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Social Ecological Model Interpretation of Multilevel Determinants of Severe Adverse Outcomes among Low Birth Weight Neonates in a Kenyan County Referral Hospital

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Abstract

Background.

Adverse outcomes among low-birth-weight (LBW) neonates in low-resource settings are shaped by determinants that operate at several levels simultaneously, from neonatal biology to the organisation of the health system. Analysing these determinants in isolation obscures how they interact. This paper reframes the findings of a mixed-methods study of LBW neonates admitted to a Kenyan county referral hospital through the Social-Ecological Model (SEM), to show how individual, interpersonal, community, institutional and policy-level factors together shape the risk of a severe adverse outcome.

Methods.

This is an interpretive secondary synthesis of an existing mixed-methods cross-sectional study (169 LBW neonates and nine key-informant interviews with newborn-unit providers) conducted at Kericho County Referral Hospital. No new data were collected and no new models were fitted. Each quantitative determinant and qualitative theme reported in the parent papers was mapped to one of the five SEM levels using a determinant-by-level matrix, and quantitative and qualitative evidence were triangulated in a joint display. Detailed statistics are cited from the empirical papers rather than recomputed.

Results.

A severe adverse outcome occurred in 136 of 169 neonates (80.5%). Determinants were distributed across every ecological level. At the individual level, prematurity (85.8%), very low birth weight (18.3%), lower birth weight (adjusted odds ratio [AOR] 0.997 per gram) and maternal pregnancy-induced hypertension (25.4%; AOR 18.49) were the strongest and most consistent contributors. Interpersonal and community determinants — delayed care-seeking, transport problems (32.5%) and long distances (34.3%) — shaped the pre-hospital pathway. Institutional determinants (warm-chain care 92.9%; drug and feed shortages 58.6%; staffing pressure) and policy-level referral coordination (referred/outborn 49.1%; crude odds ratio 2.25) dominated provider accounts. Qualitative and quantitative strands converged on prematurity, low birth weight, maternal hypertension, supply shortages and referral gaps as priority targets, while staffing, infection prevention and bedside monitoring emerged as strong provider concerns not captured by measured variables.

Conclusions.

Viewed through the SEM, severe adverse outcomes among LBW neonates are not attributable to any single level but emerge from interacting individual, household, community, facility and system factors. The framework identifies where evidence is strong and where measurement gaps remain, and argues for

multilevel interventions that pair biological risk stratification with strengthened referral systems, thermal-care capacity, reliable supplies and adequate neonatal nursing staffing.

1. Background

Low birth weight (LBW; <2,500 g) remains one of the strongest predictors of neonatal morbidity and mortality worldwide, and its burden falls disproportionately on sub-Saharan Africa [1, 2]. An estimated 19.8 million infants are born with LBW each year, the majority in low- and middle-income countries, and these newborns carry a markedly elevated risk of hypothermia, respiratory distress, sepsis, hypoglycaemia and death [2, 3]. Reducing preventable neonatal deaths is central to Sustainable Development Goal 3.2, yet progress in many settings has stalled because the risks facing small and sick newborns are generated at multiple, interacting levels rather than by any single cause [3, 4].

A companion body of work from Kericho County Referral Hospital examined the determinants of adverse outcomes among LBW neonates using a mixed-methods design. Those analyses established the burden and pattern of adverse outcomes [5], the maternal and neonatal predictors of severe outcomes [6], the care pathway barriers understood through the Three Delays framework [7], and the care-related determinants and provider perspectives on newborn-unit practice [8]. Read individually, each paper isolates one slice of the problem. Read together, they describe determinants that sit at different ecological levels — the neonate's biology, the family's decisions, the community's geography, the facility's readiness and the county's referral system — and that plainly interact.

