers who initiated breastfeeding within the 1st hour after birth (v10a)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X
Assisted vaginal delivery (v11)	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Neonates initiated on Kangaroo Mother Care (v12)	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Neonatal deaths (0–28 days) (v13)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Maternal deaths (v14)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mothers receiving PNC within 2–3 days (v15)	X	X	X	X	X	X	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Babies receiving PNC within 2–3 days (v15a)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mothers receiving PNC within 6 weeks (v16)	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Babies receiving PNC within 6 weeks (v16a)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Babies applied chlorhexidine for cord care (v17)	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Perinatal Deaths 0–7 days (v18)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Newborn resuscitation (Bag and mask ventilation (v19)	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Newborns treated with neonatal sepsis (v20)	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X
Skilled attendant at birth (v21)	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Infants who were reported to be exclusively breastfed (v22)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ANC 4+ visits for Women (v23)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

*Ghana's preterm births (v7) data element was present, although all values were zero, suggesting a reporting artefact rather than genuine data capture and all data from Ghana are from only hospitals. Zimbabwe had no separate live-births data element; deliveries were used as a proxy.

throughout their respective reporting periods. All countries further differentiated stillbirths into intrapartum and antepartum categories (Table 3; Table S5 in the Online Supplementary Document).

Caesarean section rates and low birthweight reached 100% reporting across study years and countries. In contrast, preterm birth data were consistently captured in Kenya and Uganda only; in Ghana the preterm-birth element was present but recorded only zero values throughout. Early breastfeeding initiation was tracked by all countries except Zimbabwe, with Uganda being the only country specifically recording mothers who initiated breastfeeding within the first hour.

Data on delivery types such as normal vaginal deliveries and assisted vaginal deliveries were mostly reported in Kenya and less so in the other four countries. Postnatal care was documented primarily in Kenya and Uganda, with systematic newborn postnatal care available in Uganda from 2020 and Zimbabwe from 2015. Kangaroo Mother Care was variably recorded in Kenya (from 2020), Tanzania (from 2015), and Uganda (from 2019). Newborn resuscitation and treatment of neonatal sepsis were captured mainly in Tanzania and Uganda (Table 3; Table S5 in the Online Supplementary Document).

Several ENAP indicators had universal implementation gaps, notably: no country had captured data on neonatal morbidity (indicator 19), disability after neonatal conditions (indicator 20), small for gestational age births (indicator 18), or quality of care standards (indicator 13). Birth registration data (indicator 14) was collected only in Uganda from 2021 onwards. Similarly, service readiness indicators for emergency obstetric care (indicator 11), care of small and sick newborns (indicator 12), and quality of care standards were universally unavailable across all five countries (Table S4 in the Online Supplementary Document).

Objective 2: completeness of reporting

Tanzania had the highest complete reporting, *i.e.* nearly 95% of all facilities submitted data throughout 2015–2022, with minimal variation between dispensaries and high-level facilities (hospitals and health centres) compared to the other countries (Figure 1, Panels A–C). Ghana maintained high hospital reporting (87–92%) from 2017–2021, though the 2022 data should be interpreted with caution because it covers only six months (Ghana's data are hospital-only throughout; see Limitations) (Figure 1, Panel A; Table S6 in the Online Supplementary Document). In Kenya, hospitals maintained relatively high reporting rates (95–98%), while lower-level facilities gradually declined from 81 to 54% over five years (Figure 1, Panel C). In Uganda, hospital reporting started at 75% in 2014, peaked at 86% in 2018, dropped sharply to 50–51% in 2019–2020, then recovered to 77% by 2023 (Figure 1, Panels A–C; Table S6 in the Online Supplementary Document). In Zimbabwe, hospital completeness ranged between 86–87% from 2015 to 2023, with no pronounced change over time (Figure 1, Panels A–C, Table S6 in the Online Supplementary Document). Under the stricter facility-level measure, only 26% of the 22,166 facilities that ever reported did so in every expected month from their first report onwards (Ghana 83%, Zimbabwe 56%, Tanzania 33%, Uganda 23%, Kenya 14%), and 26% reported in fewer than half of their expected months. Hospitals reported more consistently, with 52% reporting in every expected month (Table S7 in the Online Supplementary Document).

Objective 3: internal consistency of indicators

Internal consistency metrics revealed country-specific deviations from expected benchmarks (Figure 2, Panels A–B, Table 2). Most countries showed problematic mortality-related ratios, with SBR:NMR ratios frequently exceeding the expected 0.7–1.0 range. Ghana demonstrated the most extreme inconsistencies, with ratios reaching 5.0–12.5, suggesting substantial stillbirth over-reporting or neonatal death under-reporting. Uganda maintained ratios between 2.0–3.0. Kenya and Tanzania displayed values closer to expected ranges, while Zimbabwe remained stable and within the expected levels (Figure 2, Panel A).

