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Health-system readiness for the care of preterm, small and sick newborns in Western Kenya: a mixed-methods assessment of facilities, workforce and service delivery

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Abstract

Background

Preterm, small and sick newborns depend on facilities that are not only equipped but staffed, protocol-guided and able to refer, record and improve. Multidomain readiness evidence at county level in Kenya is limited. We assessed readiness in selected facilities in Western Kenya and examined health-system factors explaining the gaps.

Methods

Facility-level cross-sectional mixed-methods study in ten facilities (levels 3–5) in Bungoma and one neighbouring county. A structured assessment scored 59 items across 11 domains (0 = not available; 1 = available but non-functional; 2 = fully available and functional). Domain and overall readiness, tracer functionality and eight service bundles were computed from observed scores. Two provider interviews and facility free-text responses were analysed using a framework approach and integrated in a joint display.

Results

No item-level score was missing. Median overall readiness was 49.2% (IQR 45.8–72.7; range 29.7–94.9), with five facilities below 50%. Readiness was highest for health information systems (median 75.0%) and infrastructure (71.4%) and lowest for kangaroo mother care (20.0%), clinical guidelines (30.0%) and quality improvement (31.2%). No facility had an adequate nurse-to-newborn ratio; a preterm care guideline was fully functional in one. Two facilities met the full stabilisation bundle, one the respiratory bundle, and one met all four core bundles. Providers attributed gaps to staffing shortages, donor dependence and audit recommendations that recur unimplemented.

Conclusions

In this network, commodities were more available than the workforce, protocols and governance needed to use them. Priority investment should target neonatal staffing, protocol dissemination, KMC capacity and facility quality-improvement structures rather than equipment alone.

1 Introduction

Preterm birth is the leading cause of death in children under five years, and newborns who are born too soon or too small account for most neonatal deaths worldwide. An estimated 13.4 million babies were born preterm in 2020, with sub-Saharan Africa and southern Asia carrying the greatest burden [1, 2]. Kenya's neonatal mortality rate stands at 21 deaths per 1,000 live births, and complications of prematurity remain a leading cause [3].

Most of these deaths are preventable. The interventions that save small and sick newborns — thermal protection, kangaroo mother care (KMC), safe oxygen and respiratory support, appropriate antibiotics, feeding support and timely referral — are neither novel nor expensive [4, 5]. What determines whether they reach a newborn is whether the facility to which that newborn is brought can actually deliver them at the moment they are needed. The World Health Organization (WHO) Standards for improving the quality of care for small and sick newborns therefore frame capability across eight standards spanning clinical practice, information systems, referral, communication, rights, developmental support, human resources and physical resources [6].

Health-system readiness is consequently more than the physical presence of commodities. A radiant warmer that is present but not working, a CPAP machine without a clinician trained to initiate it, a KMC policy without space or beds, or a referral protocol without transport, all register as 'available' on a checklist while delivering nothing at the bedside. Readiness assessments that distinguish availability from functionality, and that span workforce, medicines, protocols, referral, information systems and governance alongside equipment, are therefore more informative than commodity inventories [7, 8]. This is the distinction that the WHO and UNICEF-aligned health facility assessment approach developed for small and sick newborn care was designed to capture [7].

Across sub-Saharan Africa, such assessments consistently find capability concentrated in a small number of higher-level units. In 64 neonatal units implementing with NEST360 in Kenya, Malawi, Nigeria and Tanzania, median service readiness for WHO level-2 + care was around half of the maximum achievable, with readiness to provide CPAP at 46% (IQR 33–54%) in Kenya [8], and repeat assessment three years later showed measurable but uneven improvement [9]. Workforce is the most persistent constraint: median nurse-to-baby ratios in the same network were 1:6 by day and 1:10 at night, and direct observation in Kenyan neonatal units has shown workloads several times above recommended levels, with measurable consequences for the care that is delivered [10, 11]. Neonatal transport remains poorly planned and poorly resourced across the region, with most newborns arriving in a caregiver's arms rather than an equipped ambulance [12].

Kenya delivers newborn care through a devolved, tiered system in which health centres (level 3) and sub-county hospitals (level 4) stabilise and refer, and county referral hospitals (level 5) provide inpatient newborn care. Counties have carried responsibility for health service delivery since 2013, so decisions about neonatal equipment, staffing and infrastructure are now made at county level. Kenya has meanwhile invested in newborn information systems, including the KEMRI-coordinated Clinical Information Network, which links structured newborn records to audit and feedback [13, 14], and reports to the national Kenya Health Information System. Earlier assessments nevertheless found that Kenyan facilities frequently lacked the equipment and information capacity needed to support newborn care and evidence-informed decisions [15, 16, 17].

What remains scarce is multidomain readiness evidence from an entire county newborn-care network — the referral hospital together with the sub-county hospitals and health centres that feed it. Most published readiness data come from neonatal units already enrolled in improvement programmes, which are, by selection, the better-equipped facilities. Yet the newborns who die are disproportionately those born at, or first presenting to, facilities that are not in such programmes. Assessing readiness across facility levels within a single referral network, and asking providers to explain the gaps, is what allows a county to decide where to invest first.

We therefore assessed health-facility readiness to provide essential care for preterm, small and sick newborns in selected facilities in Western Kenya, quantified readiness across 11 health-system domains and four core service bundles, described variation by facility level and service configuration, explored whether readiness corresponded to patient-level care indicators where facility linkage was possible, and used provider accounts to explain the observed gaps.

2 Methods

Study design

This was a facility-level cross-sectional mixed-methods study, nested within a wider programme assessing health-system readiness and quality of care for preterm births in Western Kenya. The quantitative component comprised a structured facility readiness assessment. The explanatory qualitative component comprised provider key-informant interviews and free-text responses recorded within the facility assessment. Readiness was measured once at each facility and represents conditions at the time of assessment; no longitudinal measurement of readiness was undertaken. Reporting follows STROBE for the cross-sectional quantitative component [18], GRAMMS principles for the mixed-methods design [19], and selected COREQ principles for the provider interviews [20]; the completed STROBE checklist is provided as Online Resource 1.

Study setting

Bungoma County lies in Western Kenya and operates a devolved, tiered public health system. Health centres (level 3) and sub-county hospitals (level 4) provide maternity services and stabilise and refer newborns needing more than basic care, while the county referral hospital (level 5) provides inpatient newborn care for the county and receives referrals from lower-level facilities. This tiered structure is central to newborn survival because a preterm newborn's outcome depends not only on the capability of the facility that eventually admits them but on the capability of the facility at which they are born and on the transport link between the two. Ten facilities were assessed: nine in Bungoma County and one county referral hospital in the neighbouring county of Busia. Contextual figures beyond those measured in this study are not reported, because facility counts and admission volumes for the county were not independently verified.

Facility selection and study population

Facilities were purposively selected to represent the levels at which preterm and small newborns receive care within the referral network, comprising the county referral hospital, sub-county hospitals and high-volume health centres offering maternity and newborn

services. The unit of analysis was the facility. All ten assessments initiated were completed and none was excluded (Fig. 1). No formal sampling frame of eligible facilities was constructed, and the assessed facilities are therefore not a probability sample of facilities in Western Kenya.

Facility readiness assessment tool

Readiness was assessed using a structured instrument adapted from WHO-aligned readiness indicators for the care of small and sick newborns [6]. The instrument covered 11 health-system domains and, in the version applied, 59 scored items: infrastructure and organisation (7 items); human resources and skills (7); equipment and supplies (9); medicines and consumables (5); clinical guidelines and protocols (5); kangaroo mother care (5); infection prevention and control (5); feeding and nutrition (4); referral and continuity of care (4); health information systems (4); and quality improvement and governance (4). It also recorded facility characteristics, respondent cadre and experience, and free-text responses on key strengths, major gaps and recommendations. The instrument provides a structured, WHO-aligned readiness measure; it is not a validated WHO certification instrument, and readiness percentages reported here should not be read as such.

Assessments were conducted by trained research assistants using Kobo Toolbox on tablets, in the presence of a senior facility respondent, with items scored on direct observation of the service area and inspection of equipment, medicines, registers and protocols wherever the item was physically verifiable.

Readiness scoring

Each item was scored 0 (not available), 1 (available but non-functional or inconsistently used) or 2 (fully available and functional). Domain readiness was calculated as the observed domain score divided by the maximum achievable score for completed applicable items within that domain, multiplied by 100; overall readiness was calculated on the same basis across all 59 items. Only observed item scores were used. No readiness score was statistically created and no blank value was converted to zero; a blank would have been excluded from its denominator, but in practice no item-level score was missing in any facility. Domain and overall scores were independently recalculated from item-level data as part of a formal data audit and verified against the audited workbook before reporting.

For description, facilities were grouped as low (< 50%), moderate (50–74.9%) or high (≥ 75%) overall readiness. These are study-defined descriptive categories used to aid presentation; they are not validated WHO thresholds and carry no certification meaning.

Critical service bundles

Eight service-readiness bundles were constructed from prespecified items, each treated as complete only when every component scored 2. Four were designated core. The basic preterm stabilisation bundle comprised 11 items: a nurse or midwife trained in newborn care; 24-hour skilled coverage; a functional warmer or incubator; a functional oxygen source; a pulse oximeter with neonatal probe; a neonatal bag and mask; functional suction; a neonatal weighing scale; intravenous fluids; neonatal antibiotics; and stabilisation before referral. The respiratory support bundle comprised functional oxygen, CPAP, pulse oximetry, a clinician trained in newborn care and newborn monitoring charts. The KMC readiness bundle comprised dedicated KMC space, staff trained in KMC counselling, support for continuous KMC, breastfeeding or expressed-breast-milk support, and a KMC follow-up system. The data and governance bundle comprised newborn registers, gestational-age and birth-weight documentation, perinatal death audits, KHIS/DHIS2 reporting, an active quality-improvement team and use of audit data. Four descriptive bundles — thermal care, infection prevention and control, feeding and nutrition support, and referral readiness — were also computed. For each bundle we report the number and percentage of facilities meeting the complete bundle, the distribution of the proportion of components fully functional, and the components that most often limited completion.

