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Measuring facility readiness to provide childbirth care: a comparison of indices using data from a health facility survey in Ethiopia

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ABSTRACT

Background Actionable information about the readiness of health facilities is needed to inform quality improvement efforts in maternity care, but there is no consensus on the best approach to measure readiness. Many countries use the WHO's Service Availability and Readiness Assessment (SARA) or the Demographic and Health Survey (DHS) Programme's Service Provision Assessment to measure facility readiness. This study compares measures of childbirth service readiness based on SARA and DHS guidance to an index based on WHO's quality of maternal and newborn care standards.

Methods We used cross-sectional data from Performance Monitoring for Action Ethiopia's 2019 survey of 406 health facilities providing childbirth services. We calculated childbirth service readiness scores using items based on SARA, DHS and WHO standards. For each, we used three aggregation methods for generating indices: simple addition, domain-weighted addition and principal components analysis. We compared central tendency, spread and item variation between the readiness indices; concordance between health facility scores and rankings; and correlations between readiness scores and delivery volume.

Results Indices showed moderate agreement with one another, and all had a small but significant positive correlation with monthly delivery volume. Ties were more frequent for indices with fewer items. More than two-thirds of items in the relatively shorter SARA and DHS indices were widely (>90%) available in hospitals, and half of the SARA items were widely (>90%) available in health centres/clinics. Items based on the WHO standards showed greater variation and captured unique aspects of readiness (eg, quality improvement processes, actionable information systems) not included in either the SARA or DHS indices.

Conclusion SARA and DHS indices rely on a small set of widely available items to assess facility readiness to provide childbirth care. Expanded selection of items based on the WHO standards can better differentiate between levels of service readiness.

Key questions

What is already known?

- Many health facilities in low-income and middle-income countries operate under significant constraints, such as inadequate staffing, medicine stock-outs, equipment shortages and poorly functioning information and referral systems, which limit their capacity to provide safe and effective childbirth care.
- Information about the readiness of health facilities to provide childbirth care is needed to guide quality improvement efforts, but there is no consensus on the best approach to measure readiness.

What are the new findings?

- This study compares three facility survey assessment tools and statistical methods for constructing indices to measure facility childbirth service readiness in Ethiopia and finds that indices show moderate agreement with one another.
- More than two-thirds of items in the relatively shorter tools were widely (>90%) available in hospitals in Ethiopia, limiting the ability of the tools to discriminate between readiness levels.
- Items based on the WHO quality of care standards showed greater variation and captured unique aspects of readiness not included in other indices.

What do the new findings imply?

- It is feasible to create a service readiness index without the use of complex statistical methods; additive methods produce indices that are easy to generate, interpret and deconstruct to identify bottlenecks to health system performance.
- Item selection should favour inclusion of items with a strong theoretical basis and the ability to discriminate between levels of service readiness.

INTRODUCTION

Building on momentum to end preventable maternal and newborn deaths, country and global stakeholders have committed to meet the Sustainable Development Goals (SDGs) of reducing the global maternal mortality ratio to less than 70 deaths per 100 000 live births and neonatal mortality rates to 12 or fewer deaths per 1000 live births in all countries

by 2030.[1] Achievement of these targets will depend on improving coverage of life-saving interventions during the intrapartum period and the first 24 hours following birth, when an estimated 46% of maternal deaths and 40% of neonatal deaths and stillbirths occur.[2]

Improving skilled birth attendance, primarily through increasing the proportions of births at health facilities, is a key intervention for achieving the SDG-3 goals. A recent analysis of household survey and routine health information system data show an increase in the global proportion of deliveries that occur in a health facility from 65% in 2006–2012 to 76% in 2014–2019, with the largest increases observed in sub-Saharan Africa and South Asia.[3] However, increased use of facility childbirth services has not consistently translated into the expected gains in maternal and neonatal survival. Research offers mixed evidence of the relationship between use of facility childbirth services and maternal and newborn health outcomes in low-income and middle-income countries (LMICs).[4–12] For maternal health, these inconsistent findings may, in part, be explained by differences in the risk profile of patients accessing services,[4 5 9 10] with high-risk patients being more likely to seek care at a health facility, therefore, biasing the results towards the appearance of limited or no effectiveness. The mixed evidence also points to significant variations in the quality of care provided across facilities and contexts. Secondary analysis of two large population-based cluster-randomised control trials in Ghana found no evidence of an association between facility birth and mortality outcomes, but the overall result masked differences in quality of care across facilities; proximity to facilities offering high-quality care was associated with lower risk of intrapartum stillbirth and composite mortality outcomes.[7] Indeed, the quality of childbirth care is now receiving heightened attention globally.[13]

Ensuring facility readiness is an essential first step towards improving the quality of care in LMICs. Readiness, as conceptualised by WHO, is the capacity of a facility to provide services to a defined minimum standard, including the presence of trained staff, commodities and equipment; appropriate systems to support quality and safety; and provider knowledge.[14] Kanyangarara *et al*'s analysis of survey data from health facilities in 17 LMICs found wide variation in the availability of such essential resources. For example, the availability of magnesium sulphate—a drug used to prevent or treat seizures for patients with (pre-)eclampsia—ranged from 10% to 97% across countries.[15] Moreover, inadequate provider knowledge and poor adherence to clinical practice standards exacerbate deficiencies in the provision of quality care.[16–20] As a result, large gaps exist between 'service contact' (ie, individuals who use childbirth services) and 'effective coverage' (ie, individuals who experience a positive health gain from using childbirth services) in maternal and newborn health in LMICs.[21–23]

For childbirth services, several indices have been proposed to measure service readiness. The WHO's health facility assessment tool, Service Availability and Readiness Assessment (SARA), proposes indices to measure basic and comprehensive obstetric care readiness.[24 25] The Demographic and Health Surveys (DHS), the major source of data on population, health and nutrition in LMICs, have also collected facility level data in selected countries using the Service Provision Assessment (SPA) tool since 1999. The SPA surveys cover facility readiness in terms of infrastructure, resources and management systems for antenatal care, delivery services, newborn care and emergency obstetric care. Wang *et al* offer an alternative obstetric and newborn care readiness index in an analytical study using the DHS data.[26 27] Others have measured readiness to perform obstetric signal functions based on the framework for monitoring emergency obstetric care developed by the WHO, United Nations Population Fund (UNFPA), UNICEF and the Mailman School of Public Health Averting Maternal Death and Disability programme,[28–33] expanded by some to include signal functions for routine childbirth and newborn care as well as emergency referrals.[34–40] More recently, researchers and practitioners have proposed using indicators from the WHO's Standards for improving quality of maternal and newborn care in health facilities to assess a broader range of quality domains.[41–45]

These measurement approaches share many commonalities. However, there are important differences in item selection and aggregation methods and, to date, there is no consensus on the best approach for measuring facility readiness for childbirth services in LMICs. Conventional indices tend to focus on the availability of commodities with limited consideration of the systems necessary to support quality and safety. These conventional indices may not fully capture the readiness elements predictive of quality care. A previous study by Leslie *et al* found that service readiness, based on an index constructed from SARA tracer items, was weakly associated with observed clinical quality of care in Kenya and Malawi.[46] The need to refocus health facility assessments to measure quality of care—including key readiness, process and outcomes measures—has been a key consideration in the ongoing process to revise the DHS SPA as well as the process led by the WHO, in collaboration with the Health Data Collaborative, to develop a standardised health facility assessment.

Health authorities require actionable information about the readiness of health facilities to guide quality improvement efforts, but there is no agreement on how best to measure readiness. The objective of this study is to compare childbirth service readiness indices to ascertain their relative utility for programming and decision making.

METHODS

Study setting

The study is based on data from health facilities in Ethiopia. The public sector health service in Ethiopia

is designed as a three-tiered system. In rural areas, the primary level consists of an interconnected network of health posts, health centres and primary hospitals, with linkages to general and specialised hospitals.[47] In urban areas, health centres are linked directly to general hospitals and specialised hospitals. The public sector provides labour and delivery services at health centres and hospitals. Government health centres provide routine delivery services and basic emergency obstetric and neonatal care (BEmONC); government hospitals provide comprehensive emergency obstetric and neonatal care (CEmONC),[48] which includes caesarean sections and blood transfusions.[47 48] However, in practice, gaps exist in the capacity of health facilities to provide the full range of obstetric and neonatal care services. A 2016 survey found that only 5% of government health centres were able to provide all BEmONC signal functions, and only 52% of government hospitals had the capacity to offer all CEmONC components.[48]

The private health sector in Ethiopia encompasses a heterogeneous mix of private-for-profit, non-profit and faith-based hospitals and clinics. However, the 2014 SPA-Plus survey estimated that less than one-third of private-for-profit facilities offer labour and delivery services.[49] These services are generally limited to routine delivery services; few private facilities have the capacity to provide emergency care.[48 49] Among women who delivered in a health facility, the Ethiopia Mini DHS 2019 estimated that 95% of women delivered in a public facility and only 5% delivered in a private facility.[50]

Study design and procedures

The study uses cross-sectional data collected between September and December 2019 from a sample of service delivery points (SDPs) across all regions and two city administrations in Ethiopia. SDPs were identified following selection of the study's enumeration areas (EAs) as described in the study protocol available elsewhere.[51] All government health posts, health centres, and primary level and general hospitals whose catchment area covers a sampled EA were eligible for the survey. In addition, private sector SDPs located within the EA's kebele—the lowest level administrative division in Ethiopia—were invited to participate in the survey, up to a maximum of three private SDPs per EA. Private health facilities are relatively rare in rural Ethiopia, and few women in Ethiopia deliver in private facilities.[50] Our sample reflects this reality, where most kebeles in the Performance Monitoring for Action Ethiopia (PMA-ET) sample did not have even one private SDP.

After obtaining consent from the head of the facility or designated authority, data were collected using a standardised questionnaire, publicly available at http://www.doi.org/10.34976/kvvr-t814.[52] A total of 534 hospitals, health centres and health clinics completed the survey, a response rate of 98.9%; among these, 406 facilities provide childbirth services. The survey was administered as part of PMA-ET, a project implemented by the Addis Ababa University School of Public Health and the Johns Hopkins Bloomberg School of Public Health, and funded by the Bill & Melinda Gates Foundation (INV 009466).

Measurement

Selection of items for the childbirth service readiness indices followed existing guidance or theoretical frameworks (online supplemental table S1). The first approach to item selection relies on tracer items for basic and comprehensive obstetric care listed in the WHO SARA Reference Manual[24]; these items were selected by WHO in consultations with service delivery experts.[25] A second approach uses items included in the index developed by Wang *et al* for a DHS analytical study[26 27]; item selection for this index was also guided by the WHO SARA Reference Manual,[24] as well as the recommendations by the Newborn Indicator Technical Working Group and a review conducted by Gabrysch *et al*.[40]

In the third approach, PMA-ET items were mapped to the WHO Standards for improving quality of maternal and newborn care in health facilities[41 53] to identify a pool of 67 candidate items for health centres/clinics and 79 candidate items for hospitals. Analyses were performed to identify a smaller, parsimonious set of items that would capture the three 'provision of care' standards (evidence-based practices, information systems, referral systems) and two 'cross-cutting' standards (human resources, physical resources) in the WHO framework.[41 53] To assess the value of candidate items, we first calculated the percentages of hospitals and the percentages of health centres/clinics that had each item available at the time of the 2019 PMA survey. We excluded items that were nearly universally (>97%) available since these items had limited ability to differentiate between facilities, and we excluded items flagged for concerns about response bias or with unclear interpretations (online supplemental table S2). After this initial round of exclusions, we examined the correlation structure between items overall and by readiness domain: (1) equipment, supplies and amenities; (2) medicines and health commodities; (3) staffing and systems for quality and safety; and (4) performance of signal functions. For each domain, a two-parameter logistic item response model was fitted to characterise item discrimination (ie, the ability of the item to differentiate between facilities of different readiness levels) and item difficulty (ie, whether the item is widely or rarely available in facilities irrespective of readiness level). The final set of 44 items for health centres and 52 items for hospitals was determined based on statistical properties and conceptual alignment with the WHO framework (online supplemental tables S1, S2). Retained items showed variation across facilities and good discrimination, and together, the selection ensured representation across the four readiness domains and five WHO standards.