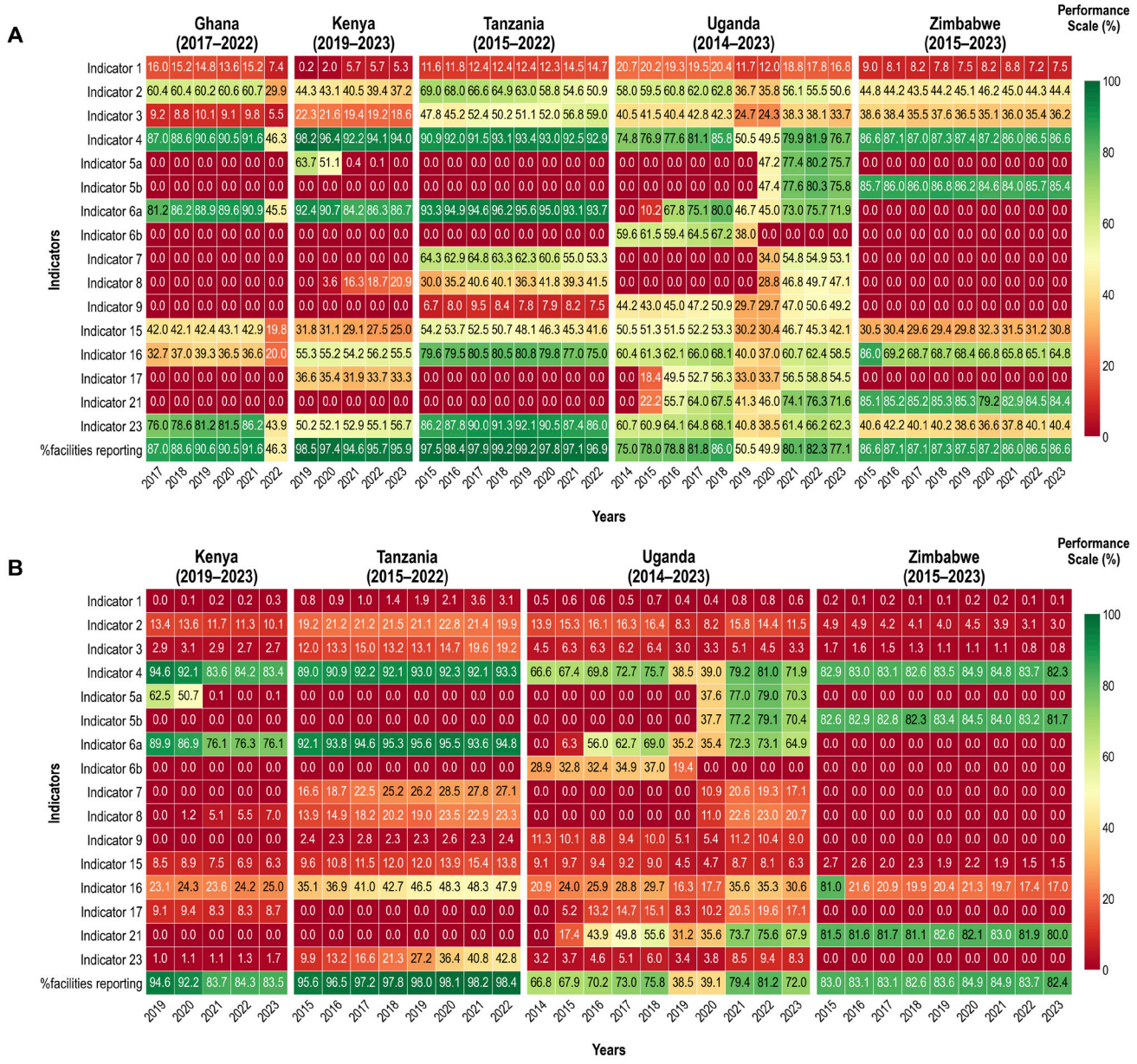
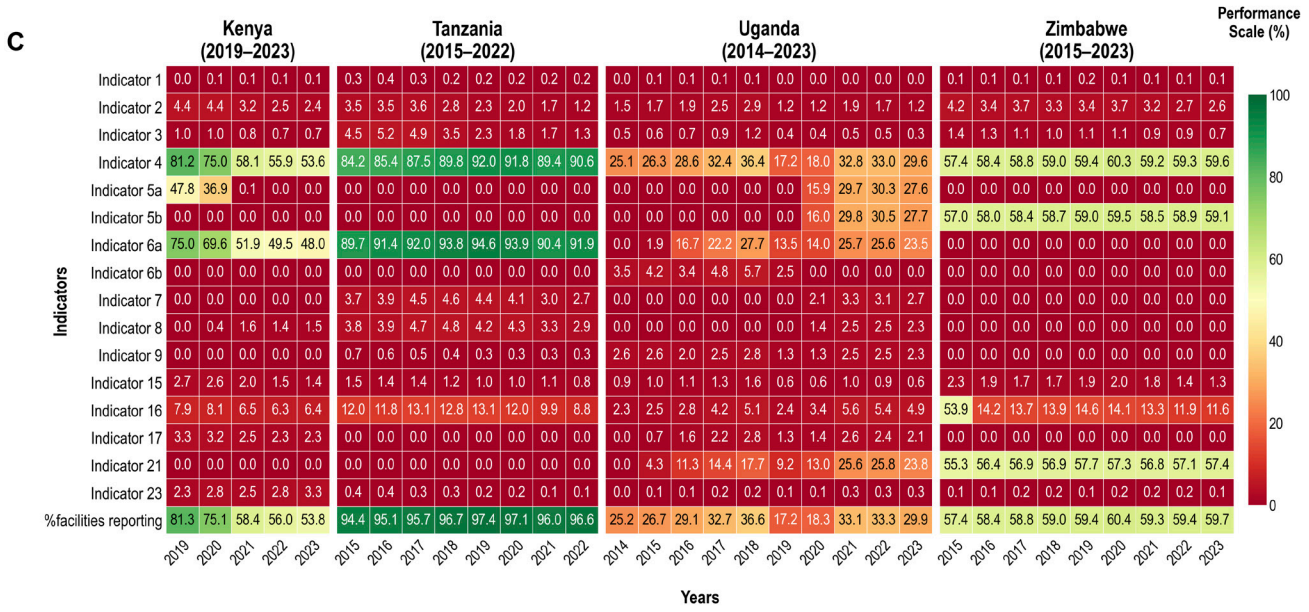