Provider qualitative component

Two provider key-informant interviews were conducted at the county referral hospital, with the consultant paediatrician and head of the newborn service and with the newborn-unit nurse manager. These cadres were selected because they hold operational responsibility for newborn services and can speak to workforce, equipment, referral, information and governance arrangements. Interviews were conducted in English, audio-recorded with consent and transcribed verbatim; interview duration and recording equipment were not documented and are not reported. Free-text responses on strengths, gaps and recommendations from all ten facility assessments

provided additional contextual qualitative data. The two detailed interviews are treated as an embedded explanatory referral-hospital case rather than as representative of all assessed facilities.

Data management and audit

The facility assessment export was subject to an independent data audit before analysis. Raw worksheets were reconciled cell-by-cell against the authoritative source export, with no discrepancy identified; facility names were standardised using an audited crosswalk mapping every observed alias to a standard facility name, KHIS code, sub-county and level; and the analytic pipeline was re-executed under a fixed seed with outputs verified by hash. Readiness item scores were based on recorded facility observations and were not statistically created at any stage.

Quantitative analysis

Because ten facilities were assessed, the analysis was principally descriptive. Domain and overall readiness are summarised as medians with interquartile ranges, minima and maxima, with the number and percentage of facilities scoring below 50% and at or above 75%. Item-level results are reported as the number and percentage of facilities scoring 0, 1 and 2. Facility readiness is compared descriptively by facility level, presence of an operational newborn unit, KMC availability, and county. Exploratory Kruskal–Wallis and Mann–Whitney tests are reported with exact p-values, but are explicitly labelled exploratory and interpreted with reference to effect magnitude rather than statistical significance, given very low power. No regression model was fitted to predict facility readiness and no multilevel model was attempted.

Facility–patient linkage

Where the audited facility crosswalk permitted linkage, facility readiness was related to summary indicators derived from the newborn clinical records abstracted in the wider study at the same facilities. Seven facilities linked successfully. For each, we computed the mean overall and early-care patient-level quality score, mean KMC and thermal-care domain scores, the proportion of newborns with hypothermia documented at admission, the proportion with a completed discharge or death summary, and in-hospital mortality among newborns with a known final outcome. Relationships were examined using scatterplots and Spearman rank correlation with 95% confidence intervals. These analyses are facility-level, ecological and exploratory: they cannot demonstrate that facility readiness caused any individual newborn outcome, and no patient-level modelling was undertaken, that analysis belonging to a separate manuscript in this programme.

Qualitative analysis

Transcripts and facility free-text responses were analysed using the framework method [21]. A deductive codebook was developed from the study instrument and covered workforce availability; staff skills and mentorship; infrastructure and overcrowding; equipment; oxygen and respiratory support; medicines and consumables; KMC; referral systems; health information systems; quality improvement and governance; and health-system financing and donor dependence. Inductive codes were added as they emerged. Coding was conducted independently by two analysts and reconciled by consensus. Coding and charting were performed manually. Analysis focused on why readiness gaps exist rather than on cataloguing them. Provider statements about patient volumes, staffing ratios, survival or mortality are reported as participant-reported and are distinguished throughout from independently measured findings. No claim of thematic saturation is made, and quantitative proportions were not computed from two interviews.

Mixed-methods integration

Quantitative and qualitative evidence were analysed separately and then integrated in a joint display pairing each readiness gap with its provider or facility explanation, likely service-delivery consequence and proposed health-system response, with each row classified as convergence, complementarity, expansion or discordance. Qualitative explanations were not constructed for quantitative gaps that no participant addressed.

Sensitivity analyses

Two prespecified sensitivity analyses were conducted: restriction to the nine Bungoma County facilities, and restriction to the seven facilities with an operational newborn unit. Domain and overall medians were recomputed for each.

Ethics and regulatory approvals

Approvals are reported in full under Declarations. Providers gave informed consent to participate and to be audio-recorded in accordance with the approved study protocol. Facility assessments recorded institutional rather than personal data; respondent names and contact details were not carried into the analytical dataset and are not reported. Facilities are identified by name in this report because the approved study and publication plan permit facility-level reporting to the County Government of Bungoma and because de-identification would remove the operational value of the findings for county planning.

3 Results

Characteristics of assessed facilities

Ten facilities were assessed and all ten contributed complete data (Fig. 1). Nine were in Bungoma County and one was a county referral hospital in the neighbouring county of Busia. Three were level 3 health centres, five were level 4 sub-county hospitals and two were level 5 county referral hospitals; all were public. All ten provided maternity services, seven had an operational newborn unit, nine offered KMC and two had a neonatal intensive care unit. Respondents were nurses at seven facilities, and a clinical officer, a doctor and a facility in-charge at one each (Table 1). Not one of the 590 item-level scores was missing.

Table 1
Characteristics of health facilities assessed for preterm, small and sick newborn care

Facility	County	Sub-county	Level	Ownership	Maternity	Newborn unit	NICU	KMC	Respondent cadre	Overall readiness %
Bungoma County Referral Hospital	Bungoma	Kanduyi	5	Public	Yes	Yes	Yes	Yes	Facility In-charge	83.1
Busia County Referral Hospital	Busia	Matayos	5	Public	Yes	Yes	Yes	Yes	Nurse	76.3
Bumula Sub-County Hospital	Bungoma	Bumula	4	Public	Yes	No	No	Yes	Nurse	48.3
Chwele Sub-County Hospital	Bungoma	Kabuchai	4	Public	Yes	Yes	No	Yes	Doctor	61.9
Naitiri Sub-County Hospital	Bungoma	Tongaren	4	Public	Yes	Yes	No	Yes	Nurse	44.9
Sirisia Sub-County Hospital	Bungoma	Sirisia	4	Public	Yes	Yes	No	Yes	Nurse	50.0
Webuye County Hospital	Bungoma	Webuye West	4	Public	Yes	Yes	No	Yes	Nurse	94.9
Kabula Health Centre	Bungoma	Bumula	3	Public	Yes	Yes	No	Yes	Nurse	48.3
Mechimeru Model Health Centre	Bungoma	Kanduyi	3	Public	Yes	No	No	No	Nurse	29.7
Tongaren Sub-County Hospital	Bungoma	Tongaren	3	Public	Yes	No	No	Yes	Clinical Officer	40.7

NICU neonatal intensive care unit, KMC kangaroo mother care. Facilities are ordered by level and then alphabetically. All ten facilities were publicly owned. Respondent cadre describes the professional role of the senior facility respondent present during the assessment; no personally identifying respondent information was recorded in the analytical dataset

Overall facility readiness

Median overall readiness was 49.2% (IQR 45.8–72.7), ranging from 29.7% at Mechimeru Model Health Centre to 94.9% at Webuye County Hospital — a spread of 65 percentage points across facilities serving the same referral network. Using the study-defined descriptive categories, five facilities were low (< 50%), two moderate (50–74.9%) and three high (≥ 75%) (Table 3). The three high-readiness facilities were the two county referral hospitals and one sub-county hospital; notably the single highest score was not a level 5 facility.

Table 3
Facility readiness scores across 11 health-system domains and overall

Domain	Items	Facilities with a valid score	Median %	IQR	Minimum %	Maximum %	< 50%, n (%)	≥ 75%, n (%)
Infrastructure and organisation	7	10	71.4	58.9–83.9	50.0	100.0	0 (0)	5 (50)
Human resources and skills	7	10	42.9	37.5–66.1	14.3	71.4	6 (60)	0 (0)
Equipment and supplies	9	10	63.9	55.6–77.8	38.9	88.9	1 (10)	4 (40)
Medicines and consumables	5	10	65.0	35.0–90.0	10.0	100.0	3 (30)	5 (50)
Clinical guidelines and protocols	5	10	30.0	20.0–37.5	0.0	100.0	8 (80)	1 (10)
Kangaroo mother care	5	10	20.0	10.0–97.5	0.0	100.0	6 (60)	4 (40)
Infection prevention and control	5	10	60.0	60.0–70.0	10.0	100.0	1 (10)	2 (20)
Feeding and nutrition	4	10	62.5	28.1–75.0	12.5	100.0	4 (40)	5 (50)
Referral and continuity of care	4	10	56.2	40.6–81.2	25.0	100.0	3 (30)	3 (30)
Health information systems	4	10	75.0	62.5–96.9	50.0	100.0	0 (0)	6 (60)
Quality improvement and governance	4	10	31.2	12.5–75.0	12.5	100.0	5 (50)	4 (40)
Overall readiness (all 59 items)	59	10	49.2	45.8–72.7	29.7	94.9	5 (50)	3 (30)

IQR interquartile range. Domain readiness is the observed domain score divided by the maximum achievable score for completed applicable items, multiplied by 100. The highest- and lowest-scoring facility for each domain is given in Supplementary Table S2

Readiness across the 11 domains

Readiness was markedly uneven across domains (Table 3, Fig. 2). It was highest for health information systems (median 75.0%, IQR 62.5–96.9) and infrastructure and organisation (71.4%, IQR 58.9–83.9), the only two domains in which no facility scored below 50%. Equipment and supplies (63.9%), medicines and consumables (65.0%), feeding and nutrition (62.5%), infection prevention and control (60.0%) and referral and continuity (56.2%) occupied an intermediate band.