A scoping review of published and grey literature identified three common approaches for aggregating items to generate a single composite readiness score for childbirth care: simple addition of items, domain-weighted addition

Table 1 Methods to construct service readiness indices

Item selection	
SARA tracer items for obstetric care*	15 items for health centres plus seven additional items for hospitals based on the WHO SARA basic and comprehensive obstetric care tracer items.[23] These correspond to three readiness domains: (A) staff and training; (B) equipment and (C) medicines and commodities.
DHS analytical study's obstetric and newborn care readiness indicators*	30 items for health centres plus three additional items for hospitals based on obstetric and newborn readiness indicators described in the DHS analytical studies No. 65.[24 25] This includes items across five readiness domains: (A) performance of signal functions for emergency obstetric care; (B) performance of newborn care functions; (C) general requirements; (D) equipment and (E) medicines and commodities. The DHS programme proposes an additional domain for 'guidelines, staff training and supervision'; however, this domain is excluded from the domain-weighted addition given limited availability of these items in the PMA-ET survey.
WHO standards for improving quality of maternal and newborn care readiness items*	44 items for health centres plus eight additional items for hospitals available in the PMA-ET survey instrument mapped to the WHO Standards for improving quality of maternal and newborn care in health facilities.[39] These include three 'provision of care' standards and two 'cross-cutting' standards: (1) evidence-based practices for routine care and management of complications; (2) actionable information systems; (3) functional referral systems; (4) competent, motivated human resources and (5) essential physical resources. These items are also grouped in four readiness domains: (A) equipment, supplies and amenities; (B) medicines and health commodities; (C) staffing and systems for quality and safety; and (D) performance of signal functions.
Aggregation method	
Simple addition of items	The number of items that is available on the day of the assessment is added together. The number of available items is divided by the total number of possible items to compute a score ranging from 0 to 1. Each item is given equal weight.
Weighted addition of items by readiness domain	Within each readiness domain, the number of items that is available on the day of the assessment is added together. The number of available items per domain is divided by the number of possible items per domain to compute a domain score. The sum of the domain scores is divided by the number of domains to compute a score ranging from 0 to 1. Each domain is given equal weight.
Principal components analysis (PCA)	PCA is a data reduction technique that converts a set of correlated items into orthogonal components. Each component explains some proportion of the variation across the items, with the first component explaining the largest proportion. The first component is extracted and rescaled to a score ranging between 0 and 1.
Composite indices	
Combination of item selections with aggregation methods	Each of the item selections (1=SARA, 2=DHS, 3=WHO standards) are aggregated using three different methods (1=simple addition, 2=weighted addition, 3=PCA) to generate nine childbirth service readiness indices.

*Please refer to online supplemental tables S1 and S6 for the complete list of items selected for each of the readiness indices and for information on any items excluded due to lack of available data.
DHS, Demographic and Health Survey; PMA-ET, Performance Monitoring for Action Ethiopia; SARA, Service Availability and Readiness Assessment.

of items and the data dimensionality reduction method of principal components analysis (PCA). We paired each of the three-item selection methods with the three aggregation methods to generate nine indices (table 1). Prior to aggregation, all items were coded as 0 'no' or 1 'yes' to indicate whether the item was observed on the day of the assessment, whether the function was reported as performed, or whether the system was reported as being in place. The few instances (<1%) where a response was missing or where interviewees responded 'don't know' were coded to 0. Additionally, five items were only asked for a subset of health facilities (eg, government facilities) and marked 'not applicable' for the remainder (3%–8%). For those facilities, the 'not applicable' items were excluded and the denominator adjusted accordingly to calculate scores using simple or weighted addition; the 'not applicable' responses were coded to 0 prior to aggregation by PCA.

Readiness scores were calculated separately for hospitals and for health centres/clinics to reflect the difference in services provided at different levels of Ethiopia's tiered health system. In addition to routine childbirth services, health centres offer BEmONC whereas hospitals offer CEmONC that includes caesarean sections and blood transfusions.[47] Thus, readiness scores for hospitals were computed using an expanded list of items relevant for CEmONC. Similarly, PCA scores were generated separately for hospitals and for health centres/clinics. As a result, scores are comparable within each tier, but not directly comparable across tiers.

Statistical analysis

We calculated readiness scores for each health facility in the sample using all nine indices. We then compared measures of central tendency, spread, skewness and kurtosis across approaches. We also examined eigenvalues and loadings for indices generated using PCA in order to assess the variance explained by the first component, subsequently used to calculate the readiness score.

To compare the variability and distribution of scores across indices, we adopted an approach similar to that used by Sheffel *et al* to develop quality of antenatal care indices. [54] Ideally, an index can accurately differentiate between facilities with differing levels of readiness, including those at the high and low ends. To assess this characteristic, we calculated the coefficient of variation

and proportion of facilities scoring either a 0 (floor) or 1 (ceiling). Another desirable characteristic is that the individual items that comprise an index demonstrate a range of variability. We assess this by calculating the proportion of items that are rare (<40%) or widely available (>90%).

We calculated differences between readiness scores and between rankings within health facilities measured using different indices and compared these differences using graphical displays. We expected facilities to consistently score high or low regardless of the methods used to assess their readiness. If an index score deviates substantially relative to other indices, this likely indicates that it is measuring a different construct or that particular item(s) are unduly influencing the score. Next, to understand differences in the data structure and composition of the indices, we deconstructed the composite scores into domain-specific scores, and then we examined interdomain correlations, interitem correlations, and the internal consistency of items overall and within each domain.

Prior research suggests an association between childbirth service readiness and delivery volume.[26] We evaluated this association using Spearman's ranked correlation coefficient. All statistical analyses were performed using Stata IC, V.15.1.[55]

Patient and public involvement

Patients were not involved in the research. A project advisory board, chaired by the Deputy Minister of Health, and composed of representatives from the Federal Ministry of Health, professional associations, multilateral organisations, non-governmental organisations and donors provided input during survey design and development. The project advisory board advises PMA-Ethiopia on data analysis, utilisation and dissemination.

RESULTS

Of the 406 facilities that provide childbirth services, the vast majority are public facilities: 96.3% of hospitals and 93.9% of health centres and clinics (table 2). Facilities are distributed across all regions of the country, with a higher proportion located in the more populous regions of Oromiya, Amhara and the Southern Nations, Nationalities and Peoples Region (SNNP).

Figure 1 shows the distribution of scores by index (see also online supplemental table 3). Median index scores range from 0.92 to 0.96 for hospitals and from 0.75 to 0.86 for health centres/clinics. WHO standards-based indices generate slightly lower median scores relative to other indices. Across indices, scores show substantial skewness and kurtosis, with observations clustered around the highest scores (online supplemental figure S1). Scores generated using PCA show the greatest skewness and kurtosis.

Scores generated using SARA tracer items show limited item variation and more ceiling effects (table 3); using the SARA simple addition method, 34 (21.2%) hospitals receive a perfect score and 50 (31.2%) tie for the next highest score. Among health centres, 16 (6.5%) receive a perfect score and 45 (18.3%) tie for the next highest rank (online supplemental table S4). The inclusion of more items in the WHO standards-based indices reduces ceiling effects and limits ties in rankings. Use of PCA produces a higher coefficient of variation relative to the simple or domain-weighted addition methods for SARA, DHS and WHO standards-based indices. PCA-derived scores are calculated using the first component, and the eigenvalues for the first component range from 2.5 to 6.6 across indices, explaining 12%–17% of the total variance among items (online supplemental table S5).

Individual items contribute different levels of information to the index. Items that are almost universally available—such as fetal scopes, sharps containers, sterile gloves, delivery beds and toilets—provide little information to differentiate between health facilities (online supplemental table S6). Over 70% of items that comprise the SARA and DHS indices are widely available (>90%) in hospitals, and half of items that comprise the SARA index are widely available (>90%) in health centres/clinics (table 3). A slight but significant positive correlation is observed between service readiness scores and monthly delivery volume (table 3).

Table 2 Sample characteristics

	Hospitals (n=160)		Health centres/clinics (n=246)	
	n	%	n	%
Managing authority				
Government	154	96.3	231	93.9
Private	6	3.8	15	6.1
Teaching status				
Teaching facility	23	14.4	n/a	n/a
Region				
Addis	5	3.1	24	9.8
Afar	6	3.8	10	4.1
Amhara	33	20.6	51	20.7
Benishangul-Gumuz	3	1.9	9	3.7
Dire Dawa	3	1.9	12	4.9
Gambella	4	2.5	7	2.8
Harari	3	1.9	5	2.0
Oromiya	38	23.8	51	20.7
SNNP*	38	23.8	43	17.5
Somali	5	3.1	6	2.4
Tigray	22	13.8	28	11.4

*Includes facilities located in the newly formed Sidama region. The survey was administered in 2019 prior to the ratification of regional statehood for Sidama; data reflects the regional distribution at the time of data collection.
n/a, not applicable; SNNP, Southern Nations, Nationalities, and Peoples Region.

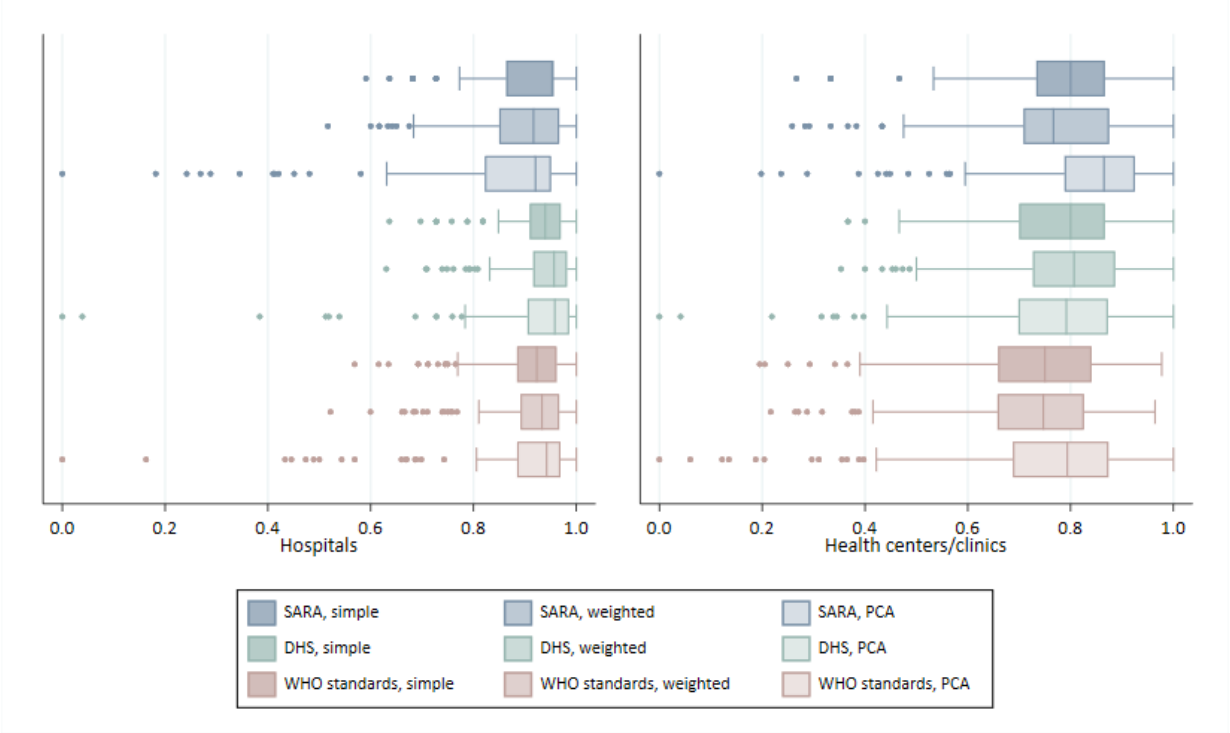

Figure 1 Comparison of childbirth service readiness index scores. DHS, Demographic and Health Survey; PCA, principal components analysis; SARA, Service Availability and Readiness Assessment.