Figure 1. Facility reporting completeness for ENAP indicators by country and facility level. Panel A. Facility reporting completeness by country – hospitals. Ghana 2022 data covers only six months. ENAP indicators: 1=institutional maternal mortality ratio; 2=stillbirth rate; 3=institutional neonatal mortality rate; 4=skilled attendant at birth; 5a=postnatal care for mothers; 5b=postnatal care for newborns; 6a=early initiation of breastfeeding (newborns); 6b=early initiation of breastfeeding (mothers); 7=newborn resuscitation; 8=Kangaroo Mother Care; 9=treatment of neonatal sepsis; 10=antenatal corticosteroids; 11=emergency obstetric care; 12=care of small/sick newborns; 13=quality of care standards; 14=birth registration; 15=intrapartum stillbirth rate; 16=low birthweight rate; 17=preterm birth rate; 21=ANC 4+ visits; 23=caesarean section. Panel B. Facility reporting completeness by country – higher-level health centres. ENAP indicators: 1=institutional maternal mortality ratio; 2=stillbirth rate; 3=institutional neonatal mortality rate; 4=skilled attendant at birth; 5a=postnatal care for mothers; 5b=postnatal care for newborns; 6a=early initiation of breastfeeding (newborns); 6b=early initiation of breastfeeding (mothers); 7=newborn resuscitation; 8=Kangaroo Mother Care; 9=treatment of neonatal sepsis; 10=antenatal corticosteroids; 11=emergency obstetric care; 12=care of small/sick newborns; 13=quality of care standards; 14=birth registration; 15=intrapartum stillbirth rate; 16=low birthweight rate; 17=preterm birth rate; 21=ANC 4+ visits; 23=caesarean section. Panel C. Facility reporting completeness by country – lower-level health centres, clinics and dispensaries. ENAP indicators: 1=institutional maternal mortality ratio; 2=stillbirth rate; 3=institutional neonatal mortality rate; 4=skilled attendant at birth; 5a=postnatal care for mothers; 5b=postnatal care for newborns; 6a=early initiation of breastfeeding (newborns); 6b=early initiation of breastfeeding (mothers); 7=Newborn resuscitation; 8=Kangaroo Mother Care; 9=treatment of neonatal sepsis; 10=antenatal corticosteroids; 11=emergency obstetric care; 12=care of small/sick newborns; 13=quality of care standards; 14=birth registration; 15=intrapartum stillbirth rate; 16=low birthweight rate; 17=preterm birth rate; 21=ANC 4+ visits; 23=caesarean section.

Figure 1. Continued



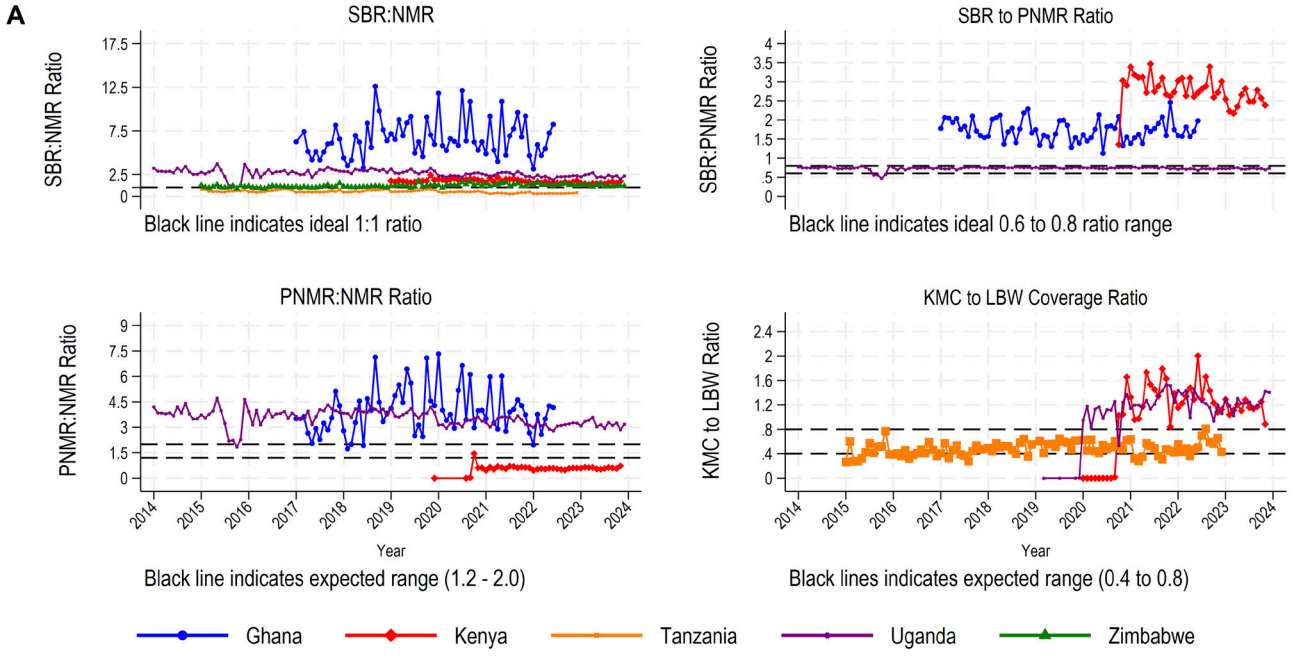
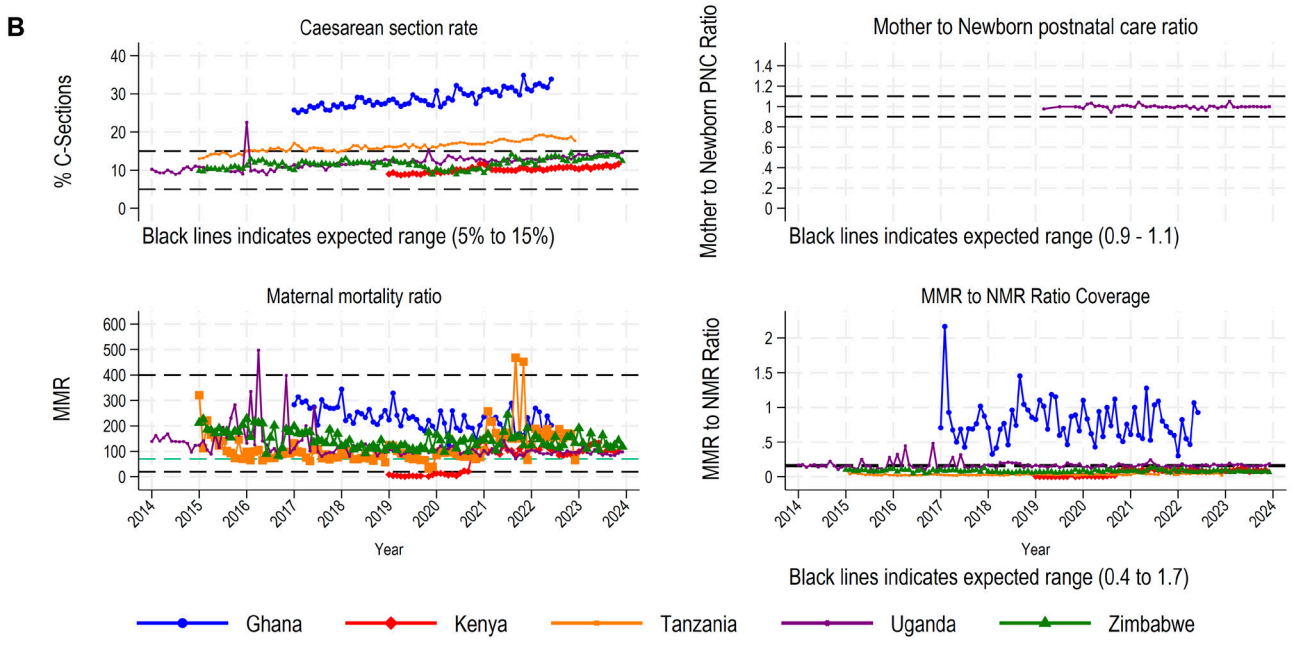