Three domains stood out as system-wide weaknesses. Kangaroo mother care had the lowest median at 20.0%, but also the widest spread of any domain (IQR 10.0–97.5; range 0–100), splitting the network into four facilities at or above 90% and six at or below 20%. Clinical guidelines and protocols had a median of 30.0% with eight of ten facilities below 50%, the highest proportion of any domain. Quality improvement and governance had a median of 31.2%, with five facilities below 50% and six scoring 12.5% — a floor value reflecting the absence of a quality-improvement team, review meetings and use of audit data, with only partial supportive supervision. Human resources and skills had a median of 42.9% with six facilities below 50% and, uniquely, no facility reaching 75%.

Item-level availability and functionality

The item-level pattern shows that basic commodities were largely secured while the capabilities needed to use them were not (Table 2, Fig. 3). Three items were fully functional in every facility: neonatal weighing scales, functional suction and KHIS/DHIS2 reporting. A neonatal bag and mask was fully functional in nine facilities, and functional oxygen, 24-hour skilled coverage and documentation of gestational age and birth weight in eight each.

Table 2
Availability and functionality of essential facility resources for preterm, small and sick newborn care

Domain and item	Score 0: not available, n (%)	Score 1: available but not fully functional, n (%)	Score 2: fully available and functional, n (%)	Missing, n
Infrastructure and organisation				
Designated newborn care area	4 (40.0)	3 (30.0)	3 (30.0)	0
Dedicated KMC space	1 (10.0)	4 (40.0)	5 (50.0)	0
Reliable electricity with back-up	0 (0.0)	1 (10.0)	9 (90.0)	0
Running water	0 (0.0)	1 (10.0)	9 (90.0)	0
Adequate space for newborn care	3 (30.0)	3 (30.0)	4 (40.0)	0
Room temperature control	1 (10.0)	6 (60.0)	3 (30.0)	0
Waste segregation and disposal	0 (0.0)	4 (40.0)	6 (60.0)	0
Human resources and skills				
Nurse/midwife trained in newborn care	4 (40.0)	2 (20.0)	4 (40.0)	0
Clinician trained in newborn care	5 (50.0)	2 (20.0)	3 (30.0)	0
Adequate nurse-to-newborn ratio	5 (50.0)	5 (50.0)	0 (0.0)	0
24-hour skilled coverage	0 (0.0)	2 (20.0)	8 (80.0)	0
Staff trained in neonatal resuscitation	1 (10.0)	7 (70.0)	2 (20.0)	0
Staff trained in comprehensive newborn care	4 (40.0)	5 (50.0)	1 (10.0)	0
Staff trained in KMC counselling	5 (50.0)	3 (30.0)	2 (20.0)	0
Equipment and supplies				
Functional radiant warmer or incubator	2 (20.0)	2 (20.0)	6 (60.0)	0
Thermal mattress or warming device	9 (90.0)	1 (10.0)	0 (0.0)	0
Caps, blankets and wraps	6 (60.0)	3 (30.0)	1 (10.0)	0
Functional oxygen source	1 (10.0)	1 (10.0)	8 (80.0)	0
Functional CPAP	5 (50.0)	1 (10.0)	4 (40.0)	0
Pulse oximeter with neonatal probe	1 (10.0)	3 (30.0)	6 (60.0)	0
Neonatal weighing scale	0 (0.0)	0 (0.0)	10 (100.0)	0
Neonatal bag and mask	1 (10.0)	0 (0.0)	9 (90.0)	0
Functional suction	0 (0.0)	0 (0.0)	10 (100.0)	0
Medicines and consumables				
Neonatal antibiotics	2 (20.0)	4 (40.0)	4 (40.0)	0
Intravenous fluids	1 (10.0)	4 (40.0)	5 (50.0)	0
Antenatal corticosteroids	1 (10.0)	3 (30.0)	6 (60.0)	0
Vitamin K	6 (60.0)	0 (0.0)	4 (40.0)	0

All percentages are of the ten assessed facilities. Score 0 = not available; 1 = available but non-functional or inconsistently used; 2 = fully available and functional. No item-level score was missing at any facility. This table reproduces Supplementary Table S1 in full

Domain and item	Score 0: not available, n (%)	Score 1: available but not fully functional, n (%)	Score 2: fully available and functional, n (%)	Missing, n
Infrastructure and organisation				
Neonatal consumables	3 (30.0)	0 (0.0)	7 (70.0)	0
Clinical guidelines and protocols				
Preterm/small newborn care guideline	6 (60.0)	3 (30.0)	1 (10.0)	0
Neonatal resuscitation protocol	5 (50.0)	1 (10.0)	4 (40.0)	0
Newborn feeding protocol	6 (60.0)	0 (0.0)	4 (40.0)	0
Neonatal infection management protocol	4 (40.0)	2 (20.0)	4 (40.0)	0
Newborn monitoring charts	8 (80.0)	1 (10.0)	1 (10.0)	0
Kangaroo mother care				
Dedicated KMC space	2 (20.0)	3 (30.0)	5 (50.0)	0
Staff trained in KMC counselling	4 (40.0)	3 (30.0)	3 (30.0)	0
Continuous KMC supported	6 (60.0)	0 (0.0)	4 (40.0)	0
Breastfeeding/expressed breast milk support	6 (60.0)	0 (0.0)	4 (40.0)	0
KMC follow-up system	6 (60.0)	0 (0.0)	4 (40.0)	0
Infection prevention and control				
Hand hygiene facilities	0 (0.0)	7 (70.0)	3 (30.0)	0
Personal protective equipment	2 (20.0)	4 (40.0)	4 (40.0)	0
Sterilisation/disinfection capacity	1 (10.0)	2 (20.0)	7 (70.0)	0
Routine cleaning schedule	1 (10.0)	5 (50.0)	4 (40.0)	0
Isolation capacity	3 (30.0)	5 (50.0)	2 (20.0)	0
Feeding and nutrition				
Early breastfeeding support	0 (0.0)	3 (30.0)	7 (70.0)	0
Expressed breast milk support	3 (30.0)	2 (20.0)	5 (50.0)	0
Feeding devices (cup, NG tube, syringe)	4 (40.0)	1 (10.0)	5 (50.0)	0
Daily weight monitoring	7 (70.0)	1 (10.0)	2 (20.0)	0
Referral and continuity of care				
Written referral protocol	6 (60.0)	2 (20.0)	2 (20.0)	0
Stabilisation before referral	0 (0.0)	7 (70.0)	3 (30.0)	0
Functional ambulance/transport	1 (10.0)	2 (20.0)	7 (70.0)	0
Referral documentation	1 (10.0)	5 (50.0)	4 (40.0)	0
Health information systems				
Newborn registers	5 (50.0)	1 (10.0)	4 (40.0)	0

All percentages are of the ten assessed facilities. Score 0 = not available; 1 = available but non-functional or inconsistently used; 2 = fully available and functional. No item-level score was missing at any facility. This table reproduces Supplementary Table S1 in full

Domain and item	Score 0: not available, n (%)	Score 1: available but not fully functional, n (%)	Score 2: fully available and functional, n (%)	Missing, n
Infrastructure and organisation				
Gestational age and birth weight documented	0 (0.0)	2 (20.0)	8 (80.0)	0
Perinatal death audits	1 (10.0)	4 (40.0)	5 (50.0)	0
KHIS/DHIS2 reporting	0 (0.0)	0 (0.0)	10 (100.0)	0
Quality improvement and governance				
Active quality improvement team	5 (50.0)	1 (10.0)	4 (40.0)	0
Regular review meetings	7 (70.0)	1 (10.0)	2 (20.0)	0
Use of audit data	4 (40.0)	2 (20.0)	4 (40.0)	0
Supportive supervision	1 (10.0)	6 (60.0)	3 (30.0)	0

All percentages are of the ten assessed facilities. Score 0 = not available; 1 = available but non-functional or inconsistently used; 2 = fully available and functional. No item-level score was missing at any facility. This table reproduces Supplementary Table S1 in full

At the other extreme, two items were fully functional in no facility. No facility had an adequate nurse-to-newborn ratio; five scored 1 and five scored 0, so this was the only tracer on which every facility fell short. No facility had a thermal mattress or dedicated warming device, with nine scoring 0. A preterm or small newborn care guideline was fully functional in one facility and absent in six; newborn monitoring charts were fully functional in one and absent in eight; and comprehensive newborn care training in one, with five facilities partially trained.

A distinct third pattern was items present but inconsistently functional — the category that a simple availability checklist would score as present. Stabilisation before referral scored 1 in seven facilities and 0 in none, meaning that every facility does something to stabilise newborns before transfer but only three do so fully and consistently. Neonatal resuscitation training scored 1 in seven facilities and 2 in two. Hand hygiene facilities scored 1 in seven and 2 in three. Supportive supervision scored 1 in six and 2 in three. Counting availability alone rather than functionality would have overstated readiness on these four items by between three and seven facilities each.

Among items directly determining respiratory capability, functional CPAP was fully functional in four facilities and absent in five, and a clinician trained in newborn care in three, absent in five. Radiant warmers or incubators and pulse oximeters with neonatal probes were each fully functional in six.

Essential service bundles

Bundle completion was low and the limiting components differed by bundle (Table 4, Supplementary Figure S1). Two of ten facilities met the complete basic preterm stabilisation bundle, although the median proportion of its 11 components fully functional was 63.6% — so most facilities held most of the stabilisation commodities while failing at least one. The two most frequently limiting components were stabilisation before referral (fully functional in three facilities) and a nurse or midwife trained in newborn care (four).