Figure 2 is Bland-Altman graphs that show agreement between service readiness scores generated using different indices (see also online supplemental table S7 and figure S2). There are minimal systemic differences in readiness scores, although WHO standards-based indices produce slightly lower scores than SARA-based or DHS-based indices. SD of differences range from 0.05 to 0.14 among hospitals and from 0.07 to 0.11 among health centres/clinics. DHS and WHO standards-based indices show the greatest consistency in scores, with smaller SD of differences. Among aggregation methods, simple addition produces smaller SD and fewer outliers than PCA and domain-weighted addition.

By and large, there are minimal systemic differences in facility rankings across indices; facilities ranked in the top and bottom tiers by one index are generally ranked similarly by other indices (online supplemental tables S4 and S7). However, some variations do exist, with SARA and WHO standards-based indices displaying the greatest differences in facility rankings (online supplemental figure S2, S3). Additionally, ties are frequent for indices with fewer items, such as the SARA-based indices and, to a lesser extent, the DHS-based indices.

Indices can be deconstructed to measure readiness by their component domains. The SARA and DHS-based indices rely on relatively few items to calculate each domain score and interitem correlation is low; as a result, the internal consistency among items that comprise each domain is weak (online supplemental table S8). Internal consistency improves with the addition of items in the WHO standards-based indices. Across indices, domain-specific rankings generally show slight to moderate correlation with one another (online supplemental table S9). As expected, correlations in domain-specific rankings are highest for domains comprised of similar items (eg, SARA equipment and supplies domain is highly correlated with the WHO standards' equipment and supplies domain). Meanwhile, the WHO standards' domain of staffing and systems to support quality, a highly unique domain, exhibits significant but slight correlation with most other domains (r: 0.07–0.30 for hospitals; 0.15–0.43 for health centres). Of note, the DHS newborn signal functions domain appears misaligned to other domains, displaying either no significant or small correlation with other domains.

DISCUSSION

Our study compares childbirth service readiness scores generated using three different item selection approaches (SARA tracer items, DHS items and WHO standards items) and three-item aggregation methods for each. To our knowledge, it is the first study to compare existing methods for assessing facility readiness using the SARA and DHS guidance and a new method based on the WHO quality of care standards. We find moderate agreement between indices generated using different combinations of items and aggregation methods. Different indices usually produce similar readiness scores—the majority of within-facility scores differ by less than 0.1 on a 0–1 scale—but exceptions occur where scores for the same facility differ by more than 0.4. Importantly, indices also differ in their ability to discriminate between

Table 3 Key characteristics of childbirth service readiness indices

	No of items	Items <40%	Items ≥90%	Coefficient of variation	Floor effects (score=0)	Ceiling effects (score=1)	Correlation with delivery volume	
	n	%	%		%	%	r*	P value
Hospitals (n=160)								
SARA tracer, simple	22	0	73	0.10	0	21	0.33	<0.001
SARA tracer, weighted	"	"	"	0.11	0	21	0.32	<0.001
SARA tracer, PCA	"	"	"	0.20	1	<1	0.33	<0.001
DHS, simple	33	0	85	0.07	0	14	0.25	0.002
DHS, weighted†	"	"	"	0.07	0	20	0.20	0.013
DHS, PCA	"	"	"	0.15	1	<1	0.31	<0.001
WHO standards, simple	52	0	67	0.09	0	6	0.23	0.003
WHO standards, weighted	"	"	"	0.09	0	6	0.26	<0.001
WHO standards, PCA	"	"	"	0.16	1	<1	0.29	<0.001
Health centres/clinics (n=246)								
SARA tracer, simple	15	7	53	0.17	0	7	0.19	0.004
SARA tracer, weighted	"	"	"	0.19	0	7	0.18	0.004
SARA tracer, PCA	"	"	"	0.18	1	7	0.20	0.002
DHS, simple	30	3	33	0.16	0	1	0.35	<0.001
DHS, weighted†	"	"	"	0.16	0	2	0.39	<0.001
DHS, PCA	"	"	"	0.20	1	1	0.36	<0.001
WHO standards, simple	44	2	23	0.20	0	0	0.31	<0.001
WHO standards, weighted	"	"	"	0.20	0	0	0.35	<0.001
WHO standards, PCA	"	"	"	0.24	1	<1	0.31	<0.001

*Spearman's correlation coefficients.
†Weighted addition of DHS items excluded the domain for 'guidelines, staff training and supervision' given limited information on these items for this sample.
DHS, Demographic and Health Survey; PCA, principal components analysis; SARA, Service Availability and Readiness Assessment.

facilities with similar readiness. The SARA-based and DHS-based indices generate more frequent ties and are more prone to ceiling effects, particularly among hospitals with higher levels of readiness. As expected, indices generated using the larger set of WHO standards items produce fewer ties and slightly lower median index scores, a result of selecting items with greater variation across facilities. Among aggregation methods, PCA tends to produce scores with the greatest skewness and kurtosis, and its results are the most difficult to interpret. Other studies have, likewise, found challenges in the use and interpretation of PCA-derived quality of care indices.[54 56]

Differences across the indices arise mainly from differences in item selection and, to a lesser extent, aggregation methods. The DHS and WHO standards-based indices show the greatest agreement. Unlike SARA, these indices include items to measure the past performance of signal functions. We expect service readiness to be closely tied to the ability to perform signal functions when required. A 2016 national assessment of emergency obstetric and newborn care in Ethiopia found that lack of medicines, supplies, equipment and staff were common reasons given by facility staff for not performing a signal function, but other reasons, such as a supportive policy environment and training, were also important.[48] Past performance of a signal function can be a proxy indicator for these unmeasured elements of readiness and may better predict readiness than the availability of inputs alone, since past performance requires that staff have a minimum level of capacity to recognise and manage obstetric or neonatal emergencies.

Another important difference in the composition of indices is whether they include systems to support quality and patient safety. These include functional referral systems, actionable information systems and processes for continuous quality improvement as conceptualised in the WHO framework for the provision of quality maternal and newborn care.[53] With the exception of one item related to emergency transport, these systems are not captured in SARA-based or DHS-based indices. Their inclusion in the WHO standards-based indices provides unique information not otherwise captured.

Other differences between indices relate to which medicines are included and how their availability is determined. There are few medicines in the SARA tracer items and these are widely available (eg, oxytocin, magnesium

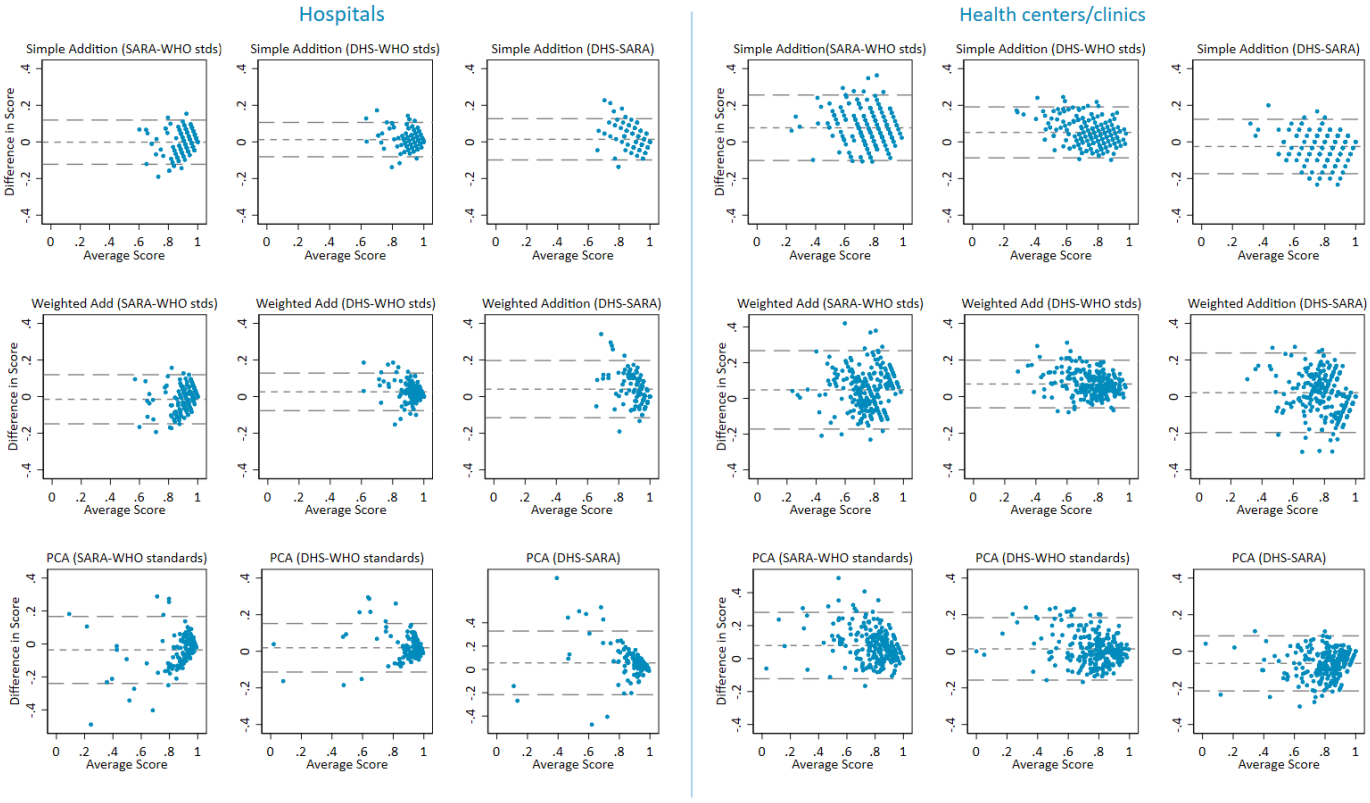

Figure 2 Difference against mean childbirth services readiness Scores. Note: short dashed line indicates mean difference in Readiness Scores and long dashed line indicates 2 SD of the mean difference. DHS, Demographic and Health Survey; PCA, principal components analysis; SARA, Service Availability and Readiness Assessment.

sulfate), whereas WHO standards items include a broader set of medicines for the mother and newborn (eg, BCG vaccine, chlorhexidine gel, dexamethasone/betamethasone, benzathine benzylpenicillin). Of note, SARA and WHO standards-based indices require that medicines be observed in the facility on the day of the assessment, while DHS-based indices require that the medicine be observed in the delivery room.

A key consideration when weighing the merits of a facility readiness index is its usefulness to decision-makers. A good index should provide a clear and accurate overview of readiness, which can be easily deconstructed into its components to assist decision-makers in pinpointing areas of weakness. The SARA-based and DHS-based indices generate domain-specific scores using relatively few items with weak internal consistency; this raises concerns about the robustness of domain-specific scores. Conversely, the greater number items for all readiness domains in the WHO standards-based indices improves internal consistency and generates confidence that domain-specific scores are not excessively sensitive to differences in a single item.