Figure 2. Internal consistency of DHIS2 maternal and newborn indicators by country. Panel A. Internal consistency over time of mortality indicator ratios and the KMC:LBW ratio. Monthly values plotted by country for three inter-mortality ratios and the KMC:LBW ratio. Black dashed lines indicate expected ranges from published literature (Table 2): SBR:NMR ratio 0.7–1.0; PNMR:NMR ratio 1.2–2.0; SBR:PNMR ratio 0.6–0.8; KMC:LBW ratio 0.4–0.8. Country data periods: Ghana 2017–2022; Kenya 2019–2023; Tanzania 2015–2022; Uganda 2014–2023; Zimbabwe 2015–2023. Ghana 2022 data covers only six months. Panel B. Internal consistency over time of coverage indicators, maternal mortality ratio and MMR:NMR ratio. Monthly values plotted by country for coverage and mortality indicators. Expected ranges from published literature (Table 2): mother-to-newborn PNC ratio 0.9–1.1; caesarean section rate 5–15%; MMR 20–400 per 100,000 live births; MMR:NMR ratio 0.4–1.7. KMC – Kangaroo Mother Care, LBW – low birthweight, MMR – maternal mortality ratio, NMR – neonatal mortality rate, PNC – postnatal care, PNMR – perinatal mortality rate, SBR – stillbirth rate.

Figure 2. Continued



Black lines indicates expected for range: 20-400 maternal deaths per 100,000 live births for Low and Middle-income countries.
Green line indicated SDG targets: <70 maternal deaths per 100,000 live births forall countries by 2030

Similar patterns emerged in the PNMR:NMR ratios, where Ghana (3.0–7.0) and Uganda (3.0–4.0) consistently exceeded the expected 1.2–2.0 range. Kenya showed gradual improvement in this metric over time, suggesting evolving reporting practices. Tanzania and Zimbabwe showed values closer to expected ranges. SBR:PNMR ratios exceeded the expected 0.6–0.8 range in Kenya (>2.5) and Ghana (>1.2), while Uganda remained within expected levels (Figure 2, Panel A).

Service coverage ratios reflected country-specific patterns and varied markedly. Mother-to-newborn postnatal care ratios in Uganda were within the expected range (0.9–1.1) (Figure 2, Panel B). The KMC:LBW ratio frequently exceeded the expected 0.4–0.8 range in Kenya (often >2.0) and Uganda (1.0–1.5), indicating either over-reporting of the intervention or under-detection of low birthweight infants (Figure 2, Panel A). Caesarean section rates were within expected ranges (5–15%) in most countries and periods except Ghana (26–32%).

MMR showed expected ranges (20–400 deaths per 100,000 live births) for low-resource settings, though with significant month-to-month variability suggesting reporting challenges rather than true epidemiological shifts (Figure 2, Panel B).

Objective 4: external consistency of indicators

DHIS2-derived estimates showed variable alignment across the four key indicators examined (Figure 3, Panels A–D). Mortality estimates were adjusted for facility birth coverage using country-specific factors (Ghana ×1.16, Kenya ×1.14, Tanzania ×1.23, Uganda ×1.10, Zimbabwe ×1.18) as described in methods, though these adjustments assume similar outcome rates among facility and non-facility births. Where complicated pregnancies present preferentially to facilities this assumption may not hold, so the adjusted external-consistency comparisons should be interpreted with caution.

Caesarean section rates showed considerable variation from international reference data across countries (Figure 3, Panel A). Ghana reported higher C-section rates through DHIS2 (26–32%) compared to WHO reference estimates (13–14.5%). Tanzania similarly showed higher DHIS2 rates than external estimates (14–19 *vs.* 7–9%). Conversely, Kenya (9–11%) generally reported lower rates than