The Social-Ecological Model (SEM) offers an established structure for interpreting such multilevel determinants [9, 10]. Originally articulated by Bronfenbrenner and later adapted for public health, the SEM situates health outcomes within nested levels of influence — individual, interpersonal, community, institutional and policy — and emphasises that effective interventions usually require action at more than one level [10, 11]. The model has been applied productively to maternal and newborn health in low-resource settings, where individual vulnerability, household decision-making, structural access barriers and health-system capacity converge on the mother–newborn dyad [11, 12].

The purpose of this paper is therefore interpretive rather than empirical. It does not present a new analysis; it reframes the existing findings as multilevel determinants, using a determinant-by-level matrix and a mixed-methods joint display to show how individual biology, relationships, community context, institutional readiness and policy interact to shape severe adverse outcomes. In doing so it aims to help clinicians, nurse leaders and county planners see where the evidence is strongest, where it converges across data strands, and where measurement gaps mean that important determinants remain only qualitatively described.

2. Methods

2.1 Design and rationale

This is an interpretive secondary synthesis of a completed mixed-methods cross-sectional study. Its contribution is conceptual: it re-organises previously reported determinants and themes within the SEM and triangulates them, in line with recommendations that mixed-methods findings be integrated rather than merely juxtaposed [13]. No new data were collected, no participants were re-contacted, and no new statistical models were fitted. Detailed effect estimates are cited from the empirical manuscripts [5–8] and are reproduced here only to the extent needed to support the multilevel interpretation.

2.2 Parent study and setting

The parent study was conducted in the newborn unit of Kericho County Referral Hospital, Kenya. The quantitative strand comprised 169 LBW neonates characterised across maternal, neonatal, community-access and facility-care variables, with a composite severe adverse outcome (respiratory distress, sepsis, hypothermia, hypoglycaemia, prolonged newborn-unit stay of at least seven days, or death) as the primary endpoint [5, 6]. The qualitative strand comprised nine key-informant interviews with newborn-unit providers — one paediatrician, five nurses, two clinical officers and one unit manager, with two to ten years of neonatal experience — analysed thematically [7, 8].

2.3 Level mapping and synthesis

Following the SEM, five levels were defined a priori: individual (maternal and neonatal biology), interpersonal/household (family decision-making and caregiver support), community (residence, distance, transport and contextual factors), institutional/facility (staffing, equipment, protocols, supplies and referral handling) and policy/health system (county neonatal-care systems, referral readiness and newborn-care guidelines). Each quantitative determinant and each qualitative theme reported in the parent papers was assigned to one level and recorded in a determinant-by-level matrix (Table 1). Themes from the interviews (Table 2) were then aligned with their corresponding quantitative evidence in a mixed-methods joint display (Table 3), and each pairing was classified as convergent (strands agree), divergent (strands differ) or qualitative-only (no measured variable existed). The matrix and joint display serve as the auditable backbone of the synthesis.

2.4 Boundary rule and overlap control

To avoid duplicating the empirical papers, the adjusted logistic-regression model and the Three-Delays pathway analysis are not re-presented here as primary results; they are cited as established findings and re-read at the level of the framework [6, 7]. The present contribution is limited to the multilevel interpretation.

2.5 Ethics

The parent study was approved by the Kabarak University Research Ethics Committee (KUREC-170226; reference KABU01/KUREC/001/17/02/26; valid 19 February 2026 to 19 February 2027) and licensed by the National Commission for Science, Technology and Innovation (NACOSTI/P/26/4186446; reference 625542, issued 3 April 2026). Written informed consent was obtained from mothers or guardians for the

neonatal records and from key informants for the interviews. As a secondary interpretive synthesis of de-identified, already-approved data, this paper required no additional primary data collection.

3. Multilevel synthesis

A severe adverse outcome occurred in 136 of 169 LBW neonates (80.5%) [5]. Table 1 consolidates the quantitative determinants carried into this synthesis and their ecological level; Table 2 summarises the provider themes; Table 3 integrates the two strands across levels; and Fig. 1 displays the populated SEM. The remainder of this section reads the evidence level by level.