Table 4
Completion of critical newborn service-readiness bundles

Bundle	Type	Components	Facilities meeting complete bundle, n (%)	Median component completion %	IQR	Range	Principal limiting components
Basic preterm stabilisation	Core	11	2 (20)	63.6	54.5–77.3	36.4–100.0	Stabilisation before referral (3/10); trained newborn-care nurse or midwife (4/10)
Respiratory support	Core	5	1 (10)	50.0	25.0–60.0	0.0–100.0	Newborn monitoring charts (1/10); clinician trained in newborn care (3/10)
Kangaroo mother care readiness	Core	5	3 (30)	10.0	0.0–95.0	0.0–100.0	Staff trained in KMC counselling (3/10); continuous KMC supported (4/10)
Data and governance	Core	6	2 (20)	58.3	37.5–79.2	16.7–100.0	Newborn registers (4/10); active quality-improvement team (4/10)
Thermal care	Descriptive	4	0 (0)	25.0	25.0–25.0	0.0–75.0	Thermal mattress (0/10); caps, blankets and wraps (1/10)
Infection prevention and control	Descriptive	5	1 (10)	40.0	20.0–40.0	0.0–100.0	Isolation capacity (2/10); hand hygiene facilities (3/10)
Feeding and nutrition support	Descriptive	4	1 (10)	50.0	25.0–75.0	0.0–100.0	Daily weight monitoring (2/10); expressed breast milk support (5/10)
Referral readiness	Descriptive	4	2 (20)	25.0	6.2–68.8	0.0–100.0	Written referral protocol (2/10); stabilisation before referral (3/10)

A bundle was counted as complete only where every component scored 2 (fully available and functional). Component completion is the percentage of a bundle's components scoring 2 at that facility. Limiting components are the two items within each bundle scoring 2 at the fewest facilities, with the number of facilities in parentheses. Component completion by facility is given in Supplementary Table S3 and Supplementary Figure S1

One facility met the complete respiratory support bundle, with a median component completion of 50.0%; the limiting components were newborn monitoring charts (one facility) and a trained clinician (three). Three facilities met the complete KMC readiness bundle, but the median component completion was 10.0% and six facilities scored 0% — the bipolar pattern already evident in the domain score. Two facilities met the complete data and governance bundle, with newborn registers and an active quality-improvement team the limiting components (four facilities each).

One facility, Webuye County Hospital, met all four core bundles. Seven facilities met none of them, and the median number of core bundles met across the network was zero. Among the four descriptive bundles, thermal care was the weakest: no facility met it and the median component completion was 25.0%, constrained by the universal absence of thermal mattresses and the near-absence of caps, blankets and wraps (fully functional in one facility).

Variation by facility level and service configuration

Overall readiness rose with facility level: median 40.7% at level 3 (n = 3, range 29.7–48.3), 50.0% at level 4 (n = 5, range 44.9–94.9) and 79.7% at level 5 (n = 2, range 76.3–83.1) (Table 5; exploratory Kruskal–Wallis H = 5.14, p = 0.077). The level 4 range is the more instructive figure: it spans almost the entire distribution of the study, indicating that facility level alone is a weak predictor of what a sub-county hospital can actually do.

Table 5
Facility readiness according to facility level and service configuration

Comparison group	Facilities, n	Median overall readiness %	IQR	Range
Facility level				
Level 3 (health centre)	3	40.7	35.2–44.5	29.7–48.3
Level 4 (sub-county hospital)	5	50.0	48.3–61.9	44.9–94.9
Level 5 (county referral hospital)	2	79.7	78.0–81.4	76.3–83.1
Newborn unit status				
No newborn unit	3	40.7	35.2–44.5	29.7–48.3
Operational newborn unit	7	61.9	49.2–79.7	44.9–94.9
Kangaroo mother care service				
KMC service available	9	50.0	48.3–76.3	40.7–94.9
No KMC service	1	29.7	29.7–29.7	29.7–29.7
County				
Bungoma County	9	48.3	44.9–61.9	29.7–94.9
Outside Bungoma County	1	76.3	76.3–76.3	76.3–76.3

Comparisons are descriptive. Exploratory tests: facility level, Kruskal–Wallis H = 5.14, p = 0.077; newborn unit status, Mann–Whitney p = 0.052; kangaroo mother care service, Mann–Whitney p = 0.162; county, Mann–Whitney p = 0.485. With ten facilities these tests have very low power and are reported for magnitude rather than statistical significance. The county comparison involves a single facility outside Bungoma and is not interpretable

Facilities with an operational newborn unit had a median overall readiness of 61.9% (n = 7) against 40.7% for those without (n = 3), a difference of 21.2 percentage points (exploratory Mann–Whitney p = 0.052). Facilities offering KMC had a median of 50.0% (n = 9) against 29.7% for the single facility without. The one facility outside Bungoma County had an overall readiness of 76.3%, above the Bungoma median of 48.3%, but with only one facility in that group no comparison is interpretable.

Sensitivity analyses

Restricting to the nine Bungoma County facilities changed median overall readiness only marginally, from 49.2% to 48.3%, and left the ranking of domains essentially unchanged; the outside-county facility did not materially alter overall or domain readiness patterns. Two domain medians shifted appreciably: quality improvement and governance fell from 31.2% to 12.5% and medicines and consumables from 65.0% to 50.0%, reflecting the relatively strong performance of the excluded facility in those domains.

Restricting to the seven facilities with an operational newborn unit raised median overall readiness from 49.2% to 61.9% and raised most domain medians, most dramatically KMC (20.0% to 90.0%) and quality improvement and governance (31.2% to 75.0%). Two domain medians did not move at all: clinical guidelines and protocols remained at 30.0% and infection prevention and control at 60.0%. The persistence of the guideline gap across every restriction is the single most consistent finding of the sensitivity analyses — having a newborn unit does not, in this network, mean having the protocols to run it (Supplementary Table S4).

Exploratory facility–patient linkage

Seven facilities linked to newborn clinical records, contributing 211 newborn records in total, although two contributed fewer than five records each and their facility means are correspondingly unstable. Facility-level associations were positive for several indicators but imprecise throughout (Fig. 4). Overall readiness correlated with mean early-care patient-level quality score at rho 0.78 (95% CI − 0.15 to 0.98, n = 6, p = 0.066) but showed essentially no association with the mean overall quality score (rho − 0.05, 95% CI − 0.80 to 0.76, n = 7, p = 0.908). KMC domain readiness was not associated with the mean patient-level KMC score (rho − 0.27, n = 6, p = 0.612).

Two associations run counter to a naive reading and require care. Overall readiness correlated positively with the proportion of newborns in whom hypothermia was documented at admission (rho 0.77, 95% CI − 0.03 to 0.97, n = 7, p = 0.045) and with in-hospital

mortality (rho 0.59, 95% CI − 0.35 to 0.94, n = 7, p = 0.166). Neither should be read as readiness worsening outcomes. The higher-readiness facilities are the referral hospitals, which measure and record admission temperature more consistently and which receive the sickest and smallest newborns from across the network; both correlations are more plausibly explained by ascertainment and case mix than by any effect of readiness. These are ecological, facility-level and exploratory analyses and cannot establish that readiness caused, prevented or worsened any individual newborn outcome.

Provider perspectives on health-system readiness

Providers located the binding constraint in the workforce rather than in commodities. Provider KII 2 described the nursing establishment as the determinant of what the unit can deliver: 'if the nurses are not empowered, then neonatal care will go down', and reported that shortage forces triage of clinical tasks — 'we also monitor vitals hourly. That is the bad thing. Hourly with the shortage, sometimes we miss, sometimes we do it.' The same provider reported that only four neonatal nurses at the referral hospital had been trained in neonatal resuscitation, KMC, essential and comprehensive newborn care, with the remainder learning through on-the-job training. Provider KII 1 described the workforce as the mechanism by which survival improved: 'when you train people and you are available to mentor them, create a good working team… it makes survival better.' Staff shortage was named as a major gap in the free-text responses of nine of the ten assessed facilities, the single most frequent facility-identified constraint.

On skills, both providers distinguished knowledge from capability. Provider KII 2 estimated that continuing medical education had translated into practice for only a limited proportion of staff because sessions lacked practical components: 'the CMEs, they are not having the practical sessions. So whatever you are listening to, yes, you might want to carry it on, but how? The how part is the problem.' Provider KII 1 described a weekly continuing education programme, a mentorship arrangement for new providers, and a skills laboratory under development for simulation teaching. These are participant-reported descriptions of arrangements at one hospital and were not independently verified.

On equipment, providers described capability limited by quantity and by type rather than by absence. Provider KII 1 reported sharing of incubators and radiant warmers and that 'the one baby, one cot rule has not worked here because of the shortage', and identified continuous cardiac monitoring, neonatal blood-pressure cuffs and mechanical ventilation as capabilities the unit lacks: 'we are capable of doing the mechanical ventilation. We have the knowledge and the skills, but we don't have the machines.' Provider KII 2 questioned whether the available incubators met the requirement at all — 'could I say that they are just warm boxes? They are not the current incubators we need. They are only giving us warmth' — and identified oxygen supply as the constraint on respiratory support, reporting reliance on cylinders and consequent rationing between newborns needing CPAP. This account is consistent with the quantitative finding that oxygen was fully functional in eight facilities while CPAP was fully functional in only four.