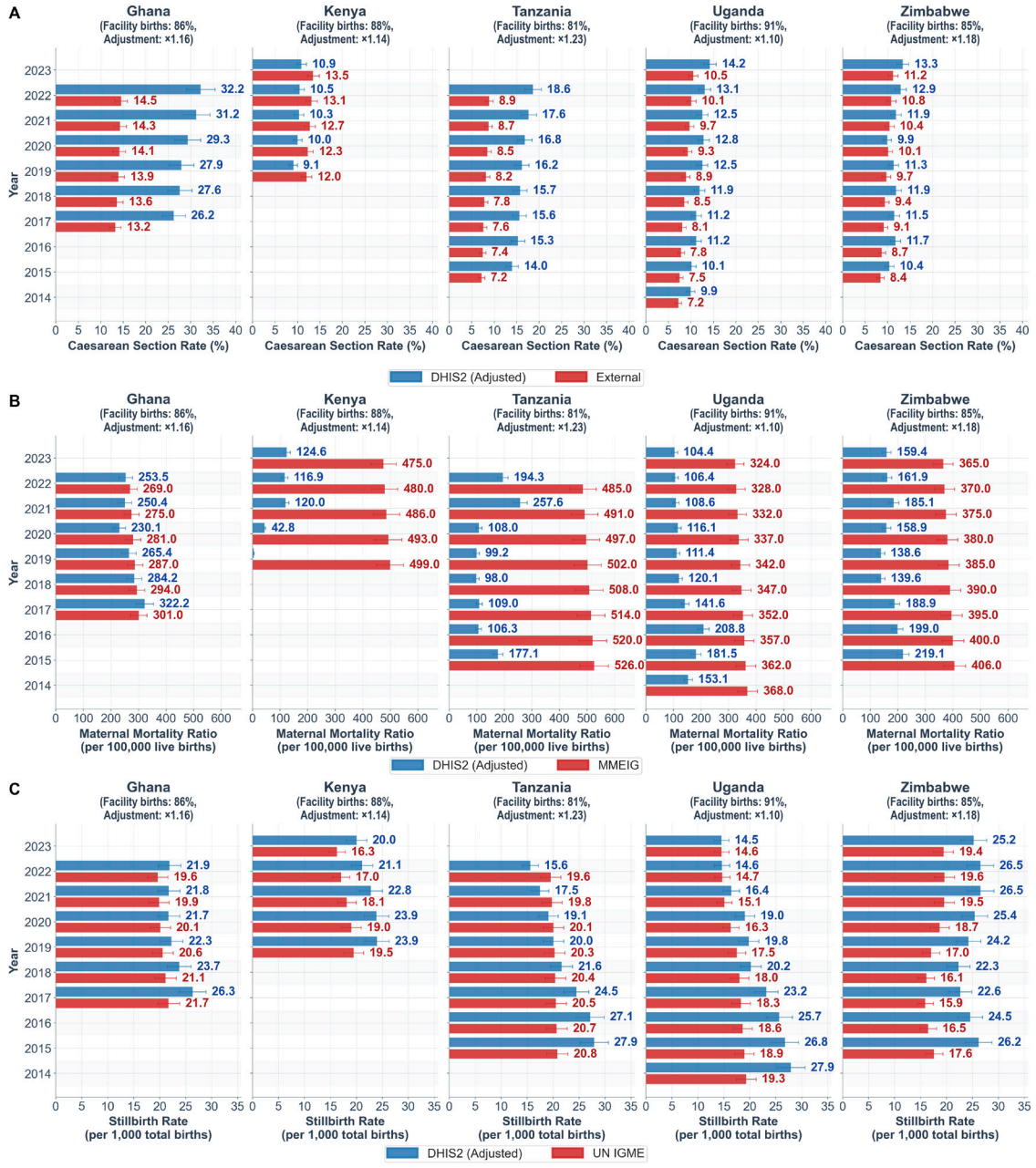
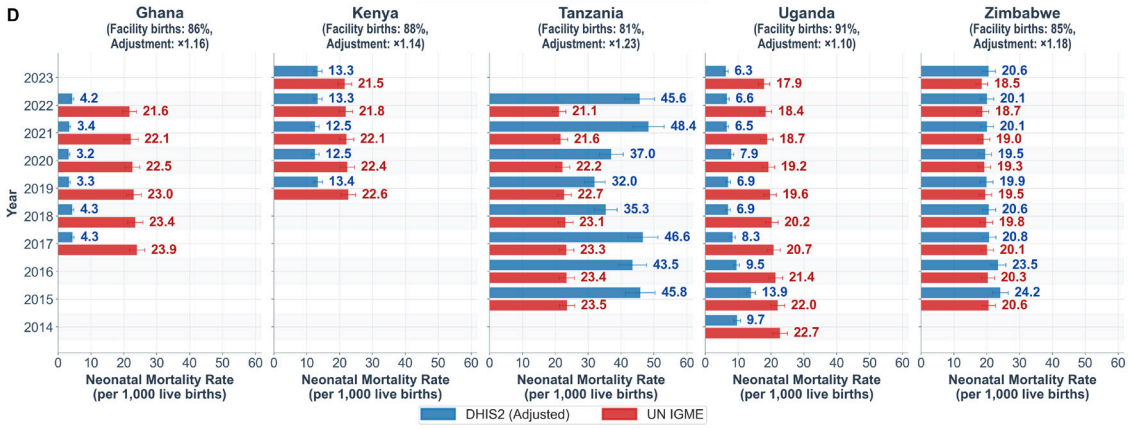


Figure 3. External consistency of DHIS2 maternal and newborn indicators with global reference estimates. Panel A. Comparison of caesarean section rate by country and year for DHIS2 estimates *vs.* WHO Global Health Observatory estimates with 95% CI. Comparison of caesarean section rates (%) by country and year. Ghana 2022 data covers only six months. Panel B. Comparison of maternal mortality ratio (MMR) by country and year for DHIS2 (adjusted for facility birth coverage) *vs.* maternal mortality estimation inter-agency group (MMEIG) estimates with 95% CI. Comparison of adjusted maternal mortality ratio (per 100,000 live births) by country and year. DHIS2 estimates were adjusted for facility birth coverage and compared with maternal mortality estimation inter-agency group (MMEIG) estimates with 95% confidence intervals. Ghana 2022 data covers only six months (January-June). Panel C. Comparison of stillbirth rate (SBR) by country and year for DHIS2 (adjusted for facility birth coverage) *vs.* UN inter-agency group for child mortality estimation (UN IGME) estimates with 95% CI. Comparison of adjusted stillbirth rate (per 1000 total births) by country and year. DHIS2 estimates were adjusted for facility birth coverage and compared with UN inter-agency group for child mortality estimation (UN IGME) estimates with 95% confidence intervals. Ghana 2022 data covers only six months (January–June). Panel D. Comparison of neonatal mortality rate (NMR) by country and year for DHIS2 (adjusted for facility birth coverage) *vs.* UN inter-agency group for child mortality estimation (UN IGME) estimates with 95% CI. Comparison of adjusted neonatal mortality rate (per 1000 live births) by country and year. DHIS2 estimates were adjusted for facility birth coverage and compared with UN IGME estimates with 95% confidence intervals. Ghana 2022 data covers only six months (January–June).

Figure 3. Continued



reference estimates (12–13.5%). Uganda (10–14% *vs.* 7–10.5%) and Zimbabwe (10–13% *vs.* 8–11%) showed rates broadly aligned with reference estimates.