Table 1

Quantitative determinants of severe adverse outcome across Social-Ecological domains (N = 169).

Determinant (variable)	SEM domain	Prevalence / value	Crude OR [95% CI] (p)	Adjusted AOR [95% CI] (p)
Preterm birth	Individual–neonatal	85.8%	3.79 [1.50, 9.56] (.003)	0.10 [0.01, 1.29] (.077)
Very low birth weight (< 1500 g)	Individual–neonatal	18.3%	NE† (χ^2=9.21, p=.002)	—
Birth weight (per gram)	Individual–neonatal	M = 1784.5 g	1705 vs 2113 g (p<.001)	0.997 [0.995, 0.999] (.012)
Low Apgar score	Individual–neonatal	M = 8.5	ns (p=.825)	—
No. of neonatal risk factors	Individual–neonatal	M = 1.3	1.4 vs 0.9 (p<.001)	6.15 [0.61, 62.2] (.124)
Pregnancy-induced hypertension	Individual–maternal	25.4%	6.69 [1.53, 29.27] (.004)	18.49 [1.87, 182.5] (.013)
Attended ANC in pregnancy	Individual–maternal	89.3%	0.81 [0.22, 2.97] (.746)	—
Decision-to-seek-care delay	Interpersonal / household	13.6%	χ^2=9.72 (p=.002)‡	—
Transport access problem	Community	32.5%	χ^2=11.70 (p<.001)‡	—
Long distance to facility	Community	34.3%	—	—
Skilled personnel at admission	Institutional / facility	94.7%	1.19 [0.24, 6.01] (.834)	0.51 [0.02, 13.3] (.686)
Warm chain maintained	Institutional / facility	92.9%	4.81 [1.44, 16.07] (.006)	10.94 [1.40, 85.4] (.023)
Shortage of essential drugs/feeds	Institutional / facility	58.6%	2.26 [1.04, 4.90] (.036)	—
Referred / Outborn	Policy / health system	49.1%	2.25 [1.01, 5.00] (.043)	—

Note. Estimates are cited from the parent empirical papers [5–8]. OR = crude (bivariate) odds ratio; AOR = adjusted odds ratio (multivariable logistic regression); CI = confidence interval; ANC = antenatal care; NE = not estimable (zero cell); ns = not significant; M = mean; — = not modelled. †All 31 very-low-birth-weight neonates had a severe outcome. ‡Delay indicators showed an inverse (protective-appearing) association, most plausibly reflecting confounding by indication (see Section 3.2).

3.1 Individual level: maternal and neonatal biology

The individual level carried the strongest and most consistent determinants. Prematurity was common (85.8%) and roughly quadrupled the crude odds of a severe outcome (odds ratio [OR] 3.79, p=.003), and mean gestational age was lower among severe cases (31.9 vs 34.7 weeks, p<.001) [6]. Lower birth weight was independently predictive after adjustment (AOR 0.997 per gram, p=.012), and every one of the 31 very-low-birth-weight (< 1,500 g) neonates experienced a severe outcome [5, 6]. On the maternal side, pregnancy-induced hypertension was both common (25.4%) and the single strongest independent predictor in the adjusted model (AOR 18.49, p=.013) [6]. Providers independently emphasised prematurity, very low birth weight, poor condition at birth and maternal hypertension, so these determinants are convergent across strands (Table 3). By contrast, low Apgar score and poor antenatal-care attendance were stressed by informants but were not statistically significant here (p=.825 and p=.746), a divergence that most likely reflects limited variability — antenatal-care coverage was high at 89.3% — rather than clinical irrelevance.