Our study has some limitations. First, health facility assessments are not standardised, and survey items vary across the SARA, SPA and PMA-ET instruments. The PMA-ET survey did not collect data on a few items collected by SARA and SPA (online supplemental table S1). As a result, we are unable to construct the SARA-based and DHS-based indices according to the full list of items referenced in their guidance. Likewise, as recognised in reviews by Brizuela *et al* and Sheffel *et al*,[42 43] conventional health facility assessments do not generate data to fully measure all standards in the WHO framework; this finding also applies to the PMA-ET survey. As a result, we are unable to consider all potential items that that could be relevant for constructing a WHO standards-based index. In particular, the lack of measures to assess provider knowledge and competency (standard 7 in the WHO framework) is missing across most conventional health facility assessments. While some assessments ask about the receipt of training or supervision, these are not direct measures of provider knowledge or competency. Provider knowledge and competency are, therefore, missing from all facility readiness indices we compared. Second, limited information is available to validate the individual items that comprise the indices. While the majority of items are based on the enumerator's observation of at least one valid dose or one functional item on the day of assessment per recommended practice,[57] other items are based on self-reported information prone to recall and other response bias. Third, this study analyses data from a sample of health facilities in one country; results may not be generalisable across other LMIC settings. Finally, traditional epidemiological methods for validating measures are not appropriate for this study—no gold standard exists and the lack of information on individual risk factors complicates assessment against patient outcomes. Instead of validating the index against a traditional gold standard, we considered the face validity and construct validity of indices. Indicative of face validity, items selected for the indices are closely aligned

with existing guidelines and the WHO framework for the provision of quality maternal and newborn care, the latter having been developed through an extensive literature review and expert consultations.[41 53] Indicative of construct validity, service readiness scores are positively correlated with delivery volume.

Our findings have implications for the measurement of service readiness. First, it is feasible to create a service readiness index without the use of complex statistical methods. Simple addition and domain-weighted addition performed better than PCA. These methods produce indices that are easy to generate, interpret and deconstruct to identify bottlenecks to health system performance. Second, indices generated using relatively few items are prone to frequent ties and ceiling effects, a deficiency that is more pronounced when a large proportion of items are almost universally available. The addition of items improves index performance, but should be balanced against the additional data collection burden. Item selection should favour inclusion of high value items with a strong theoretical basis and the ability to discriminate between levels of service readiness. Moreover, we recognise that the availability of medicines, equipment, staff and systems are necessary but not sufficient for the provision of quality care. Incorporating measures of provider knowledge and competency into standard health facility assessment tools—potentially through clinical vignettes as done with the World Bank's Service Delivery Indicator surveys[58] or through the observation of real or simulated cases—could better assist decision-makers in identifying and addressing readiness gaps. Understanding the relationship between service readiness, processes of care and outcomes is critical for improving quality and addressing gaps to effective coverage of care during childbirth. Future research by PMA-ET aims to explore these relationships, by linking data on facility readiness to data collected from peripartum women residing in facilities' catchment area.

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Table S1: Detailed description of item selection for readiness indices

Index	Items included	Items not included (not available in dataset)
WHO SARA obstetric care tracer items (1)	**Health centers (15 items; 3 domains):** Medicines and commodities (observed in facility): Antibiotic eye ointment (tetracycline) for newborn; Oxytocin; Injectable antibiotic; Magnesium sulphate; Intravenous solution and infusion set; Equipment: Access to a functional ambulance/car on-site for emergency transportation; Sterile cord ties/clamp and scissors/blades (either in sealed delivery kit or separate); Functional suction apparatus for use with catheter and/or manual suction device for fluid extraction; Obstetric forceps and/or functioning electrical vacuum extractor; D&C kit and/or MVA; Self-inflating bag and newborn masks (size 0 and size 1) for resuscitation; Delivery bed; Sterile gloves; Staff and training: FMOH Management protocol on selected obstetric topics, 2010 (2)[1]; Skilled birth attendant present or on call 24h; **Hospitals (22 items; 3 domains):** 14 items listed above; and Medicines and commodities: Blood transfusion available at all times facility open (sufficiency); Access to blood bank (safety); Lignocaine/Lidocaine; Equipment: Functional incubator; Sterilization equipment; Staff and training: Skilled provider who can perform C-section present or on call 24h; Skilled provider who can administer anesthesia	**Health centers (4 items):** Examination light; Partograph, Skin disinfectant; Sterilization equipment[2] **Hospitals (13[1] items):** Examination light; Partograph, Skin disinfectant; Staff trained in CEmOC; Anesthesia equipment; Blood typing; Cross match testing; Epinephrine; Halothane; Atropine; Thiopental; Suxamethonium bromide; Ketamine
DHS obstetric and newborn care readiness indicators (3)	**Health centers (30 items; 5 domains[3]):** Medicines and commodities (observed in delivery room or nurse/staff station): Injectable antibiotic; Oxytocin; Magnesium sulphate; Intravenous solution and infusion set; Chlorohexidine gel; Antibiotic eye ointment (tetracycline) for newborn; Equipment: Delivery bed; Sterile cord ties/clamp and scissors/blades (either in sealed delivery kit or separate); Functional suction apparatus for use with catheter and/or manual suction device for fluid extraction; Obstetric forceps and/or functioning electrical vacuum extractor; D&C kit and/or MVA; Sterile gloves; Self-inflating bag and newborn masks (size 0 and size 1) for resuscitation; Infant scale; Blood pressure apparatus; Alcohol hand scrub and/or soap and running water for staff handwashing; General requirements: Electricity available at all times when facility was open in last 7 days and/or back-up energy source; Water outlet on site; Functional toilet available for patient use; Skilled birth attendant present or on call 24h; Access to a functional ambulance/car on-site for emergency transportation; Comprehensive emergency obstetric care: Provided parenteral antibiotics for infections related to pregnancy, abortion, labor or delivery in past 3 months; Provided parenteral or oral uterotonics to prevent or treat PPH in past 3 months; Provided parenteral anticonvulsants to	**Health centers (17 items):** Performed removal of retained products in past 3 months; Practices drying and wrapping newborns; Examination light; Partograph; Hydrocortisone; Skin disinfectant; Guidelines for standard precautions; Training in neonatal resuscitation; Training in early and exclusive breastfeeding; Training in newborn infection management; Training in thermal care; Training in cord care; Training in IMPAC; Training in routine care during labor and delivery; Training in CEmOC; Training in AMTSL; Training in

	manage high blood pressure in pregnancy in past 3 months; Performed manual removal of placenta in past 3 months; Provided instrument/ assisted deliveries in past 3 months; Newborn signal functions and immediate care: Performed neonatal resuscitation in past 3 months; Practices skin-to-skin care; Assists mother to breastfeed; Guidelines, staff training, and supervision:[3] FMOH Management protocol on selected obstetric topics, 2010 (2)[4] **Hospitals (33 items; domains[3]):** 30 items listed above; and Equipment: Sterilization equipment; Comprehensive emergency obstetric care: Performed blood transfusions for maternity care in past 3 months; Performed cesarean delivery in past 3 months	Kangaroo Mother Care; Supervision **Hospitals (17 items):** All above
WHO standards for improving quality of maternal and newborn care readiness items	**Health centers (44 items; 4 domains):** Equipment, supplies, and amenities: Sterile cord ties/clamp and scissors/blades (either in sealed delivery kit or separate); Alcohol hand scrub and/or soap and running water for staff handwashing; Infant scale; Obstetric forceps and/or functioning electrical vacuum extractor; D&C kit and/or MVA; Functional suction apparatus for use with catheter and/or manual suction device for fluid extraction; Self-inflating bag and newborn masks (size 0 and size 1) for resuscitation; Resuscitation table/trolley with light source; Electricity available at all times when facility was open in last 7 days and/or back-up energy source; Private delivery room or visual privacy ensured in delivery area; Newborn corner; Medicines and commodities (observed in facility): Chlorohexidine gel; Injectable vitamin K; Antibiotic eye ointment (tetracycline) for newborn; BCG vaccine; Magnesium sulphate; Calcium gluconate; At least one antihypertensive (hydralazine, nifedipine, or methyldopa); Injectable diazepam, Injectable oxytocin; Misoprostol; Injectable ergometrine; Injectable ampicillin; Injectable gentamicin; Injectable metronidazole; Dexamethasone / betamethasone; Nevirapine (NVP); Benzathine benzylpenicillin; Staffing and systems to support quality: Functional mechanism for reporting data on maternal deaths to the Maternal and Perinatal Death Surveillance Response; Conducts maternal death reviews; Produces monthly reports for the zonal, district, regional, or national HMIS and receives feedback on the facility's HMIS reports that includes recommendations for action; Skilled birth attendant present or on call 24h; Ratio of skilled health personnel to delivery volume meets or exceeds desired levels in FIGO statement (4); Has a performance monitoring team that meets at least quarterly; Access to a functional ambulance/car on-site for emergency transportation; Printed referral form observed; Functional system for recording and sharing outcomes of cases referred in and out; Performance of signal functions: Provided parenteral anticonvulsants to manage high blood pressure in pregnancy in past 3 months; Provided parenteral or oral uterotonics to prevent or treat PPH in past 3 months; Performed manual removal of placenta in past 3 months; Provided instrument/ assisted deliveries in past 3 months; Provided parenteral antibiotics for infections related to pregnancy, abortion, labor or delivery in past 3 months; Performed neonatal	**Health centers and hospitals:** Items: Performed removal of retained products in past 3 months Quality statements: 2.1 Standardized medical record; 3.1 Assessment on admission for referral decision; 7.2 Staff competence and skills mix Quality standards: "Experience of care" standards are excluded: Effective communication; Respect and preservation of dignity; Emotional support

	resuscitation in past 3 months; Provided antenatal corticosteroids for fetal lung maturation in past 3 months; **Hospitals (52 items; 4 domains):** 44 items listed above; and Equipment, supplies, and amenities: Sterilization equipment; Functional incubator; Oxygen supply; Pulse oximeter; Staffing and systems to support quality: Skilled provider who can administer anesthesia; Performance of signal functions: Performed blood transfusions for maternity care in past 3 months; Performed cesarean delivery in past 3 months; Neonatal intensive care provided at facility.	

[1] WHO SARA includes two sets of guidelines: integrated management of pregnancy and childbirth (IMPAC) and comprehensive emergency obstetric care (CEmOC). The PMA Ethiopia survey measures availability of one set of national guidelines that covers both topics: FMOH management protocols on selected obstetric topics (2010).
[2] The PMA-ET survey assessed the availability of sterilization equipment for hospitals but not for health centers.
[3] The DHS program proposes a domain for 'guidelines, staff training, and supervision'; however, only a single item in this domain is available in the PMA-ET survey: FMOH management protocols on selected obstetric topics (2010). This item is included in indices generated using simple addition of items and PCA. The domain is excluded from the index generated using domain-weighted addition given the limited availability of relevant items to calculate a domain score.
[4] DHS includes three sets of guidelines: IMPAC, CEmOC, and preterm labor. The PMA Ethiopia survey measures availability of one set of national guidelines that covers all topics: FMOH management protocols on selected obstetric topics (2010).