Adjusted maternal mortality ratios (Figure 3, Panel B) revealed persistent underreporting relative to MMEIG estimates in most countries, though the gap was narrower than unadjusted comparisons would suggest. Ghana demonstrated the closest alignment, with adjusted DHIS2 estimates (230.1–322.2 per 100,000) closely approximating MMEIG estimates (269.0–301.0 per 100,000) capturing >70% of expected maternal deaths, and in 2017, the adjusted DHIS2 value (322.2) exceeded the MMEIG estimate (301.0). By contrast, Kenya had the largest discrepancy, capturing only 9–26% of expected maternal deaths. Tanzania captured approximately 19–49%, Uganda 29–58%, and Zimbabwe 36–54% of MMEIG estimated deaths.

Adjusted stillbirth rates (Figure 3, Panel C) generally exceeded, or closely matched UN IGME estimates across most countries. Ghana showed adjusted rates (21.7–26.3 per 1,000 total births) consistently above IGME estimates (19.6–21.7 per 1,000), with closer alignment in later years (21.9 *vs.* 19.6 per 1,000 in 2022). Kenya demonstrated a similar pattern, with adjusted rates (20.0–23.9 per 1,000) exceeding IGME estimates (16.3–19.5 per 1,000) throughout the study period. Uganda demonstrated notable convergence over time, from substantially higher adjusted values in earlier years (27.9 *vs* 19.3 per 1,000 in 2014) to near-equivalence by 2023 (14.5 *vs.* 14.6 per 1,000). Tanzania showed a crossover pattern: adjusted DHIS2 rates were initially higher than IGME estimates (27.9 *vs.* 20.8 per 1,000 in 2015) but progressively declined below them by 2022 (15.6 *vs.* 19.6 per 1,000), suggesting deteriorating capture of stillbirths over time. Zimbabwe consistently reported adjusted rates (22.3–26.5 per 1,000) above IGME estimates (16.1–19.6 per 1,000).

Adjusted neonatal mortality rates (Figure 3, Panel D) revealed the widest range of alignment across countries. Ghana's adjusted DHIS2 system captured only 14–19% of expected neonatal deaths (3.2–4.3 *vs.* 21.6–23.9 per 1,000 live births), representing the most severe underreporting among the five countries. Uganda showed similarly substantial underreporting, capturing approximately 29–63% of expected deaths depending on the year (6.3–13.9 *vs.*17.9–22.7 per 1,000). Kenya performed somewhat better, with adjusted rates (12.5–13.4 per 1,000) representing approximately 57–62% of IGME estimates (21.5–22.6 per 1,000). In contrast, Tanzania's adjusted rates (32.0–48.4 per 1,000) substantially exceeded IGME estimates (21.1–23.5 per 1,000), possibly reflecting more complete facility-based death capture, differences in case definitions, or underestimation in modelled global estimates. Zimbabwe showed the closest alignment, with adjusted rates (19.5–24.2 per 1,000) closely matching IGME estimates (18.5–20.8 per 1,000) throughout.

Sensitivity analysis

We repeated the external consistency analysis using ratio-of-sums aggregation, which weights facilities proportionally to delivery volume, for both higher-level facilities only (Figure S4, Panels A–D in the Online Supplementary Document) and all facility levels (Figure S5, Panels A–D in

the Online Supplementary Document). Overall patterns were broadly consistent with the main ratio-of-means analysis. Stillbirth rates remained generally above or near UN IGME estimates, and MMR remained underreported across countries. However, neonatal mortality estimates differed in magnitude: Tanzania's apparent over-reporting relative to UN IGME was attenuated under ratio-of-sums, particularly when restricted to higher-level facilities (Figure S4, Panel D in the Online Supplementary Document), as higher-volume facilities contributed disproportionately to the aggregated estimate. Ghana and Uganda's underreporting persisted regardless of aggregation method or facility level. Including all facility levels (Figure S5, Panels A–D in the Online Supplementary Document) produced estimates closer to the ratio-of-means main analysis, consistent with the broader facility mix captured in both approaches.

DISCUSSION

This multi-country analysis of DHIS2 data quality for 16 ENAP indicators across five sub-Saharan African countries (2014–2023) revealed that more than half were consistently available (Uganda (94%), Kenya (69%), Tanzania (69%), Ghana (56%) and Zimbabwe (56%)). However, significant gaps existed for newborn care interventions (newborn resuscitation, Kangaroo Mother Care, treatment of severe neonatal infection), and persistent inconsistencies were observed in reporting completeness and alignment with global estimates.

The inconsistent availability of data on intrapartum stillbirth rate, low birthweight, and preterm birth further underscores the challenges in capturing and reporting MNCH data within the DHIS2 systems. Variations in the timing and the extent of DHIS2 implementation across the countries likely contributed to the observed differences in data availability and completeness. The phased rollout of DHIS2, often starting with pilot programmes in select districts before expanding nationwide, might explain the gaps in data availability for certain indicators, particularly in Uganda where full-scale implementation occurred in 2012 [20,32]. Furthermore, the reliance on paper-based data collection and aggregation processes, particularly in Kenya, may have contributed to suboptimal utilisation of the DHIS2 platform and potential delays or inconsistencies in data entry [23,29]. Furthermore, the presence of a data element in DHIS2 does not guarantee active data capture, as illustrated by Ghana's preterm birth field where all recorded values were zero throughout the study period, and our availability assessment may therefore overestimate functional data capture in some settings.

We observed notable differences in facility reporting across the five countries, consistent with patterns observed in Burkina Faso and Mozambique [33]. Uganda's sharp decline in hospital reporting from 86% (2018) to 50–51% (2019–2020) began before the COVID-19 pandemic, suggesting system transitions and health worker industrial action may have contributed, with the pandemic potentially compounding these from 2020. These factors were not directly measured in this analysis and are therefore proposed as plausible hypotheses rather than established causes. At facility level, only around a quarter of ever-reporting facilities submitted data in every expected month, and a quarter reported in fewer than half of their expected months (Table S7 in the Online Supplementary Document), indicating that intermittent reporting is common even among facilities engaged with DHIS2. Previous reports from Kenya and Uganda indicated that unavailability of the person responsible for data compilation and submission of reports affected the completeness and timeliness of data submitted to the DHIS2 [63,64]. To improve completeness, these countries can adopt methods such as internet-based reporting and continuous reminders to healthcare workers' mobile phones, as reported in other African countries [64,65]. Moreover, additional infrastructural and personnel investments into DHIS2 to facilitate continuous reviews will considerably address the data quality issues and examine fitness for purpose [32,66].