3.2 Interpersonal and community levels: the pre-hospital pathway

Household decision-making and community access shaped how, and how quickly, neonates reached definitive care. Providers described caregivers delaying because danger signs were not recognised — a very small baby judged to be “just sleepy” — and pointed to cost, night-time travel and long distances as recurrent barriers [7, 8]. Quantitatively, a decision-to-seek-care delay was recorded in 13.6% of cases, transport problems in 32.5% and long distance to the facility in 34.3% [7]. The measured delay indicators showed inverse, protective-appearing associations with severe outcome (Table 1); as argued in the pathway analysis, this is most plausibly confounding by indication and reverse causation — the sickest neonates were rushed in fastest — rather than evidence that delay protects [7]. Interpreted at the community level, these determinants locate an actionable barrier at the interface between reaching care and receiving it.

Table 2

Themes from key-informant interviews with newborn-unit providers (n = 9).

Theme	Emerging subthemes	Illustrative meaning
Timeliness of admission and triage	First hour of care; emergency stabilisation; congestion-related delays	Early assessment and intervention were viewed as critical for survival.
Staffing and workload	High nurse-to-baby ratio; night/weekend workload; burnout	Providers felt committed but overstretched.
Warm-chain maintenance	KMC dependence; inadequate incubators; cold referrals	Hypothermia was repeatedly linked to delayed or poor thermal care.
Infection prevention practices	Congestion; caregiver movement; hand-hygiene challenges	Infection prevention was difficult in a crowded unit.
Drug and equipment availability	Incubators, CPAP, oxygen, feeds, syringes, antibiotics	Supplies existed but were sometimes insufficient or inconsistent.
Referral coordination	Incomplete notes; lack of calls; poor pre-referral stabilisation	Referral gaps led to cold, unstable or poorly documented admissions.
Monitoring and documentation	Frequent observation needs; documentation sacrificed during emergencies	Inadequate monitoring increased the risk of missed deterioration.

Note. Derived from thematic analysis of nine key-informant interviews (1 paediatrician, 5 nurses, 2 clinical officers, 1 unit manager; 2–10 years' neonatal experience) [7, 8]. KMC = kangaroo mother care; CPAP = continuous positive airway pressure.

3.3 Institutional level: newborn-unit readiness and care processes

The institutional level was the richest in the provider accounts and central to the quantitative signal. Skilled personnel were present at admission in 94.7% of cases and a warm chain was recorded in 92.9%, yet warm-chain care was paradoxically associated with higher odds of a severe outcome (AOR 10.94, p=.023) [6, 8]. As in the parent analyses, this counter-intuitive direction is best read as confounding by indication — thermal support is concentrated on the coldest, sickest neonates — not as harm [6]. Shortages of essential drugs and feeds were frequent (58.6%) and were associated with severe outcome in the expected direction (OR 2.26, p=.036) [8]. Providers consistently described staffing pressure, crowding, infection-prevention difficulty and monitoring lapses during emergencies (Table 2). Several of these — staffing adequacy, infection-prevention practice and bedside monitoring — were strong qualitative themes with no corresponding measured variable, and are therefore classified as qualitative-only in Table 3, marking clear priorities for future data collection.

3.4 Policy and health-system level: referral readiness

At the policy and health-system level, referral organisation was the dominant determinant. Nearly half of the neonates were referred or outborn (49.1%), and referral/outborn status was associated with roughly doubled odds of a severe outcome (OR 2.25, p=.043) [5, 7]. Informants described the mechanisms directly: absent pre-referral communication, incomplete documentation, and poor stabilisation, so that referred neonates often arrived cold and unstable [7, 8]. This is a convergent determinant, and one that is squarely modifiable through county-level referral protocols, communication systems and pre-referral stabilisation standards.

Table 3

Mixed-methods joint display: determinants across Social-Ecological levels.