On KMC, providers described a capability constrained by space and by maternal availability rather than by policy. Provider KII 2 reported that KMC is initiated in the labour ward for vaginal deliveries but that continuous KMC cannot be sustained for newborns still on treatment because of a shortage of beds and radiant warmers, so 'instead of doing continuous kangaroo mother care for sick babies, we are doing intermittent'. Provider KII 1 described KMC as the unit's compensating strategy for the incubator shortage — 'necessity is the mother of invention. We don't have incubators… KMC is like our saviour' — and reported that KMC previously supported in 22 facilities by an external partner contracted after that partner withdrew, with some facilities unable to continue independently.

On referral, providers described the constraint as transport capability rather than referral policy. Provider KII 1 reported delays attributable to ambulance shortage, ambulances without oxygen, transport costs charged to families, and emergency transport staff trained for adult rather than newborn transfer, requiring on-the-job training in newborn transport. Downward referral was described as effectively unavailable because receiving facilities lack functional newborn units, with the consequence that stabilised newborns remain at the referral hospital and contribute to congestion.

On information systems and governance, providers described comparatively strong data infrastructure alongside weak translation into change. Both described participation in the Clinical Information Network with REDCap-based data entry, auto-generated monthly reports and partner-supported dashboards, and reported using these to monitor care. Perinatal death review was described as durable — 'every third Friday of the month is MPDSR. So it's permanent' (Provider KII 1) — and audit as having become educational rather than punitive (Provider KII 2). Yet Provider KII 1 identified implementation as the standing weakness: 'our only weakness has been in implementation of actual plans because some gaps keep recurring and recurring.' Provider KII 2 reported a scheduled review postponed because of an 18-admission day.

Finally, both providers described the newborn service as substantially donor-shaped. Provider KII 1 stated that 'we shine a lot in newborn care, but it's because of donor support', naming partner organisations as the source of most equipment and of newly installed oxygen piping, and identified county resource allocation as the underlying constraint: 'why can't we just ourselves plan for our people? … the hindrance is just resource allocation from the county.' The same provider reported that a specialist-led neonatal intensive care capability had not been established despite specialist availability.

Mixed-methods integration

Table 6 presents the joint display. Integration was convergent for workforce, where the quantitative finding that no facility achieved an adequate nurse-to-newborn ratio matched both providers' accounts of care triaged under shortage, and for KMC, where the bipolar domain distribution matched the account of space and bed constraints determining whether continuous KMC is possible. It was complementary for information systems and governance: strong information-system readiness (median 75.0%) alongside weak governance readiness (median 31.2%) is explained by provider accounts of functioning audit structures whose recommendations recur unimplemented. It was expansive for the guideline and monitoring-chart gaps, which no provider raised but which the assessment identified as the most consistent deficit across every sensitivity analysis. It was discordant in one respect: providers described referral stabilisation as routine practice, whereas stabilisation before referral was fully functional in only three of ten facilities and partially functional in seven.

Table 6
Integrated health-system readiness gaps, explanatory findings and potential system responses

Readiness domain / gap	Quantitative evidence	Provider or facility explanation	Service-delivery implication	Potential health-system response	Integration
Workforce: no facility achieved an adequate nurse-to-newborn ratio	Human resources median 42.9%; nurse-to-newborn ratio scored 2 in 0/10 facilities and 0 in 5/10; no facility reached 75% in this domain	'We also monitor vitals hourly. That is the bad thing. Hourly with the shortage, sometimes we miss, sometimes we do it.' (Provider KII 2). Staff shortage named a major gap in 9/10 facility free-text responses	Monitoring and thermal care are delivered inconsistently; commodity investment cannot compensate	Review neonatal staffing establishments against workload at every facility with a newborn unit; consider skill-mix options for non-clinical tasks	Convergence
Skills: training present but not translated into capability	Neonatal resuscitation training scored 1 in 7/10 and 2 in 2/10; comprehensive newborn care training scored 2 in 1/10	'The CMEs, they are not having the practical sessions… the how part is the problem.' (Provider KII 2)	Staff hold knowledge without demonstrated competence, particularly in resuscitation	Shift capacity building from didactic continuing education to simulation and structured mentorship with competency sign-off	Convergence
Respiratory support: oxygen available, pressure support and supervision are not	Oxygen scored 2 in 8/10; CPAP in 4/10; trained clinician in 3/10; monitoring charts in 1/10; respiratory bundle complete in 1/10	'CPAPs require a lot of oxygen and currently we are only using cylinders… so you weigh who will I wean and who will recycle.' (Provider KII 2)	Newborns are weaned from CPAP early or not started; capability is limited by supply architecture, not device count	Plan oxygen systems sized to concurrent CPAP demand alongside devices, trained clinicians and monitoring, as a single investment	Convergence
Equipment: present but insufficient in quantity and specification	Equipment median 63.9%; warmers and pulse oximeters scored 2 in 6/10; thermal mattress in 0/10; thermal-care bundle met by 0/10	'The one baby, one cot rule has not worked here because of the shortage' (Provider KII 1); 'could I say that they are just warm boxes? They are not the current incubators we need' (Provider KII 2)	Equipment sharing raises infection risk; hypothermia, associated with increased inpatient mortality, is inadequately prevented	Specify equipment to newborn requirements and to caseload rather than to presence; add low-cost thermal items (caps, blankets, wraps, warming devices)	Convergence
Kangaroo mother care: bipolar readiness across the network	KMC domain median 20.0% but range 0–100%; 4/10 facilities ≥ 90% and 6/10 ≤ 20%; KMC bundle complete in 3/10; median component completion 10.0%	'Instead of doing continuous kangaroo mother care for sick babies, we are doing intermittent' because of bed and warmer shortage (Provider KII 2); KMC previously supported in 22 facilities contracted after partner withdrawal (Provider KII 1, participant-reported)	Newborns in the weight range that benefits most from KMC do not receive continuous skin-to-skin contact at most facilities	Build KMC space, beds, trained counsellors and follow-up at the six facilities scoring ≤ 20%; institutionalise rather than project-fund KMC	Convergence
Referral: transport available, pre-transfer stabilisation is not	Referral median 56.2%; functional ambulance scored 2 in 7/10 but stabilisation before referral in 3/10 (scored 1 in 7/10)	Ambulances without oxygen, transport costs charged to families, and emergency staff trained for adult transfer (Provider KII 1); downward referral	Newborns arrive compromised despite transport being available; stabilised newborns cannot be transferred	Standardise and document pre-transfer stabilisation; equip ambulances for newborn transfer; build lower-level newborn capability	Discordance

KII key informant interview, KMC kangaroo mother care, CPAP continuous positive airway pressure, KHIS Kenya Health Information System. Provider quotations are verbatim from the two key-informant interviews conducted at the county referral hospital and describe that setting; statements about volumes, ratios or historical coverage are participant-reported and were not independently verified. Integration category: convergence (quantitative and qualitative evidence agree), complementarity (qualitative evidence explains a quantitative pattern), expansion (quantitative finding without a corresponding provider account), discordance (evidence sources diverge).

Readiness domain / gap	Quantitative evidence	Provider or facility explanation	Service-delivery implication	Potential health-system response	Integration
	and written protocol in 2/10	unavailable because receiving facilities lack functional newborn units	back, producing congestion	to enable down-referral	
Information systems strong, governance weak	Health information systems median 75.0% with no facility below 50% and KHIS reporting scored 2 in 10/10; quality improvement median 31.2% with 6/10 at the 12.5% floor	'Our only weakness has been in implementation of actual plans because some gaps keep recurring and recurring.' (Provider KII 1); a scheduled review postponed after an 18-admission day (Provider KII 2)	Data are reported upward reliably but rarely converted into local change; the same deficits recur across review cycles	Establish a quality-improvement team and scheduled review meetings at the six facilities at the governance floor; assign named owners, review dates and closure tracking to audit actions	Complementarity
Clinical guidelines and monitoring charts largely absent	Guidelines median 30.0% with 8/10 facilities below 50% — the highest proportion of any domain; preterm care guideline scored 2 in 1/10; monitoring charts in 1/10; unchanged in every sensitivity analysis	Not raised by providers or in facility free-text responses	Care depends on individual knowledge rather than a standard; documentation of monitoring cannot be structured without charts	Distribute and display the national preterm and small newborn care guideline and standardised monitoring charts at all ten facilities — the lowest-cost action available	Expansion
Donor dependence of newborn services	Equipment and information-system domains, which attract discrete external investment, scored highest; staffing, guidelines and governance, which depend on recurrent county decisions, scored lowest	'We shine a lot in newborn care, but it's because of donor support… the hindrance is just resource allocation from the county.' (Provider KII 1, participant-reported)	Capability may not persist beyond the funding cycle; strongest facilities may regress	Identify a domestic financing route for recurrent functions, particularly KMC, staffing and equipment maintenance	Complementarity

KII key informant interview, KMC kangaroo mother care, CPAP continuous positive airway pressure, KHIS Kenya Health Information System. Provider quotations are verbatim from the two key-informant interviews conducted at the county referral hospital and describe that setting; statements about volumes, ratios or historical coverage are participant-reported and were not independently verified. Integration category: convergence (quantitative and qualitative evidence agree), complementarity (qualitative evidence explains a quantitative pattern), expansion (quantitative finding without a corresponding provider account), discordance (evidence sources diverge).

4 Discussion

Principal findings

Across ten facilities serving one county newborn-care referral network in Western Kenya, median overall readiness for preterm, small and sick newborn care was 49.2%, with half the network below 50% and a 65-percentage-point spread between the weakest and strongest facility. The pattern of that shortfall matters more than its magnitude. Readiness was highest where commodities and reporting are concerned — weighing scales, suction, bag and mask, oxygen and KHIS reporting were fully functional in eight to ten facilities — and lowest where the capability to use those commodities is determined: no facility had an adequate nurse-to-newborn ratio, a preterm care guideline was fully functional in one, and six of ten facilities had neither a quality-improvement team nor review meetings. One facility met all four core service bundles and seven met none.