Table S2. Selection of items for WHO standards childbirth readiness index

Items	Items included	Notes on items excluded
Medicines & Commodities		
Routine Delivery		
Urine dipsticks		Low discrimination
Routine Newborn Care		
Chlorohexidine gel in facility	X	
Injectable vitamin K in facility	X	
Tetracycline ointment in facility	X	
BCG vaccine	X	
Oral polio vaccine		Limited variation (widely available); low discrimination
Basic EmONC		
Magnesium sulphate in facility	X	
Calcium gluconate in facility	X	
At least one antihypertensive (hydralazine, nifedipine, or methyldopa)	X	
Injectable diazepam in facility	X	
Oxytocin in facility	X	
Misoprostol in facility	X	
Injectable ergometrine/methergine in facility	X	
Injectable ampicillin	X	
Injectable gentamicin	X	
Injectable metronidazole	X	
IV solution in facility and infusion set (cannula, needle, and syringe)		Limited variation (widely available); low discrimination
Comprehensive EmONC		
Blood transfusion available at all times facility open		Highly correlated with performance of blood transfusion in past 3 months
Access to blood bank either inside or outside facility		Highly correlated with performance of blood transfusion in past 3 months
Lignocaine/lidocaine		Limited variation (widely available)
Small and Sick Newborn Care		
Dexamethasone / betamethasone	X	
Nevirapine (NVP)	X	
Maternal ARV regimen[4]		Highly correlated with NVP
HIV rapid test		Limited variation (widely available); low discrimination
Benzathine benzylpenicillin (for prevention of congenital syphilis)	X	
Syphilis testing (VDRL)		Low discrimination
Equipment, Supplies & Amenities		
Routine Delivery		
Thermometer		Limited variation (widely available); low discrimination
Blood pressure apparatus		Limited variation (widely available); low discrimination
Fetal stethoscope and/or fetal scope		Limited variation (widely available)
Alcohol hand scrub and/or soap and running water for staff handwashing	X	
Sterile gloves		Limited variation (widely available)

Items	Items included	Notes on items excluded
Waste receptable with lid and plastic liner		Low discrimination
Sharps container		Limited variation (widely available)
Already mixed decontaminating solution (0.5% chlorine)		Limited variation (widely available)
Routine Newborn Care		
Sterile cord ties/clamp and scissors/blades (either in sealed delivery kit or separate)	X	
Infant weight scale	X	
Basic EmONC		
Obstetric forceps and/or functioning electrical vacuum extractor	X	
Dilatation and curettage (D&C) kit and/or manual vacuum aspiration (MVA) and cannula	X	
Functional suction apparatus for use with catheter and/or manual suction device for fluid extraction	X	
Self-inflating bag and newborn masks (size 0 and size 1) for resuscitation	X	
Resuscitation table/trolley with light source	X	
Comprehensive EmONC		
Functional sterilizing equipment	X	
Small and Sick Newborn Care		
Functional incubator	X	
Oxygen supply	X	
Pulse oximeter	X	
Amenities – Routine Delivery		
Delivery bed		Limited variation (widely available)
Private delivery room or visual privacy ensured in delivery area	X	
Newborn corner	X	
Water outlet on site		Limited variation (widely available); low discrimination
Electricity available at all times when facility was open in last 7 days and/or back-up energy source	X	
Functional toilet available for patient use		Limited variation (widely available)
Staffing & Systems to Support Quality		
Routine Delivery Care		
Skilled birth attendant present at facility or on call 24 hours	X	
Ratio of skilled health personnel to delivery volume meets or exceeds desired scenario in FIGO statement	X	
Management protocols on selected obstetric topics (FMOH, 2010)		Relatively rare; difficult to interpret
Routine Newborn Care		
Baby-friendly guidelines		Relatively rare; difficult to interpret
Comprehensive EmONC		

Items	Items included	Notes on items excluded
Skilled provider available 24h to provide C-section		Highly correlated with performance of c-section in past 3 months; highly correlated with FIGO ratio
At least one staff trained in anesthesia	X	
Small and Sick Newborn Care		
National Comprehensive and Integrated Prevention of Mother-to-Child Transmission of HIV Guideline (FMOH, 2015)		Relatively rare; difficult to interpret
Information Systems & Quality Improvement Processes		
Functional mechanism for reporting data on maternal deaths to the Maternal and Perinatal Death Surveillance Response	X	
Conducts maternal death reviews	X	
Produces monthly reports for the HMIS and receives feedback that includes recommendations for action	X	
Has a performance monitoring team that meets at least quarterly	X	
Referral Systems		
Access to a functional ambulance/car on-site for emergency transportation	X	
Access to phone or radio system at all times		Limited variation (widely available); low discrimination
Printed referral form observed	X	
Functional system for recording and sharing outcomes of cases referred in and out	X	
Performance of Signal Functions		
Routine Delivery		
Used partographs to monitor labor		Limited variation (widely available); response bias concerns
Routine Newborn Care		
Skin-to-skin care		Limited variation (widely available); response bias concerns
Assist mother to breastfeed		Limited variation (widely available); response bias concerns
Basic EmONC		
Provided parenteral anticonvulsants to manage high blood pressure in pregnancy	X	
Provided parenteral or oral uterotonics to prevent or treat PPH	X	
Performed manual removal of placenta	X	
Provided instrument/ assisted deliveries	X	
Provided parenteral antibiotics for infections related to pregnancy, abortion, labor or delivery	X	
Performed neonatal resuscitation	X	
Comprehensive EmONC		
Performed blood transfusions for maternity care	X	
Performed cesarean deliveries	X	
Small and Sick Newborn Care		

Items	Items included	Notes on items excluded
Provided antenatal corticosteroids for fetal lung maturation	X	
Neonatal intensive care provided at facility	X	

Note: Variation refers to how widely available the item is across facilities; low variation indicates that either the item is widely available across facilities (i.e., nearly all have the item) or the item is rarely available across facilities (i.e., nearly all do not have the item) irrespective of readiness level. Discrimination refers to the ability of the item to differentiate between facilities of different levels of readiness.

Table S3: Comparison of childbirth service readiness scores

		Hospitals (n=160)			Health centers / clinics (n=246)		
Item selection	**Item aggregation**	Median [IQR]	Skewness	Kurtosis	Median [IQR]	Skewness	Kurtosis
SARA tracer items	Simple addition of items	0.95 [0.86-0.95]	-1.32	4.34	0.80 [0.73-0.87]	-1.06	4.59
SARA tracer items	Weighted addition of items	0.92 [0.85-0.97]	-1.35	4.90	0.77 [0.71-0.88]	-0.65	4.02
SARA tracer items	PCA of items	0.92 [0.82-0.95]	-2.56	9.98	0.86 [0.79-0.93]	-2.06	9.32
DHS items	Simple addition of items	0.94 [0.91-0.97]	-1.55	5.77	0.80 [0.70-0.87]	-0.79	3.63
DHS items[1]	Weighted addition of items	0.96 [0.92-0.98]	-1.93	7.39	0.81 [0.73-0.89]	-0.86	3.65
DHS items	PCA of items	0.96 [0.90-0.99]	-4.24	24.89	0.79 [0.70-0.87]	-1.60	7.28
WHO standards items	Simple addition of items	0.92 [0.88-0.96]	-1.82	6.91	0.75 [0.66-0.84]	-0.99	4.03
WHO standards items	Weighted addition of items	0.93 [0.89-0.97]	-2.05	7.99	0.75 [0.66-0.83]	-0.96	3.89
WHO standards items	PCA of items	0.94 [0.89-0.97]	-3.36	16.50	0.79 [0.69-0.87]	-1.51	5.84

[1] Weighted addition of DHS items exclude the domain for 'guidelines, staff training, and supervision' given limited information on these items for this sample.

Table S4a: Top 25 ranked hospitals by index

	SARA tracer, simple[1]	SARA tracer, weighted[2]	SARA tracer, PCA[3]	DHS, simple[4]	DHS, weighted[5]	DHS, PCA	WHO standards, simple[6]	WHO standards, weighted[7]	WHO standards, PCA
1 (highest)	1	1	3	1	1	5	1	1	2
2	1	1	3	1	1	5	1	1	2
3	1	1	3	1	1	5	1	1	2
4	1	1	3	1	1	5	1	1	2
5	1	1	3	1	1	5	1	1	2
6	1	1	3	1	1	5	1	1	2
7	1	1	3	1	1	5	1	1	2
8	1	1	3	1	1	5	11	16	1
9	1	1	3	1	1	5	11	16	18
10	1	1	3	1	1	5	25	11	11
11	1	1	3	1	1	5	25	11	28
12	1	1	3	1	1	5	28	16	40
13	1	1	3	1	1	5	49	32	24
14	1	1	3	1	1	5	11	26	70
15	1	1	3	1	1	5	54	49	61
16	1	1	3	1	1	5	75	49	45
17	35	66	38	23	1	27	1	1	2
18	35	66	38	23	1	27	1	1	2
19	35	35	70	1	1	5	11	16	29
20	1	1	3	23	108	2	29	29	23
21	35	66	38	23	1	27	11	11	21
22	35	66	38	23	1	27	11	16	18
23	35	48	97	1	1	5	11	16	36
24	35	35	70	1	1	5	29	32	49
25	1	1	3	23	108	2	49	47	31

[1] 34 hospitals are tied for the highest rank using simple addition of SARA tracer items. 50 hospitals are tied for the next highest rank (#35).

[2] 34 hospitals are tied for the highest rank using weighted addition of SARA tracer items. 13 hospitals are tied for the next highest rank (#35).

[3] 34 hospitals are tied for the 3rd highest rank using PCA of SARA tracer items (#3).

[4] 22 hospitals are tied for the highest rank using simple addition of DHS items. 34 hospitals are tied for the next highest rank (#23).

[5] 32 hospitals are tied for the highest rank using weighted addition of DHS items. 10 hospitals are tied for the next highest rank (#33).

[6] 10 hospitals are tied for the highest rank using simple addition of WHO standards items. 14 hospitals are tied for the next highest rank (#11).

[7] 10 hospitals are tied for the highest rank using weighted addition of WHO standards items. 5 hospitals are tied for the next highest rank (#11).

Table S4b: Bottom 25 ranked hospitals by index

	SARA tracer, simple	SARA tracer, weighted	SARA tracer, PCA	DHS, simple	DHS, weighted	DHS, PCA	WHO standards, simple	WHO standards, weighted	WHO standards, PCA
136	129	136	141	123	117	131	111	100	135
137	144	145	128	151	153	127	94	104	79
138	129	136	139	137	149	117	94	126	113
139	144	147	144	123	123	135	114	130	115
140	129	136	141	123	117	131	138	140	138
141	129	118	143	123	138	147	129	136	133
142	129	131	136	154	157	140	129	120	111
143	115	122	109	146	144	153	141	141	143
144	115	118	78	154	150	156	153	152	149
145	129	130	137	137	120	141	151	149	145
146	115	99	110	154	158	158	149	151	152
147	144	147	148	137	134	137	129	134	144
148	148	143	134	146	140	128	146	143	134
149	129	136	113	146	151	139	151	150	150
150	129	143	149	137	144	146	147	147	146
151	153	153	153	151	152	90	159	158	148
152	158	157	155	137	134	142	144	146	147
153	148	156	156	137	137	148	147	148	154
154	153	159	158	137	133	154	150	153	156
155	148	151	151	153	154	151	154	154	153
156	160	160	160	146	144	149	154	156	155
157	153	154	152	154	156	157	156	155	158
158	153	155	154	154	155	155	156	157	157
159	153	151	157	160	160	160	158	159	159
160 (lowest)	158	157	159	159	159	159	160	160	160

Table S4c: Top 25 ranked health centers/clinics by index

	SARA tracer, simple[1]	SARA tracer, weighted[2]	SARA tracer, PCA[3]	DHS, simple[4]	DHS, weighted[5]	DHS, PCA[6]	WHO standards, simple	WHO standards, weighted	WHO standards, PCA
1 (highest)	1	1	1	1	1	1	2	4	2
2	1	1	1	4	10	7	1	1	1
3	1	1	1	1	1	1	5	13	10
4	1	1	1	4	10	4	13	11	9
5	1	1	1	4	10	11	13	7	26
6	17	67	22	4	1	6	2	2	3
7	1	1	1	12	23	16	23	30	20
8	1	1	1	12	32	26	13	32	11
9	17	17	45	4	5	8	13	21	16
10	1	1	1	1	1	1	43	29	77
11	17	17	17	12	18	25	13	6	32
12	17	17	45	4	5	8	23	25	27
13	17	67	22	12	21	12	5	10	7
14	17	67	22	12	7	15	13	15	13
15	17	17	38	12	23	17	23	26	19
16	17	67	22	12	10	19	12	8	25
17	17	17	45	12	36	24	13	23	18
18	1	1	1	4	7	5	68	64	60
19	1	1	1	12	58	14	32	57	36
20	17	17	17	27	43	30	23	27	23
21	17	67	22	27	23	35	13	19	14
22	17	67	22	27	23	34	13	19	17
23	17	67	22	12	10	13	32	37	33
24	1	1	1	12	23	21	68	49	75
25	17	17	38	4	10	10	43	51	71

[1] 16 health centers/clinics are tied for the highest rank using simple addition of SARA tracer items. 45 health centers/clinics are tied for the next highest rank (#17).