Ecological level	Determinant / theme	Key qualitative finding	Corresponding quantitative evidence	Integration
Individual — neonatal	Prematurity	Among the strongest determinants; very premature (30–32 wk) most vulnerable	Preterm OR 3.79 (p=.003); GA 31.9 vs 34.7 wk (p<.001)	Convergent
	Very low birth weight	LBW/VLBW babies lose heat rapidly and are highly vulnerable	All 31 VLBW had severe outcome; BW AOR 0.997/g (p=.012)	Convergent
	Low Apgar / poor condition	Viewed as a bad prognostic sign	Apgar not significant (p=.825)	Divergent
	Temperature instability	Poor admission temperature; hypothermia common	Hypothermia 35.5%; no admission-temperature variable	Convergent; gap
Individual — maternal	Maternal hypertension (PIH)	Noted by several informants	PIH OR 6.69 (p=.004); AOR 18.5 (p=.013)	Strongly convergent
	Poor ANC attendance	Few visits meant complications were missed	ANC not significant (p=.746); coverage 89.3%	Divergent
Interpersonal / household	Care-seeking / decision delay	Caregivers delay; a small baby thought 'just sleepy'	Decision delay 13.6%; χ^2=9.72 (p=.002, inverse)	Convergent; direction confounded
Community	Transport & distance	Cost, night transport, long distances; babies arrive cold	Transport problem 32.5%; long distance 34.3%	Convergent
Institutional / facility	Staffing & workload	High nurse-to-baby ratio; night/weekend burnout	Skilled personnel 94.7% (not associated, p=.834)	Partly divergent
	Warm-chain maintenance	KMC dependence; inadequate incubators; cold referrals	Warm chain 92.9%; AOR 10.9 (p=.023)	Central; direction confounded

Note. KII = key-informant interview (n = 9). Quantitative evidence corresponds to Table 1 (severe adverse outcome, N = 169) and is cited from the parent papers [5–8]. Convergent = strands agree; Divergent = strands differ; Qualitative only = no corresponding measured variable existed; gap = priority for future measurement. GA = gestational age; PIH = pregnancy-induced hypertension; ANC = antenatal care; KMC = kangaroo mother care; IPC = infection prevention and control; VLBW = very low birth weight.

Ecological level	Determinant / theme	Key qualitative finding	Corresponding quantitative evidence	Integration
	Infection prevention	Congestion, caregiver movement, hand-hygiene challenges	Sepsis 38.5% (component); no IPC variable	Qualitative only; gap
	Drug & equipment availability	Incubators, CPAP, oxygen, feeds sometimes insufficient	Drug/feed shortage 58.6%; OR 2.26 (p=.036)	Convergent
	Monitoring & documentation	Frequent observation needed; documentation sacrificed in emergencies	No monitoring variable collected	Qualitative only; gap
	Timeliness of admission & triage	First hour and stabilisation critical; congestion delays	Prompt care 66.3%; admission time not associated (p=.139)	Emphasised qualitatively
Policy / health system	Referral coordination	Incomplete notes, no calls, poor stabilisation	Referred/outborn 49.1%; OR 2.25 (p=.043)	Convergent

Note. KII = key-informant interview (n = 9). Quantitative evidence corresponds to Table 1 (severe adverse outcome, N = 169) and is cited from the parent papers [5–8]. Convergent = strands agree; Divergent = strands differ; Qualitative only = no corresponding measured variable existed; gap = priority for future measurement. GA = gestational age; PIH = pregnancy-induced hypertension; ANC = antenatal care; KMC = kangaroo mother care; IPC = infection prevention and control; VLBW = very low birth weight.

4. Discussion

Interpreted through the Social-Ecological Model, severe adverse outcomes among LBW neonates at this referral hospital were not the product of any single level but emerged from determinants acting, and interacting, across all five. The framework makes three contributions to how the parent findings are understood. First, it locates each determinant: biological vulnerability at the individual level, delayed recognition at the household level, access barriers at the community level, readiness and care-process gaps at the institutional level, and referral organisation at the policy level. Second, by triangulating strands it distinguishes determinants that are robust across data types — prematurity, low birth weight, maternal hypertension, supply shortages and referral coordination — from those that are emphasised by providers but not statistically captured, such as staffing adequacy, infection prevention and monitoring. Third, it exposes measurement gaps precisely where the qualitative signal is strongest, giving a concrete agenda for future data collection.