Overall readiness of the facility network

A median of 49.2% is consistent with, and slightly below, the level reported for neonatal units already enrolled in improvement programmes. In 64 NEST360-implementing neonatal units across Kenya, Malawi, Nigeria and Tanzania, median WHO level-2 + service readiness was around half the achievable maximum, with Kenyan units scoring 46% (IQR 33–54%) for CPAP readiness [8]. Our network

scored comparably despite including three health centres and five sub-county hospitals that would not qualify for such programmes, which suggests the deficit is systemic rather than confined to the least-supported facilities. This is the sense in which quality, rather than access alone, is now the binding constraint on newborn survival in such systems [33], and it is why measurement frameworks for newborn care emphasise capability alongside coverage [32]. The more consequential difference is the spread: NEST360 assessments describe neonatal units, whereas we assessed an entire referral network including the facilities where preterm newborns are first born. A newborn's chance of receiving evidence-based care in this county depends heavily on which door they enter.

Workforce and skills

That not one facility achieved an adequate nurse-to-newborn ratio is the study's most uniform finding, and it aligns closely with the regional evidence. In 65 neonatal units implementing with NEST360, median nurse-to-baby ratios were 1:6 by day and 1:10 at night [10], and direct observation in Kenyan neonatal units has documented workloads several times above recommended levels, with measurable consequences for care actually delivered — Gathara and colleagues showed that missed nursing care rises as nurse-to-baby ratios worsen [11]. Multi-country bottleneck analysis of basic newborn care and resuscitation identified health workforce as the most frequently reported constraint across the same region [31]. Our providers described exactly this mechanism, reporting that hourly monitoring is performed inconsistently because of shortage. The implication for readiness measurement is important: staffing is the one domain in which a facility cannot compensate through procurement, and it is also the domain in which our network performed worst, with no facility reaching 75%.

Training told a related story. Comprehensive newborn care training was fully functional in one facility and neonatal resuscitation training in two, with seven facilities scoring 1 on resuscitation training — trained, but not to the point of consistent capability. Provider KII 2's distinction between knowing and being able to do, attributed to continuing education lacking practical components, offers a plausible and testable explanation, and points towards simulation-based rather than didactic capacity building.

Infrastructure, equipment and respiratory support

Equipment readiness (median 63.9%) exceeded workforce readiness by more than 20 percentage points, and the item pattern shows why aggregate equipment scores can mislead. Basic resuscitation and measurement equipment was near-universal, but the equipment that distinguishes level-2 newborn care was not: CPAP was fully functional in four facilities, pulse oximeters with neonatal probes and radiant warmers in six each, and thermal mattresses in none. The thermal-care bundle was met by no facility, which is notable given that hypothermia at admission is associated with a 35% increase in the odds of neonatal inpatient death in Kenyan newborn units [22].

The oxygen–CPAP gap is instructive. Oxygen was fully functional in eight facilities but CPAP in only four and a trained clinician in three, so respiratory capability is limited by the ability to deliver and supervise pressure support rather than by gas supply. Provider KII 2's account of cylinder-based supply and rationing between newborns adds a dimension the assessment could not capture: an oxygen source scored as functional on the day of assessment says nothing about whether it can supply several newborns on CPAP simultaneously. Investment in oxygen systems rather than oxygen devices has been shown to improve outcomes for children and neonates in comparable settings [23], and our data suggest the same logic applies here.

Kangaroo mother care and feeding

KMC produced the most polarised result in the study: the lowest domain median (20.0%) and the widest range (0–100%), with four facilities at or above 90% and six at or below 20%. This is not a gradient but a threshold. Facilities either have dedicated space, trained counsellors, continuous KMC support, breastfeeding support and follow-up, or they have almost none of these. The systematic review evidence identifies sufficient space and supplies as the most frequently described facilitator of facility-based KMC in sub-Saharan Africa [24], and multi-country bottleneck analysis reached the same conclusion [25]. Our providers described precisely this constraint, reporting that continuous KMC cannot be sustained for newborns still on treatment because beds and warmers are lacking, so intermittent KMC is delivered instead. Given that immediate KMC reduces mortality among newborns weighing 1,000–1,799 g by around a quarter [26], and that WHO now recommends KMC as soon as possible after birth [27], a network in which six of ten facilities score at or below 20% on KMC readiness has a specific and addressable gap.

Provider KII 1's report that KMC previously supported in 22 facilities contracted after external partner withdrawal, though participant-reported and not independently verified, is consistent with our finding that KMC readiness is bipolar: capability appears to persist where it was institutionalised and to lapse where it depended on external support.

Referral and continuity

Referral readiness had a median of 56.2% but concealed a specific deficit. A functional ambulance was available at seven facilities, yet a written referral protocol was fully functional at two and stabilisation before referral at three, with seven facilities scoring 1 on stabilisation — doing something, inconsistently. Transport availability is therefore not the rate-limiting step in this network; pre-transfer stabilisation and its documentation are. This nuance matters because regional evidence has focused on transport: a systematic review of 20 studies across ten sub-Saharan African countries found neonatal transport poorly planned and poorly resourced, with most newborns transferred in caregivers' arms and ambulances lacking human resources and equipment [12]. Our providers reported both problems — ambulances without oxygen, transport costs charged to families, and emergency staff trained for adult transfer — and additionally described downward referral as effectively unavailable because receiving facilities lack functional newborn units, producing congestion at the referral hospital. Strengthening lower-level newborn capability is therefore simultaneously a referral intervention.

Information systems and quality improvement

The sharpest contrast in the study is between health information systems (median 75.0%, no facility below 50%, KHIS reporting fully functional in all ten) and quality improvement and governance (median 31.2%, six facilities at the 12.5% floor). Data are being collected and reported everywhere; they are being used to change practice in very few places. This is the classic separation between reporting upward and improving locally that the learning health system literature was developed to address [13, 14, 28], and it mirrors the wider Kenyan pattern in which routine data are reported completely but used unevenly for local decision-making [37, 38]; and it is consistent with assessments of maternal and perinatal death surveillance across sub-Saharan Africa which repeatedly find that reports can appear comprehensive while masking weak follow-through on recommendations [29, 30]. Our providers made the point directly, describing a durable monthly perinatal death review whose recommendations recur unimplemented, and a scheduled review postponed under an 18-admission workload. The remedy indicated is not more data but named ownership, review dates and closure tracking for audit actions, of the kind shown to be feasible when a common data platform supports structured audit and feedback in Kenyan newborn units [34, 35].

Facility-level variation

Readiness rose with facility level, but the range within level 4 spanned almost the entire distribution of the study (44.9% to 94.9%), so facility level is a weak guide to capability. The presence of an operational newborn unit was associated with a larger difference (21.2 percentage points) than any level comparison, and the newborn-unit sensitivity analysis raised most domain medians substantially — but left clinical guidelines (30.0%) and infection prevention (60.0%) entirely unchanged. Having a newborn unit does not, in this network, mean having the protocols to run it. For county planners this is an actionable distinction: guideline dissemination is cheap and does not depend on unit status.

Provider explanations and donor dependence

Providers consistently framed readiness as a consequence of resource allocation rather than of clinical intent. Both attributed most equipment and the newly installed oxygen piping to external partners, and Provider KII 1 identified county prioritisation as the underlying constraint. This is a participant perspective rather than a verified financing analysis, and we report it as such. It nevertheless carries a testable implication that our quantitative data partly support: the domains that depend on recurrent county decisions — staffing establishment, guideline dissemination, quality-improvement structures — were the weakest, while the domains that attract discrete external investment — equipment and information systems — were the strongest. Sustainability of newborn care in this county depends on whether recurrent functions can be financed domestically, a consideration that bears directly on Kenya's wider progress in reducing under-five mortality [36].

Health-system interpretation

Read as a system rather than a commodity list, the findings describe consistent mismatches between inputs and the capacity to use them. Oxygen was functional in eight facilities but CPAP in four and a trained clinician in three, so gas without pressure support and supervision. KMC was offered in nine facilities but continuous KMC supported in four, so policy without space. Ambulances were functional in seven but stabilisation before referral fully functional in three, so transport without pre-transfer care. Newborn registers and KHIS reporting were near-universal but quality-improvement teams present in four, so data without improvement. Each pairing identifies where the marginal investment should go, and in each case it is not the commodity.

Strengths and limitations

The study has several strengths. It assessed 11 domains and 59 items with complete item-level data and no missing scores, distinguishing fully functional from available-but-non-functional rather than recording availability alone — a distinction that would have overstated readiness by three to seven facilities on four separate tracers. It spanned three facility levels within a single referral network rather than sampling neonatal units alone. It applied prespecified service bundles requiring every component to be fully functional. The quantitative dataset was independently audited and reconciled cell-by-cell against the source export before analysis, and readiness scores were recalculated from item-level data. Provider accounts and facility free-text responses were integrated to explain rather than merely accompany the quantitative findings.