We observed internal inconsistency issues primarily in Ghana and Kenya. This underscores the critical role of human capital in monitoring and reporting MNCH indicators [29]. Elevated SBR:PNMR ratios in Kenya and Ghana partly reflect differences in how perinatal deaths are

defined within DHIS2, as some countries record only early neonatal deaths rather than the WHO-standard definition inclusive of stillbirths. Kenya's elevated KMC:LBW ratios (>2.0) emerged from 2020. The 2022 WHO guidelines recommend KMC as routine care for all preterm or low-birthweight infants [67]. The rapid increase in KMC reporting without a corresponding rise in low birthweight detection suggests either broader application of KMC eligibility criteria or incomplete low birthweight ascertainment. The fluctuations in postnatal care coverage in Kenya may similarly reflect changing reporting practices.

Ghana's elevated C-section rates (26–32%) likely reflect the hospital-only sampling frame; referral facilities perform a disproportionate share of surgical deliveries, inflating facility-level estimates above population-based reference rates. This hospital-only frame also likely contributes to Ghana's extreme SBR:NMR ratios (5.0–12.5), as hospitals receiving complicated cases would report disproportionately more stillbirths relative to neonatal deaths; differences in stillbirth classification and denominator inaccuracies may also contribute, so these ratios are best read as hypotheses requiring further investigation rather than established evidence of neonatal death under-reporting. Similarly, Ghana's relatively close MMR alignment with MMEIG estimates may partly reflect more complete death capture in hospitals compared with mixed facility-level data from other countries.

We also observed that Kenya and Uganda reported data on both low birth weight and preterm births, whereas Ghana, Tanzania and Zimbabwe reported only low birth weight data (Ghana's preterm-birth element recorded only zero values). Such results have been previously reported from sub-Saharan African countries showing inconsistencies in maternal and newborn health indicators both regionally and subnationally [68,69]. In most countries, data fed into the DHIS2 are transferred from paper-based forms which tend to vary from facility to facility, within the same country, which might lead to inconsistent documentation and misclassification of outcomes such as stillbirth and neonatal deaths [29]. These quality gaps can sometimes originate from data generation processes (register design, training and paper-to-digital transcription), rather than from the DHIS2 platform itself. Encouragingly, all five countries are transitioning to electronic medical record systems (Electronic Medical System (EMR) powered by eAFYA and Clinic Master and an Electronic Community Health Information System (eCHIS) powered by the Community Health Toolkit and Open Smart Register for all village health teams in Uganda [70], the Lightwave Health Information Management System in Ghana [71], Impilo in Zimbabwe [72], the Government of Tanzania Health Operation Management Information System (GoT-HoMIS) and AfyaCare in Tanzania [73], and the TaifaCare digital health platform in Kenya [74]), which capture individual-level data at the point of care and could reduce paper-based transcription errors while providing more granular data than aggregate DHIS2 reporting. Differences in the definitions result in lost comparability both within and across countries. Our findings reveal specific shortcomings across Findable, Accessible, Interoperable and Reusable (FAIR) data principles [75]: for example, perinatal death definitions varied across countries, with some recording only early neonatal deaths rather than the WHO-standard definition (limiting Interoperability), data extraction required MOH-mediated requests rather than open access (limiting Accessibility), and differing data element structures prevented direct cross-country comparison (limiting Reusability).

After adjusting DHIS2 estimates for facility birth coverage to enable fairer comparison with population-level reference estimates, we found that stillbirth rates from DHIS2 generally exceeded or closely matched UN IGME estimates in most countries, suggesting that DHIS2 may capture a relatively complete picture of institutional stillbirths. Over-reporting, misclassification of early neonatal deaths as stillbirths, and differences in stillbirth case definitions could also contribute and are not mutually exclusive. However, MMR remained substantially underreported even after adjustment, with only Ghana approaching parity with MMEIG estimates. Neonatal mortality showed the most variable pattern: Ghana and Uganda showed severe underreporting, Kenya captured approximately 60% of expected deaths, Tanzania paradoxically reported substantially higher rates than global estimates, a finding unique among the five countries and warranting closer examination. Tanzania achieved near-universal reporting completeness (>95%), potentially

capturing a larger share of neonatal deaths than countries with lower reporting rates. Case definition differences may also contribute: if some early deaths classified as fresh stillbirths elsewhere are recorded as neonatal deaths in Tanzania, this would inflate NMR while reducing SBR, consistent with Tanzania's declining stillbirth rates over the study period. This finding was partially attenuated under ratio-of-sums aggregation restricted to higher-level facilities (Figure S4, Panel D in the **Online Supplementary Document**), suggesting that smaller facilities may report disproportionately higher death rates. It is also possible that IGME modelled estimates, which rely heavily on DHS data, underestimate true neonatal mortality in Tanzania if survey-based measures are subject to recall bias. Zimbabwe achieved close alignment. These findings suggest that the completeness of death reporting in DHIS2 varies by outcome type, with stillbirths more reliably captured than neonatal or maternal deaths.

Our findings on external consistency align with recent single study assessments. Shabani *et al.* found substantial underreporting of neonatal and maternal mortality in Tanzania's DHIS2 relative to DHS estimates [56] and Bhattacharya et al. reported similar patterns in Gombe State, Nigeria [57]. Our multi-country analysis extends these findings, showing that discrepancies (magnitude and direction) between DHIS2 and external estimates vary substantially by country and indicator. Our sensitivity analysis using ratio-of-sums aggregation (Figure S4, Panel A–D and Figure S5, Panels A–D in the **Online Supplementary Document**) produced broadly similar patterns to the main analysis, though Tanzania's apparent neonatal mortality over-reporting was attenuated when higher-volume facilities dominated the estimate. Our country-specific facility birth coverage adjustment, while more precise than a uniform correction, assumes similar outcome rates among facility and non-facility births. The MMEIG and UN IGME comparators are themselves modelled estimates with wide uncertainty that depend heavily on survey inputs, so discrepancies may reflect limitations in either source rather than DHIS2 alone.