These patterns are consistent with the wider literature on small and sick newborn care in low-resource settings, where biological risk interacts with health-system readiness to determine survival [3, 4]. The

prominence of thermal care and referral coordination echoes evidence that hypothermia and fragmented referral are recurrent, modifiable contributors to neonatal harm in the region [8, 12]. The apparently harmful associations of warm-chain care and shorter delay illustrate a general caution for observational neonatal data: interventions concentrated on the sickest infants can appear harmful unless confounding by indication is acknowledged [6, 7]. The SEM does not resolve this confounding, but by framing such determinants as markers of accumulated vulnerability rather than causal harms it keeps the interpretation clinically sensible.

The practical implication is that single-level interventions are unlikely to be sufficient. Individual-level risk stratification (birth weight, gestational age, maternal hypertension) needs to be paired with community-level measures that shorten the path to care, institutional investment in thermal-care capacity, reliable supplies and neonatal nursing staffing, and policy-level strengthening of referral communication, documentation and pre-referral stabilisation. Because several of the strongest provider concerns are not yet measured, county newborn-care information systems should be extended to capture admission temperature, nurse-to-patient ratios, infection-prevention adherence and monitoring frequency, so that the institutional level can be evaluated quantitatively in future.

4.1 Strengths and limitations

The main strength of this synthesis is its explicit, auditable mapping of every determinant and theme to an ecological level and its triangulation of strands in a joint display, which makes the interpretation transparent and reproducible. Its limitations follow from its design. It is an interpretation of a single-site study, so the specific prevalences and effect sizes are not generalisable beyond comparable Kenyan county settings, although the multilevel structure is likely transferable. It adds no new data, and it inherits the parent study's constraints, including the modest number of severe versus non-severe neonates, wide confidence intervals on some adjusted estimates, and the absence of variables for several qualitatively important institutional determinants. Finally, the qualitative sample, while information-rich, comprised nine providers at one facility; caregiver and community voices were not represented directly.

5. Conclusion

Severe adverse outcomes were common among LBW neonates in this Kenyan referral setting, affecting four in five infants. Read through the Social-Ecological Model, their determinants span individual biology, household recognition, community access, facility readiness and health-system referral organisation, and the strongest determinants are those on which the quantitative and qualitative strands converge — prematurity, low birth weight, maternal hypertension, supply shortages and referral gaps. Reducing this burden will require coordinated action across levels rather than any single intervention, together with better measurement of the institutional determinants that providers consistently identify but that current data do not capture.

Declarations

Competing interests.

The authors declare that they have no competing interests.

Ethics approval and consent to participate.

The parent study was approved by the Kabarak University Research Ethics Committee (KUREC-170226; reference KABU01/KUREC/001/17/02/26) licensed by NACOSTI (NACOSTI/P/26/4186446; reference 625542), and authorised by the Kericho County Referral Hospital Institutional Scientific Ethics and Research Committee (reference KCO/REC/2026/05/002). All procedures involving human participants were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments, and in compliance with relevant Kenyan national guidelines and regulations. Written informed consent was obtained from mothers/guardians and from key informants. This secondary interpretive synthesis used de-identified, previously approved data and required no additional consent.

Consent for publication.

Not applicable; no individually identifiable data are presented.

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Author Contribution

JC conceived the parent study and led data collection. MSS led the Social-Ecological interpretation and drafted the manuscript. VKM and EMN contributed to the level mapping and critical revision. All authors read and approved the final manuscript.

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Data Availability

The de-identified dataset supporting this synthesis are available on Open Science Framework https://doi.org/10.17605/OSF.IO/NMKAU. Detailed statistical outputs are reported in the parent empirical papers [5–8].