Eleven limitations qualify interpretation. First, only ten facilities were assessed, so all comparisons are underpowered and exploratory tests are reported for magnitude rather than significance. Second, the assessment is cross-sectional and represents conditions at a single assessment period; readiness may fluctuate with stock, staffing and equipment cycles. Third, one facility lies outside Bungoma County; it did not materially alter overall or domain patterns, but two domain medians shifted appreciably on its exclusion. Fourth, facilities were purposively selected without a formal sampling frame, so findings describe the assessed facilities and cannot be generalised to Western Kenya as a whole. Fifth, readiness scores measure availability and functionality, not the clinical care actually delivered. Sixth, the two detailed provider interviews were conducted at the referral hospital and reflect that setting; they explain, but do not represent, lower-level facilities where the quantitative data suggest the constraints differ. Seventh, no claim of thematic saturation is made and no proportion was derived from two interviews. Eighth, facility free-text responses varied considerably in depth, and their absence on a topic cannot be read as absence of a problem. Ninth, the linkage to newborn records is facility-level and ecological and cannot establish that readiness caused any individual outcome. Tenth, two linked facilities contributed fewer than five newborn records, making their facility means unstable, and the positive correlations with documented hypothermia and mortality are most plausibly explained by ascertainment and case mix. Eleventh, several measures that would sharpen a readiness assessment were unavailable: actual staffing numbers by shift, bed occupancy, equipment quantities and downtime, oxygen consumption and reliability, and stock-out duration. The nurse-to-newborn ratio item records a judgement of adequacy, not a counted ratio.

Policy and practice implications

Three immediate actions follow directly from the data and require little capital. Disseminating and displaying the national preterm and small newborn care guideline and newborn monitoring charts would address the domain with the highest proportion of facilities below 50% and the only deficit unchanged by every sensitivity analysis. Establishing a quality-improvement team with scheduled review meetings at the six facilities currently at the governance floor would convert existing data into local action. Standardising and documenting pre-transfer stabilisation would address the referral component that is partially performed in seven facilities.

Three medium-term actions require investment but are targeted. Neonatal staffing establishments should be reviewed against workload at every facility with a newborn unit, since no facility currently achieves an adequate ratio and no procurement can substitute. KMC capacity — space, beds, trained counsellors and follow-up — should be built at the six facilities scoring at or below 20%, given the mortality benefit of KMC in this weight range. Thermal-care capability, met by no facility, should be addressed through warming devices and the caps, blankets and wraps that were fully functional in one facility.

Two system-level actions follow. Respiratory capability should be developed as a system — oxygen supply sized to concurrent CPAP demand, devices, trained clinicians and monitoring together — rather than as device procurement. And recurrent functions currently sustained by external partners, particularly KMC and equipment maintenance, need a domestic financing route if the capability observed at the strongest facilities is to persist and spread.

5 Conclusion

Readiness for preterm, small and sick newborn care across this county referral network was moderate at best and highly uneven, with a median of 49.2% and half the facilities below 50%. Strengths lay in basic resuscitation and measurement equipment, oxygen availability, infrastructure and routine reporting to the national health information system. The most consequential gaps lay in the capabilities required to convert those inputs into care: no facility achieved an adequate nurse-to-newborn ratio, clinical guidelines and monitoring charts were largely absent, kangaroo mother care readiness was bipolar with six of ten facilities at or below 20%, and quality-improvement structures were absent in most facilities. One facility met all four core service bundles and seven met none. Priority should therefore be given to neonatal staffing, guideline dissemination, KMC capacity and facility quality-improvement

structures, with respiratory capability developed as a system rather than as devices. These findings describe ten purposively selected facilities and should not be generalised to all facilities in Kenya or Western Kenya.

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Masinde Muliro University of Science and Technology Institutional Scientific and Ethics Review Committee (MMUST-ISERC), approval number MMUST/ISERC/023/2026 (correspondence reference MMU/COR: 40312 Vol 6(01)), dated 2 February 2026 and valid from 2 February 2026 to 2 February 2027, for the research proposal titled 'Health Systems Readiness and Quality of Care for Preterm Births in Western Kenya'.

Consent for publication

No individual person's identifiable data, images or details are reported. Providers consented to the use of anonymised quotations from their interviews, and quotations are attributed by role rather than by name.

Competing interests

The authors declare no conflict of interest.

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Author Contribution

LNN conceptualized the study, developed the methodology, led data collection, and wrote the original draft. CMS contributed to the study design and methodology, participated in data collection, and critically reviewed and edited the manuscript. MSS curated the data, conducted the formal analysis and validation, and contributed to writing – review and editing. TCK supported the qualitative component, participated in investigation and validation, and contributed to writing – review and editing. ENM contributed to conceptualization and methodology, and critically reviewed and edited the manuscript. All named authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

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Data Availability

The de-identified facility readiness dataset, the derived-variable dictionary, the bundle definitions and the analysis code supporting the findings of this study are held by the study team at Kibabii University and may be made available from the corresponding author on reasonable request, subject to approval by MMUST-ISERC, the County Government of Bungoma Department of Health and Kibabii University data-governance requirements, and to a data-sharing agreement. Provider interview transcripts will not be shared, because the small number of participants and their identifiable professional roles make effective de-identification impossible. Source data is available at: https://doi.org/10.17605/OSF.IO/6FP9Z

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Figures

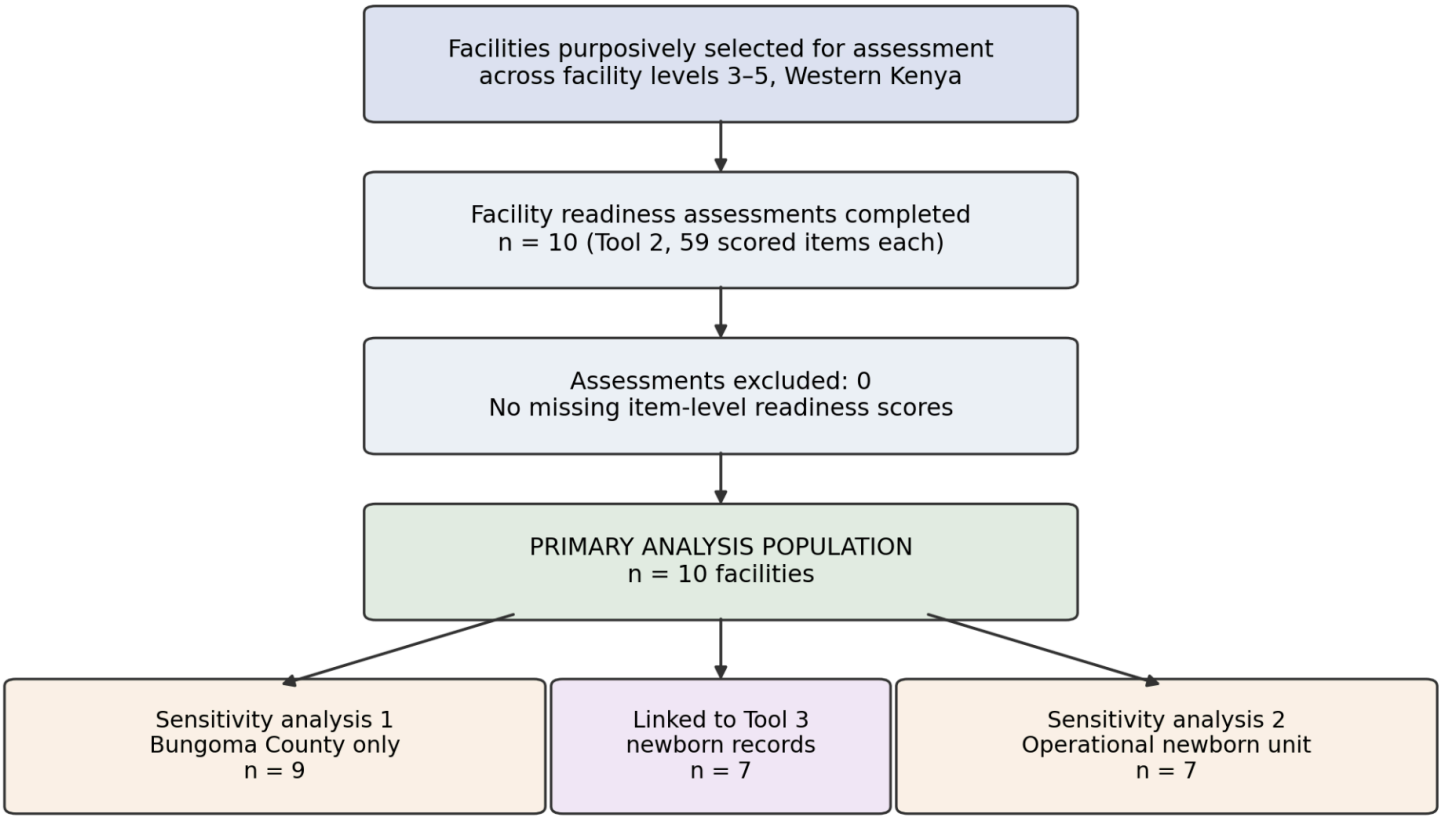


Figure 1

Facility assessment flow. Facilities purposively selected across levels 3–5, assessments completed, exclusions, the primary analysis population, the two prespecified sensitivity analysis populations and the facilities successfully linked to newborn clinical records