[2] 16 health centers/clinics are tied for the highest rank using weighted addition of SARA tracer items. 23 health centers/clinics are tied for the next highest rank (#17).

[3] 16 health centers/clinics are tied for the highest rank using PCA of SARA tracer items. 5 health centers/clinics are tied for the next highest rank (#17).

[4] 3 health centers/clinics are tied for the highest rank using simple addition of DHS items. 8 health centers/clinics are tied for the next highest rank (#4).

[5] 4 health centers/clinics are tied for the highest rank using weighted addition of DHS items. 2 health centers/clinics are tied for the next highest rank (#5).

[6] 3 health centers/clinics are tied for the highest rank using PCA of DHS items. 1 health centers/clinics holds the next highest rank (#4).

Table S4d: Bottom 25 ranked health centers/clinics by index

	SARA tracer, simple	SARA tracer, weighted	SARA tracer, PCA	DHS, simple[1]	DHS, weighted	DHS, PCA	WHO standards, simple	WHO standards, weighted	WHO standards, PCA
222	217	226	217	228	221	227	202	209	193
223	217	236	230	184	170	210	230	235	235
224	217	226	228	200	196	217	222	226	220
225	234	239	236	213	211	222	202	211	203
226	217	221	212	213	215	206	230	228	231
227	206	216	203	228	230	229	222	227	222
228	217	221	220	213	211	218	227	231	234
229	206	216	221	222	228	226	227	234	233
230	217	236	224	239	238	233	215	208	214
231	217	226	233	231	238	234	222	223	223
232	217	226	228	231	234	231	230	229	226
233	234	232	234	222	224	228	237	232	230
234	234	241	241	231	235	240	222	230	215
235	217	226	227	231	240	230	240	240	239
236	217	221	235	239	230	243	237	237	232
237	234	232	232	241	241	237	230	236	225
238	234	232	237	241	243	235	230	233	228
239	234	239	238	231	232	236	230	238	236
240	243	243	243	231	227	239	237	217	238
241	234	232	240	231	232	242	243	244	243
242	234	220	239	241	245	241	242	241	242
243	242	242	242	231	235	238	241	242	241
244	243	245	245	244	244	244	244	245	244
245	246	244	246	245	242	245	245	243	245
246 (lowest)	243	246	244	245	246	246	246	246	246

[1] 2 health centers/clinics are tied for the lowest rank using simple addition of DHS items (#245).

Table S5: Eigenvalues for PCA method

	Eigenvalue for Component 1	Proportion of variance explained
Hospitals		
SARA tracer items	3.20	0.16
DHS items	3.73	0.13
WHO standards items	6.03	0.12
Health centers/clinics		
SARA tracer items	2.51	0.17
DHS items	3.64	0.12
WHO standards items	6.55	0.15

Table S6. Summary of item availability in hospitals and health centers/clinics

	Hospital N=160		Health center/ clinic N=246		SARA	DHS	WHO standards
	No.	%	No.	%			
Medicines & Commodities							
Routine Newborn Care							
Chlorohexidine gel in delivery room or nurse/staff station	90/159[1]	56.6	119/244[1]	48.8		X	
Chlorohexidine gel in facility	98/159[1]	61.6	133	54.1			X
Injectable vitamin K in facility	151	94.4	183	74.4			X
Tetracycline ointment in delivery room or nurse/staff station	145	90.6	214	87.0		X	
Tetracycline ointment in facility	152	95.0	229	93.1	X		X
BCG vaccine[2]	136	85.0	219	89.0			X
Basic EmONC							
Magnesium sulphate in delivery room or nurse/staff station	149	93.1	173/245[1]	70.6		X	
Magnesium sulphate in facility	153	95.6	181	73.6	X		X
Calcium gluconate in facility	140	87.5	112	45.5			X
At least one antihypertensive (hydralazine, nifedipine, or methyldopa)	158	98.8	210	85.4			X
Injectable diazepam in facility	153	95.6	159	64.6			X
Oxytocin in delivery room or nurse/staff station	152	95.0	209	85.0		X	
Oxytocin in facility	159	99.4	231	93.9	X		X
Misoprostol in facility	144	90.0	123	50.0			X
Injectable ergometrine/methergine in facility	139	86.9	132	53.7			X
Injectable ampicillin	153	95.6	183	74.4			X
Injectable gentamicin	146	91.3	211	85.8			X
Injectable metronidazole	149	93.1	130	52.8			X
At least one broad-spectrum injectable antibiotic: ampicillin or gentamicin	157	98.1	231	93.9	X	X	
IV solution in delivery room or nurse/staff station and infusion set (cannula, needle, and syringe)	149	93.1	211	85.8		X	
IV solution in facility and infusion set (cannula, needle, and syringe)	152	95.0	221	89.8	X		
Comprehensive EmONC							
Blood transfusion available at all times facility open	122	76.3	--	--	X		
Access to blood bank either inside or outside facility	121	75.6	--	--	X		
Lignocaine/lidocaine	156	97.5	--	--	X		
Small and Sick Newborn Care							
Dexamethasone / betamethasone	153	95.6	146	59.3			X
Nevirapine (NVP)	152	95.0	172	69.9			X
Benzathine benzylpenicillin	113	70.6	147/244[1]	60.2			X
Equipment, Supplies & Amenities							
Routine Delivery							
Blood pressure apparatus	152	95.0	216	87.8		X	

	Hospital N=160		Health center/ clinic N=246		SARA	DHS	WHO standards
	No.	%	No.	%			
Alcohol hand scrub and/or soap and running water for staff handwashing	149	93.1	223	90.7		X	X
Sterile gloves	156	97.5	243	98.8	X	X	
Routine Newborn Care							
Sterile cord ties/clamp and scissors/blades (either in sealed delivery kit or separate)	160	100	241	98.0	X	X	X
Infant weight scale	156	97.5	235/245[1]	95.9		X	X
Basic EmONC							
Obstetric forceps and/or functioning electrical vacuum extractor	155	96.9	118	48.0	X	X	X
Dilatation and curettage (D&C) kit and/or manual vacuum aspiration (MVA) and cannula	153	95.6	208	84.6	X	X	X
Functional suction apparatus for use with catheter and/or manual suction device for fluid extraction	157	98.1	210	85.4	X	X	X
Self-inflating bag and newborn masks (size 0 and size 1) for resuscitation	135	84.4	158	64.2	X	X	X
Resuscitation table/trolley with light source	154	96.3	194/246[1]	79.2			X
Comprehensive EmONC							
Functional sterilizing equipment[3]	139	86.9	--	--	X	X	X
Small and Sick Newborn Care							
Functional incubator	120	75.0	--	--	X		X
Oxygen supply	140	87.5	--	--			X
Pulse oximeter	123	76.9	--	--			X
Amenities – Routine Delivery							
Delivery bed	160	100	244	99.2	X	X	
Private delivery room or visual privacy ensured in delivery area	137	85.6	214	87.0			X
Newborn corner	146	91.3	177	72.0			X
Water outlet on site	156	97.5	208	84.6		X	
Electricity available at all times when facility was open in last 7 days and/or back-up energy source	152	95.0	177	72.0		X	X
Functional toilet available for patient use	160	100	236	95.9		X	
Staffing & Systems to Support Quality							
Routine Delivery							
Skilled birth attendant present at facility or on call 24 hours	158	98.8	232	94.3	X	X	X
Ratio of skilled health personnel to delivery volume meets or exceeds desired scenario in FIGO statement[4]	151	94.4	234	95.1			X
Management protocols on selected obstetric topics (FMOH, 2010)	81	50.6	76	30.9	X	X	
Comprehensive EmONC							
Skilled provider available 24h to provide C-section	151	94.4	--	--	X		
At least one staff trained in anesthesia	155	96.9	--	--	X		X

	Hospital N=160		Health center/ clinic N=246		SARA	DHS	WHO standards
	No.	%	No.	%			
Information Systems & Quality Improvement Processes							
Functional mechanism for reporting data on maternal deaths to the Maternal and Perinatal Death Surveillance Response	149/159[1]	93.7	210/233[5]	90.1			X
Conducts maternal death reviews	142/159[1]	89.3	170/231[1,5]	73.6			X
Produces monthly reports for the HMIS and receives feedback that includes recommendations for action	133/159[1]	83.6	223/245[1]	91.0			X
Has a performance monitoring team that meets at least quarterly	142/154[6]	92.2	211/229[1,6]	92.1			X
Referral Systems							
Access to a functional ambulance/car on-site for emergency transportation[7]	146	91.3	143	58.1	X	X	X
Printed referral form observed	127/132[8]	96.2	207/241[8]	85.9			X
Functional system for recording and sharing outcomes of cases referred in and out	134/158[9]	84.8	171/244[9]	70.1			X
Performance of Signal Functions							
Routine Newborn Care							
Skin-to-skin care	151	94.4	229/245[1]	93.5		X	
Assist mother to breastfeed	160	100	245	99.6		X	
Basic EmONC							
Provided parenteral anticonvulsants to manage high blood pressure in pregnancy	149	93.1	101	41.1		X	X
Provided parenteral or oral uterotonics to prevent or treat PPH	153	95.6	172	69.9		X	X
Performed manual removal of placenta	152	95.0	181/244[1]	74.2		X	X
Provided instrument/ assisted deliveries	153	95.6	128/244[1]	52.5		X	X
Provided parenteral antibiotics for infections related to pregnancy, abortion, labor or delivery	155	96.9	187/244[1]	76.6		X	X
Performed neonatal resuscitation	156	97.5	178/244[1]	73.0		X	X
Comprehensive EmONC							
Performed blood transfusions for maternity care	125	78.1	--	--		X	X
Performed cesarean deliveries	150	93.8	--	--		X	X
Small and Sick Newborn Care							
Provided antenatal corticosteroids for fetal lung maturation	141	88.1	36/244[1]	14.8			X
Neonatal intensive care provided at facility	143	89.4	--	--			X

[1] Denominator adjusted to exclude responses that are missing, "no response," or "don't know".
[2] Several hospitals (n=8) and health centers/clinics (n=12) do not offer immunization services and were not asked about the availability of BCG vaccine; they are classified as not having vaccines available.
[3] At least one of the following: electric autoclave, non-electric autoclave, or electric dry heat sterilizer. For sterilizing equipment to be considered functional, electric equipment must be observed and assessed as functional. Non-electric equipment must have an observed heat source.

[4] For hospitals with surgical capacity (i.e., CEmONC), FIGO statement recommends the following desired staffing requirements: at least 5 personnel per shift for ≤1000 deliveries per year; 7 personnel per shift for 1001-2000 deliveries; and 10 personnel per shift for 2001-3000 deliveries, etc. Annual delivery volume is divided by 12 to give monthly estimate. Required staffing numbers are multiplied by two assuming two 12-hour shift pattern. Hospitals must also indicate that they have a skilled provider who can perform C-section present or on call 24h and skilled provider who can administer anesthesia. Skilled health personnel for delivery care include ObGyn, general practitioner (physician), health officer, emergency surgery and obstetrics officer, nurse, and midwife (4).
For health centers with no surgical capacity (i.e., BEmONC), FIGO statement recommends the following desired staffing requirements: at least 3 personnel per shift for ≤1000 deliveries per year; 5 personnel per shift for 1001-2000 deliveries; and 6 personnel per shift for 2001-3000 deliveries. Annual delivery volume is divided by 12 to give monthly estimate. Required staffing numbers are multiplied by two assuming two 12-hour shift pattern. Skilled health personnel for delivery care include ObGyn, general practitioner (physician), health officer, emergency surgery and obstetrics officer, nurse, and midwife (4).
[5] Private clinics (n=13) were not asked about reporting to the Maternal and Perinatal Death Surveillance Response or maternal death reviews. Thus, it is not considered a required input for private clinics to be counted as ready.
[6] Private hospitals (n=6) and private/non-profit clinics/centers (n=16) were not asked about a PMT. Thus, it is not considered a required input for private facilities to be considered ready.
[7] Functional refers to all working status, fuel and driver availability within 15 minutes of need being recognized.
[8] Only facilities that make referrals to other facilities were asked this question; n=33 facilities (28 hospitals and 5 health centers/clinics) do not make referrals. Thus, it is not considered a required input for facilities that do not make referrals.
[9] Only facilities that refer patients to other facilities and/or receive referrals from other facilities were asked about the system for sharing outcomes for cases referred in and out.