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Figures

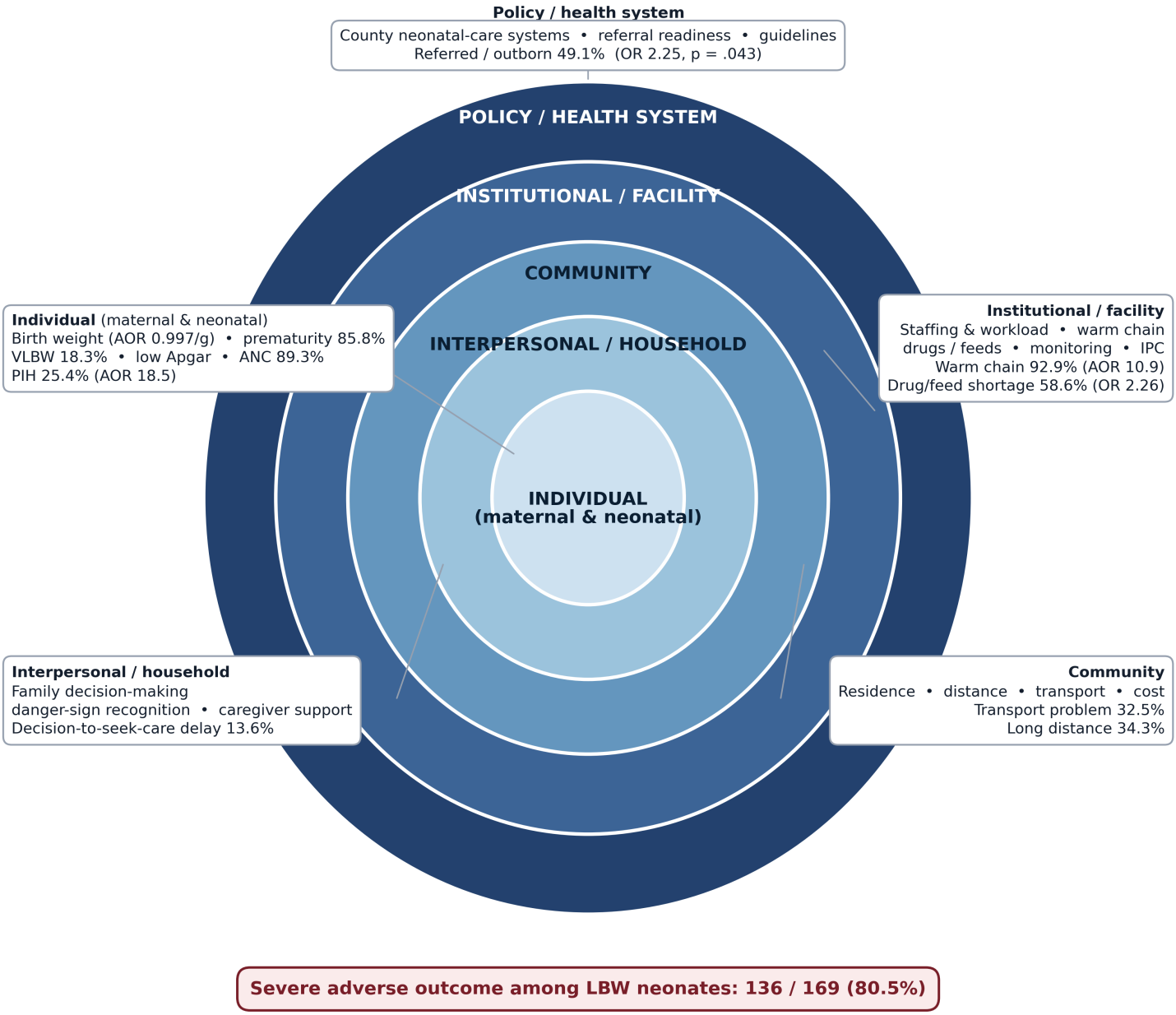


Figure 1

Social-Ecological Model populated with this study's level-specific determinants of severe adverse outcome among low-birth-weight neonates (N = 169). Effect estimates for variables are cited from the parent empirical papers [5–8].