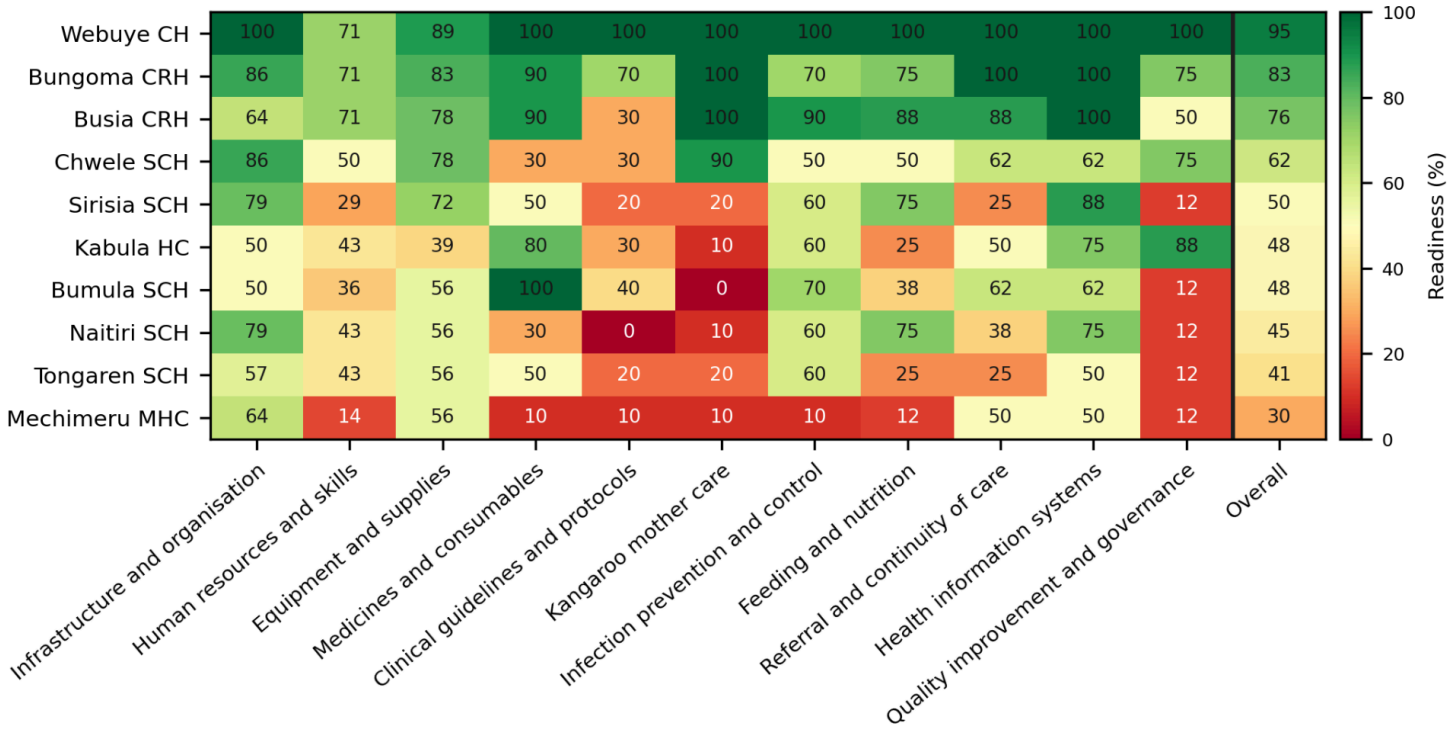


Figure 2

Facility assessment flow. Facilities purposively selected across levels 3–5, assessments completed, exclusions, the primary analysis population, the two prespecified sensitivity analysis populations and the facilities successfully linked to newborn clinical records

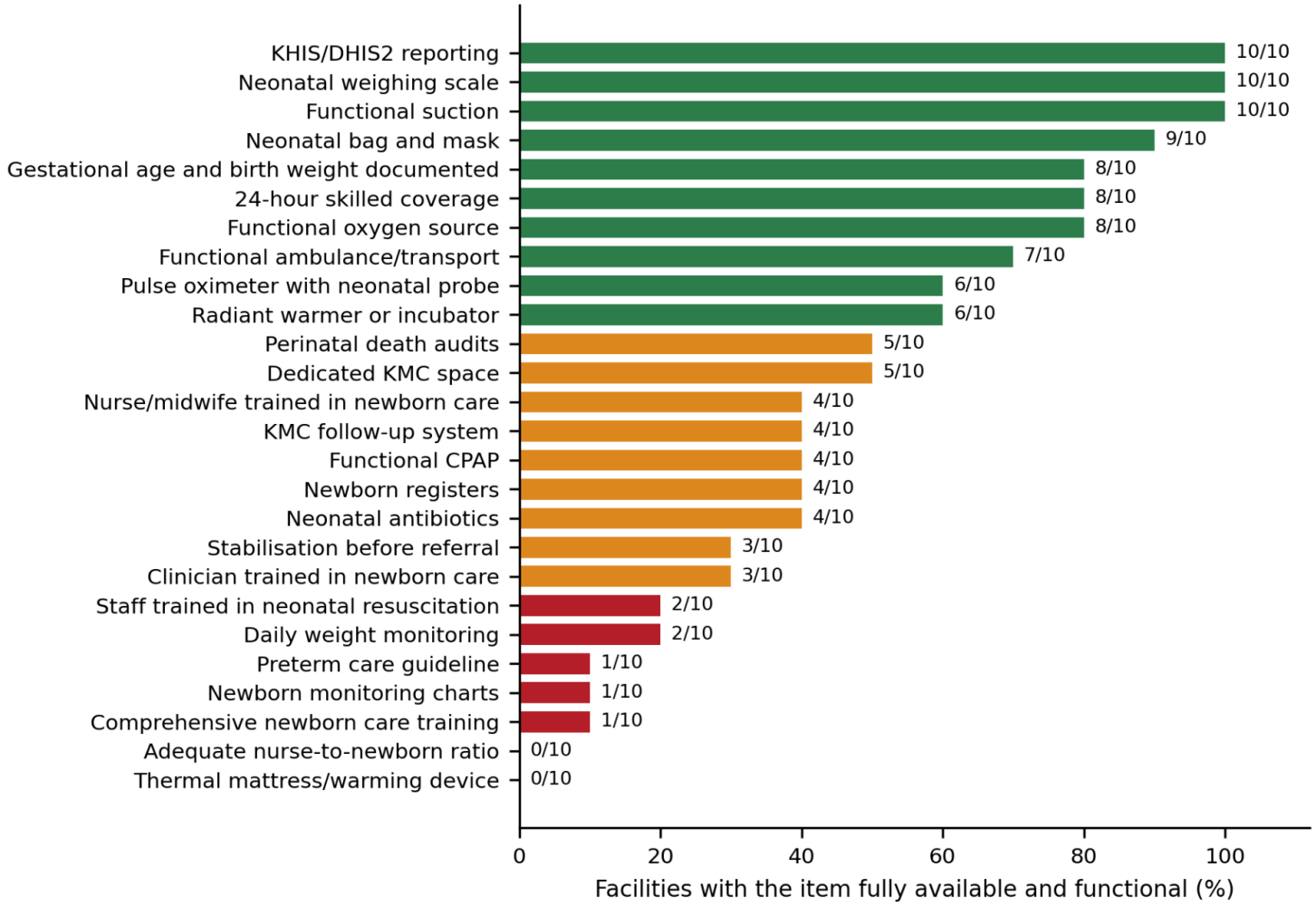


Figure 3

Tracer items fully available and functional. Bars show the percentage of the ten assessed facilities scoring 2 (fully available and functional) for each tracer item, ordered from lowest to highest functionality, with the number of facilities shown alongside each bar. Colour indicates functionality below 25% (dark), 25–59% (mid) and 60% or above (light in greyscale)

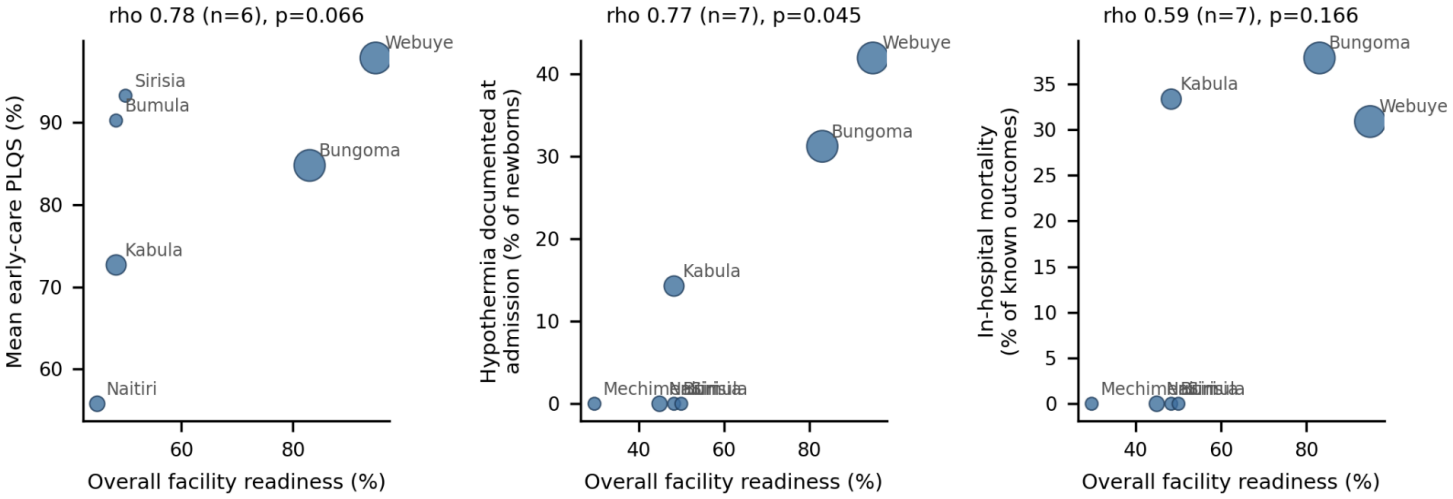


Figure 4

Exploratory facility-level associations between overall readiness and linked newborn-record indicators. Each point is one of the facilities contributing both a readiness assessment and newborn clinical records; point size is proportional to the number of newborn records contributed. Spearman rank correlations are shown. Associations are ecological and exploratory and cannot demonstrate that readiness caused any individual newborn outcome; the positive associations with documented hypothermia and mortality most plausibly reflect ascertainment and case mix at referral facilities