Table S7: Differences in childbirth service readiness scores and rankings across indices

	Hospitals (n=160)				Health centers / clinics (n=246)			
	Median	IQR (p25, p75)	Mean	SD	Median	IQR (p25, p75)	Mean	SD
Difference in scores								
Simple addition (SARA-WHO standards)	0.00	-0.04, 0.04	0.00	0.06	0.07	0.02, 0.14	0.08	0.09
Weighted addition (SARA-WHO standards)	-0.01	-0.07, 0.03	-0.02	0.07	0.05	-0.03, 0.12	0.05	0.11
PCA (SARA-WHO standards)	-0.02	-0.08, 0.01	-0.04	0.10	0.07	0.01, 0.14	0.08	0.10
Simple addition (DHS-WHO standards)	0.01	-0.02, 0.04	0.01	0.05	0.05	0.00, 0.09	0.05	0.07
Weighted addition (DHS-WHO standards)	0.02	0.00, 0.05	0.03	0.05	0.06	0.03, 0.11	0.07	0.07
PCA (DHS-WHO standards)	0.01	-0.01, 0.04	0.02	0.07	0.00	-0.04, 0.06	0.01	0.09
Simple addition (DHS-SARA)	0.01	-0.02, 0.05	0.01	0.06	-0.03	-0.07, 0.03	-0.03	0.07
Weighted addition (DHS-SARA)	0.03	0.00, 0.09	0.04	0.08	0.02	-0.05, 0.11	0.02	0.11
PCA (DHS-SARA)	0.04	0.01, 0.09	0.06	0.14	-0.06	-0.12, -0.01	-0.07	0.08
Difference in rankings								
Simple addition (SARA-WHO standards)	-3	-36, 19.5	-9.6	41.9	-9	-40, 19	-13.9	52.6
Weighted addition (SARA-WHO standards)	-0.5	-36, 23.5	-7.1	44.5	-6.5	-46, 30	-7.9	59.1
PCA (SARA-WHO standards)	1	-34, 25.5	-5.7	44.1	0	-33, 29	-2.8	53.2
Simple addition (DHS-WHO standards)	-6	-27.5, 17	-7.4	38.5	-3.5	-28, 20	-4.4	39.6
Weighted addition (DHS-WHO standards)	-3	-25, 17.5	-4.8	40.9	0	-26, 19	-1.9	35.4
PCA (DHS-WHO standards)	3	-20, 19	-2.4	36.3	1	-23, 23	0.0	42.5
Simple addition (DHS-SARA)	0	-15, 22	2.2	34.6	10	-18, 37	9.5	46.8
Weighted addition (DHS-SARA)	0	-23, 31.5	2.4	49.6	6	-33, 41	6.0	61.5
PCA (DHS-SARA)	2	-18, 19.5	3.3	40.4	0.5	-23, 26	2.7	47.2

Table S8: Comparison of domain readiness scores (simple addition of items within each domain)

	Hospitals (n=160)					Health centers / clinics (n=246)				
Domain	No. items	Cronbach alpha	Median [IQR]	Skewness	Kurtosis	No. items	Cronbach alpha	Median [IQR]	Skewness	Kurtosis
SARA Medicines	8	0.48	1.00 [0.88-1.00]	-1.53	5.38	5	0.43	1.00 [0.80-1.00]	-2.04	9.00
DHS Medicines	6	0.37	0.83 [0.83-1.00]	-1.50	6.25	6	0.45	0.83 [0.67-1.00]	-1.03	4.17
WHO Standards Medicines	17	0.62	0.94 [0.85-1.00]	-2.49	15.16	17	0.76	0.71 [0.59-0.82]	-0.66	3.22
SARA Equipment and Supplies	10	0.38[3]	1.00 [0.90-1.00]	-1.52	5.54	8	0.43	0.88 [0.63-0.88]	-0.63	2.84
DHS Equipment and Supplies	11	0.38[3]	1.00 [0.91-1.00]	-2.11	8.55	10	0.42	0.90 [0.80-0.90]	-0.97	4.16
WHO Standards Equipment, Supplies, Amenities	15	0.50[3]	0.93 [0.87-1.00]	-1.90	8.15	11	0.56	0.82 [0.73-0.91]	-1.00	4.16
DHS General[1]	5	--	1.00 [1.00-1.00]	-2.01	5.91	5	0.25	0.80 [0.60-1.00]	-0.74	3.02
SARA Staffing and Guidelines	4	0.23	0.75 [0.75-1.00]	-1.04	4.75	2	--	0.50 [0.50-1.00]	0.29	2.67
DHS Guidelines[2]	1	--	--	--	--	1	--	--	--	--
WHO Standards Staffing and Systems	10	0.48	1.00 [0.90-1.00]	-1.73	6.39	9	0.59	0.89 [0.78-1.00]	-1.26	4.93
DHS CEmONC Functions	7	0.67	1.00 [0.86-1.00]	-3.25	16.80	5	0.61	0.60 [0.40-0.80]	-0.38	2.15
DHS Newborn Functions	3	--	1.00 [1.00-1.00]	-3.07	10.40	3	0.04	1.00 [0.67-1.00]	-1.13	3.21
WHO Standards Signal Functions	10	0.78	1.00 [0.90-1.00]	-3.33	17.08	7	0.61	0.57 [0.43-0.71]	-0.40	2.34

[1] The DHS general domain includes amenities, transportation, and staff. There is no equivalent in the SARA or WHO standards index. DHS general domain items match items found in the SARA equipment and supplies domain; SARA staffing and guidelines domain; WHO standards equipment, supplies, and amenities domain; and the WHO standards staffing and systems domain.

[2] The DHS guidelines domain is calculated based on one item: Management protocol on selected obstetric topics, 2010 (2). Other items included in the domain as originally conceptualized (e.g., trainings) were not available in the PMA-ET survey.

[3] Delivery kit (sterile clamp and ties) and delivery bed dropped from analysis because constant.

Table S9a. Spearman's ranked correlation coefficients for hospital domain scores (n=160)

Domain	SARA medicines	DHS medicines	WHO Standards medicines	SARA equipment and supplies	DHS equipment and supplies	WHO standards equipment, supplies, amenities	SARA staffing and guidelines	DHS guidelines	WHO standards staffing and systems	DHS CEmONC functions	DHS newborn functions	WHO standards signal functions
SARA Medicines	1.00											
DHS Medicines	0.26***	1.00										
WHO Standards Medicines	0.29***	0.52***	1.00									
SARA Equipment and Supplies	0.35***	0.13	0.23**	1.00								
DHS Equipment and Supplies	0.31***	0.13	0.22**	0.73***	1.00							
WHO Standards Equipment, Supplies, Amenities	0.34***	0.15	0.26**	0.71***	0.67***	1.00						
SARA Staffing and Guidelines	0.25**	0.11	0.21**	0.35***	0.43***	0.40***	1.00					
DHS Guidelines	0.11	0.03	0.10	0.27***	0.35***	0.30***	0.91***	1.00				
WHO Standards Staffing and Systems	0.28***	0.25**	0.10	0.30***	0.19**	0.23**	0.23**	0.07	1.00			
DHS CEmONC Functions	0.47***	0.03	0.21**	0.27***	0.27***	0.23**	0.18*	0.00	0.30***	1.00		
DHS Newborn Functions	0.11	0.16*	0.08	0.17*	0.18*	0.14	-0.01	-0.11	0.18*	0.15	1.00	
WHO Standards Signal Functions	0.47***	0.00	0.25**	0.28***	0.24**	0.22**	0.21**	0.04	0.29***	0.92***	0.13	1.00

*denotes p<0.05; **denotes p<0.01; ***denotes p<0.001

Table S9b. Spearman's ranked correlation coefficients for health center/clinic domain scores (n=246)

Domain	SARA medicines	DHS medicines	WHO standards medicines	SARA equipment and supplies	DHS equipment and supplies	WHO standards equipment, supplies, amenities	SARA staffing and guidelines	DHS guidelines	WHO standards staffing and systems	DHS CEmONC functions	DHS newborn functions	WHO standards signal functions
SARA Medicines	1.00											
DHS Medicines	0.70***	1.00										
WHO Standards Medicines	0.51***	0.60***	1.00									
SARA Equipment and Supplies	0.25***	0.26***	0.49***	1.00								
DHS Equipment and Supplies	0.25***	0.29***	0.50***	0.86***	1.00							
WHO Standards Equipment, Supplies, Amenities	0.28***	0.31***	0.52***	0.75***	0.81***	1.00						
SARA Staffing and Guidelines	0.28***	0.29***	0.30***	0.30***	0.31***	0.28***	1.00					
DHS Guidelines	0.21**	0.23***	0.24***	0.23***	0.23***	0.23***	0.92***	1.00				
WHO Standards Staffing and Systems	0.30***	0.27***	0.37***	0.43***	0.28***	0.32***	0.29***	0.21**	1.00			
DHS CEmONC Functions	0.31***	0.25***	0.36***	0.24***	0.26***	0.27***	0.25***	0.22***	0.21***	1.00		
DHS Newborn Functions	0.18**	0.09	0.18**	0.18**	0.21***	0.14*	0.07	0.01	0.15*	0.27***	1.00	
WHO Standards Signal Functions	0.29***	0.25***	0.37***	0.28***	0.31***	0.31***	0.23***	0.19**	0.23***	0.95***	0.44***	1.00

*denotes p<0.05; **denotes p<0.01; ***denotes p<0.001

Figure S1: Histograms of childbirth service readiness indices

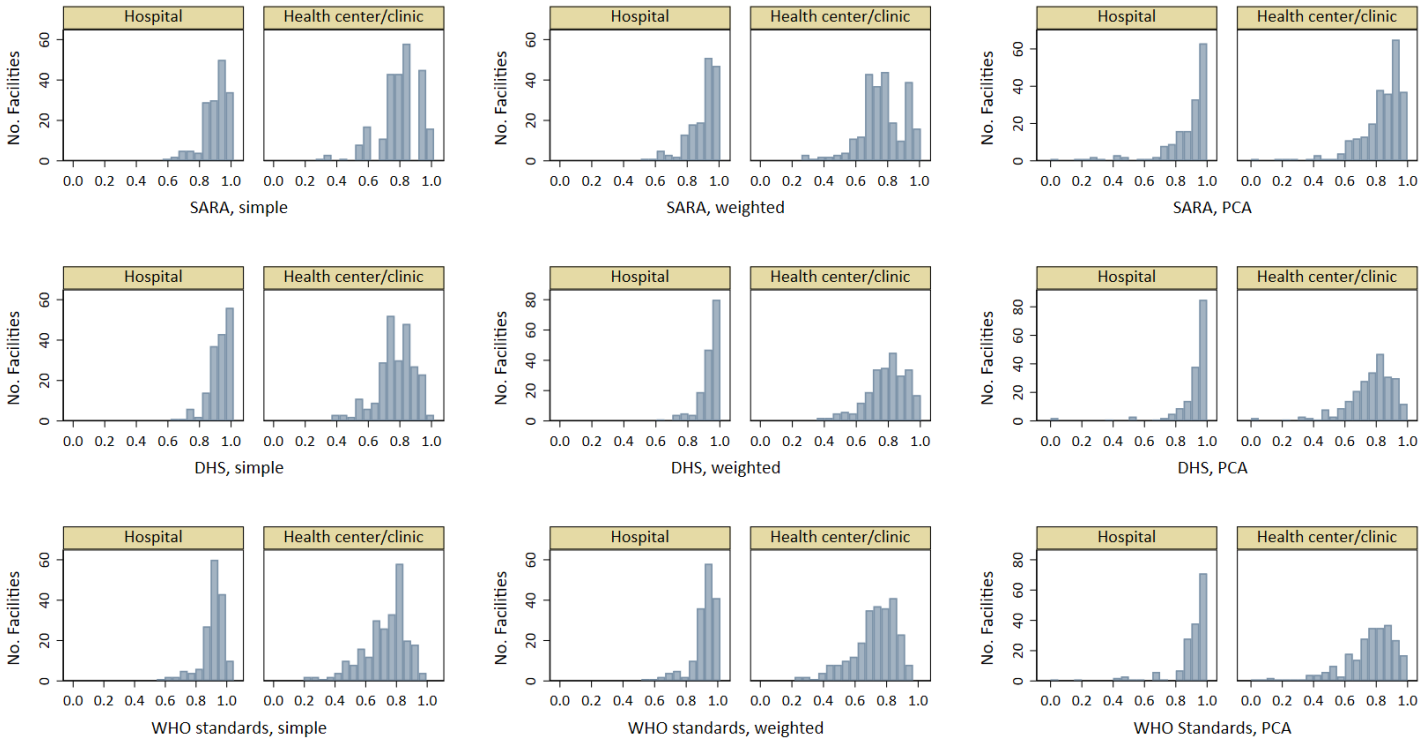


Figure S2: Boxplots of differences in childbirth service readiness scores and rankings across indices