DHIS2 relies on complex people-based and paper-based subsystems [29], and data quality may have been affected by industrial actions, limited personnel, inadequate information technology infrastructure, poor internet connectivity and unstable electricity supply [29,30,33,36,76,77]. Gradual rollouts of DHIS2, typically starting with specific region(s) before achieving national coverage [24] may have contributed to the spatial inequalities in reporting observed in this analysis. In addition, spatial differences in internet availability and reliability within the countries could have affected the quality of the data as previously reported in Uganda [63]. In this analysis, there were instances where missing data were assigned zero, making it impossible to distinguish true zeros from missing values. For instance, in Ghana all preterm data entries had the count zero throughout the period of study meaning Ghana has the data element, but zero values possibly indicating that data are not captured. Data inconsistencies can also reflect infrastructure gaps and societal barriers to accessing MNCH services [78].

Study strengths and limitations

Our study has several strengths. First, it represents the first multi-country assessment of ENAP indicator data quality within DHIS2, spanning five countries and up to ten years. Second, we applied the WHO data quality assessment framework, evaluating availability, reporting completeness, internal consistency, and external consistency with global estimates. Third, we directly collaborated with MOH representatives in each country to ensure accurate mapping, extraction and interpretation, including a data validation workshop in Nairobi (May 2025) to clarify inconsistencies with country teams.

Our study also had several limitations. First, we could not verify the accuracy of original data entry at facility level since DHIS2 captures aggregated data already compiled from primary registers. Second, paper-based data collection in some settings may have introduced transcription errors that we could not detect. Third, geographic coverage within countries could not be fully ascertained, so we cannot confirm whether reporting facilities were representative of all regions. The five countries were a purposive selection rather than a representative sample, which may

introduce selection bias towards systems with stronger existing partnerships and limit generalisability to the wider region. Nevertheless, the consistency of these data quality gaps across five contrasting health data systems suggests similar challenges are highly likely in other countries implementing DHIS2. Fourth, DHIS2 data are subject to variations in facility-level reporting practices, unreliability of denominators for incidence calculations, differences in data quality between facility types, and non-standardised case definitions across settings [33].

Fifth, temporal coverage varied across countries, from six years in Ghana to ten years in Uganda, which may affect direct comparisons. Because Ghana's extract included hospitals only, all Ghana comparisons, including reporting completeness, mortality rates, caesarean-section rates and internal-consistency ratios, reflect a referral-weighted subset, so cross-country comparisons involving Ghana should be read with caution. Sixth, our analysis used aggregate data only, so individual-level patterns in data quality could not be examined. Seventh, our adjustment for facility birth coverage assumes that the rate of adverse outcomes is similar among facility and non-facility births. Women delivering outside health facilities may face higher risks (making our adjusted estimates conservative), while facility-based populations may include more complicated referral pregnancies, potentially inflating rates relative to population averages. Lastly, we did not assess timeliness of reporting, a fourth dimension recommended by the WHO Data Quality Review framework, as submission dates were not consistently available across all five countries' DHIS2 extracts. This omission means our assessment covers only three of the four WHO Data Quality Review dimensions and is a substantive limitation rather than a minor one.

CONCLUSIONS

Our study identified specific, country-level weaknesses in MNCH data within DHIS2 that require targeted action. Ghana's extreme SBR:NMR ratios (5.0–12.5) may reflect misclassification between stillbirths and neonatal deaths at hospital level and expanding DHIS2 data capture beyond hospitals in Ghana is needed to improve representativeness. In Kenya, lower-level facility reporting declined from 81% to 54% over five years, threatening the representativeness of DHIS2 data; reversing this trend will require investment in training, data management resources, and reporting infrastructure at dispensary and health centre level. Tanzania shows that near-universal reporting completeness is achievable, but the divergence between DHIS2 and IGME neonatal mortality estimates warrants investigation of case definitions, particularly at lower-level facilities. Across all five countries, data validation mechanisms are needed to detect anomalies, and indicator definitions should be harmonised and aligned with international standards to improve cross-country comparability.

The persistent underreporting of maternal mortality (capturing only 9–70% of expected deaths depending on the country) and the universal absence of data elements for neonatal morbidity, small-for-gestational-age births, and quality-of-care indicators, and substantial cross-country inconsistencies confirm that DHIS2 alone cannot provide a complete picture of maternal and newborn outcomes. Countries should complement routine DHIS2 data with civil registration, verbal autopsy, and household survey systems, and leverage their ongoing transitions to electronic medical records as a future source of individual-level data. These systems are themselves still developing in many settings; for example, birth and death registration in Uganda was still being piloted during the study period [35]. With investment in automated data validation, periodic quality audits, and harmonised indicator definitions, DHIS2 can better support regional MNCH monitoring, but realising this potential requires addressing the country-specific challenges this analysis has identified.

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Ethics statement: The data analysed are routine aggregated data that are summarised and submitted into DHIS2-monthly by each reporting facility and therefore no ethical permission was required. Ministry of Health representatives in each country authorised data extraction from their respective DHIS2 platforms.

Consent for publication: Not applicable as no individual-level data are presented.

Data availability: The main data source is the routine health information system. Data are reported by health facilities into a national database supported by the District Health Information System software version 2 (DHIS2) https://dhis2.org. The data used in this study were extracted from national DHIS2 platforms by Ministry of Health representatives in each country. Requests for data access should be directed to the respective Ministries of Health in Ghana, Kenya, Tanzania, Uganda and Zimbabwe.

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Authorship contributions: The study was conceptualised by EOO and LM. JA led the development of the data extraction template and coordinated with Ministry of Health representatives in each country. JS coordinated data extraction for Tanzania, WC for Zimbabwe, GPO for Kenya, EK for Ghana, and DB and PM for Uganda. GPO undertook the initial data cleaning. JA undertook the validation and analyses with statistical oversight from EOO. All authors participated in the data validation workshop held in Nairobi in May 2025. The manuscript was drafted by JA with input from EOO and LM. All authors reviewed, revised and approved the final version.

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Additional material
Online Supplementary Document

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