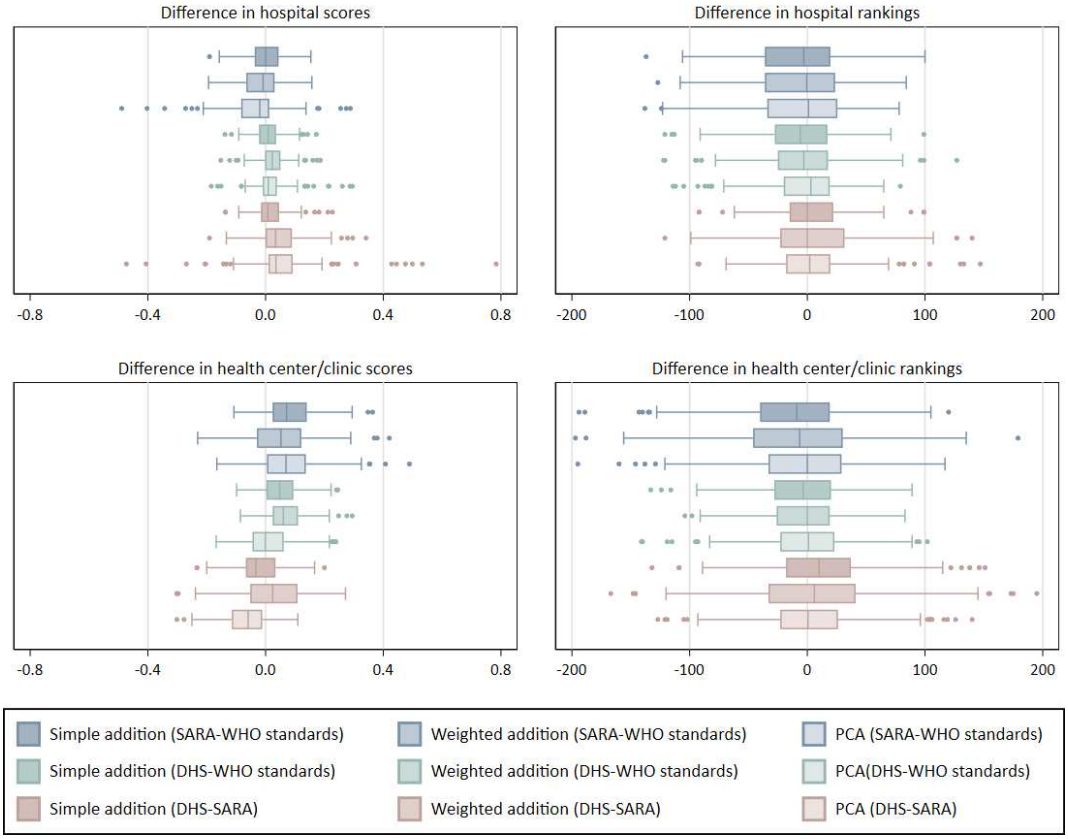


Figure S3A: Correlation between hospital rankings by index

Note: Hospitals are ranked from highest readiness (1) to lowest readiness (160). Ties are awarded 1 + the number of values that are higher.

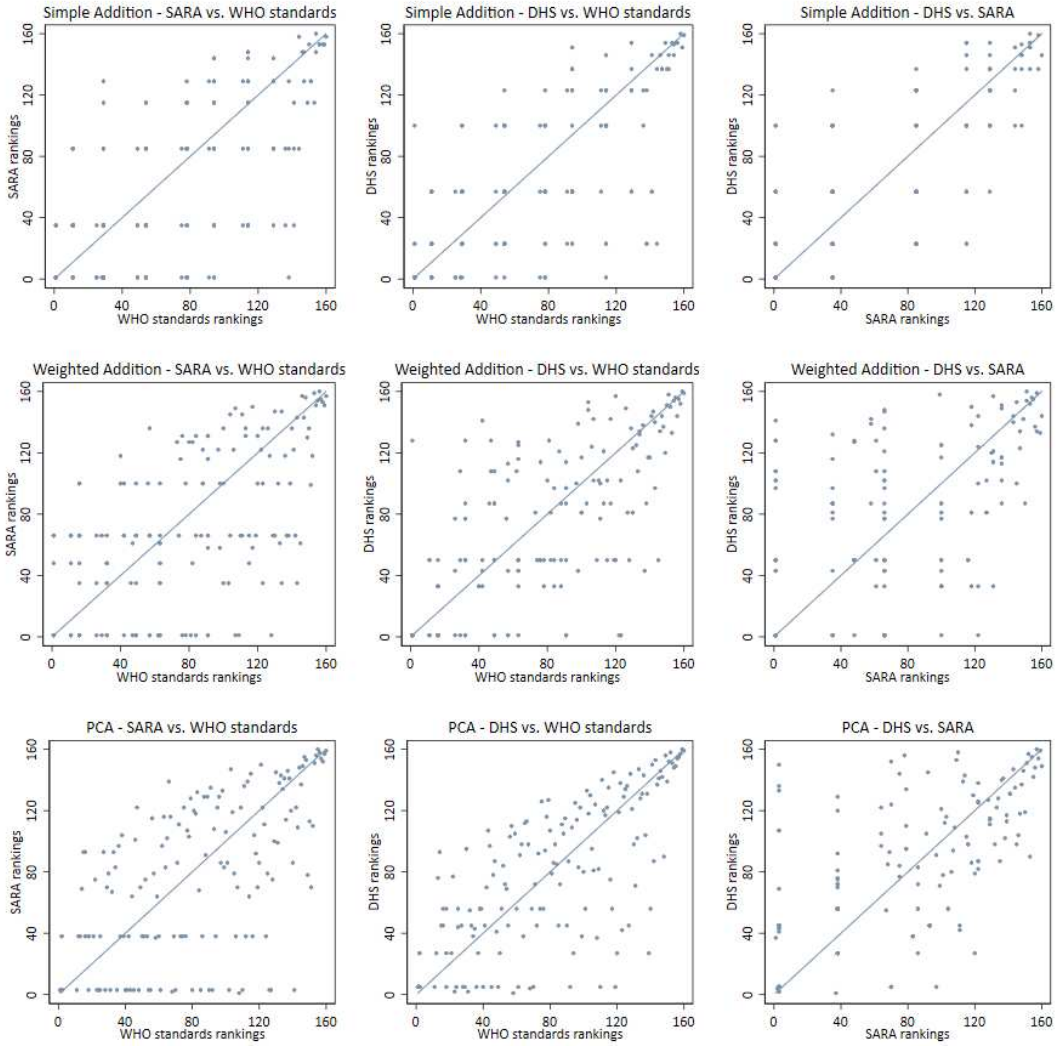
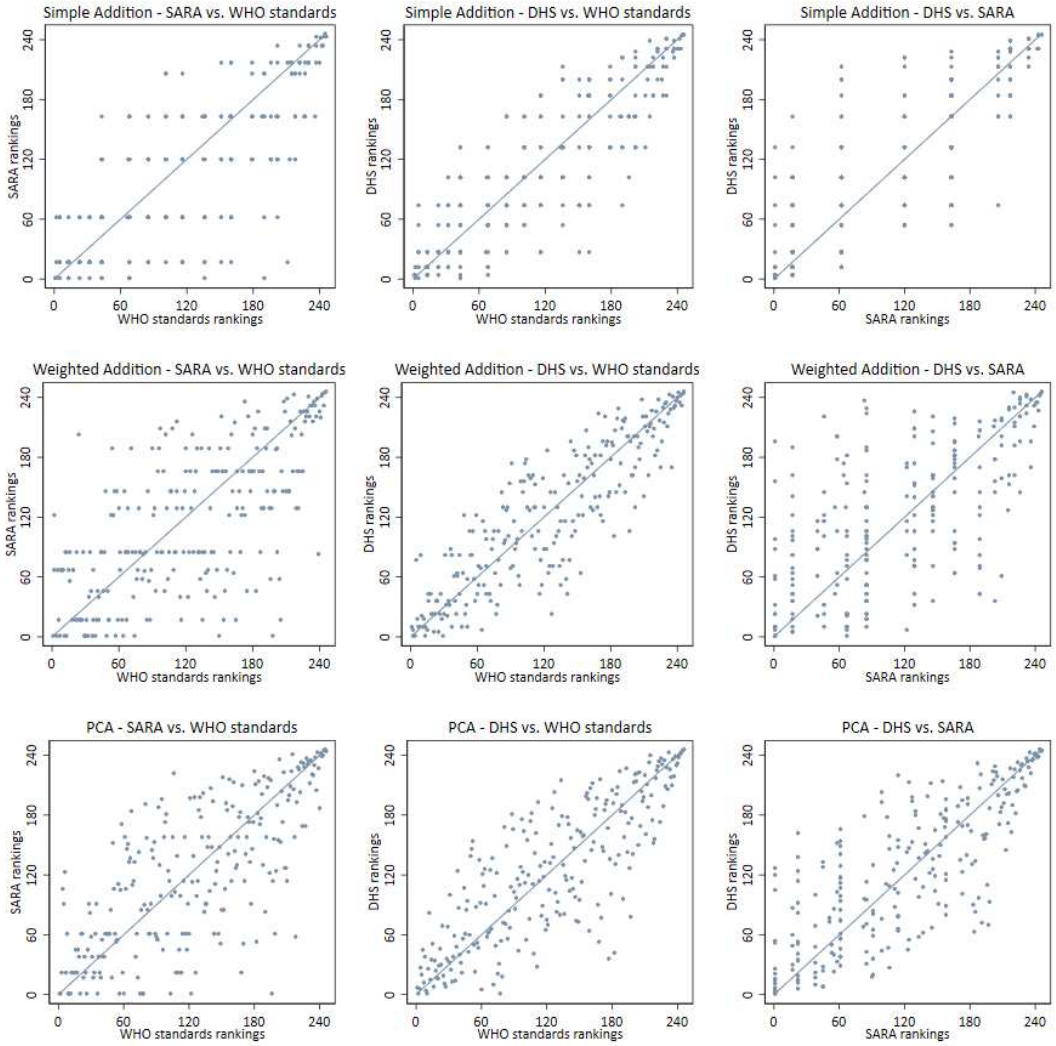


Figure S3B: Correlation between health center/clinic rankings by index

Note: Health centers/clinics are ranked from highest readiness (1) to lowest readiness (246). Ties are awarded 1 + the number of values that are higher.



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