

Post-discharge survival and incomplete postnatal care continuum among newborns discharged from hospital-based newborn care in Ethiopia: a prospective cohort study

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Abstract

Background

The period after discharge from hospital-based newborn care is a critical but often under-documented phase in the continuum of care for newborns, particularly for preterm, low-birth-weight, and sick newborns. In Ethiopia, previous studies from the same broader implementation research project documented health system readiness, referral linkage, and quality-of-care challenges affecting newborn care. However, less is known about survival and postnatal care utilization after newborns are discharged from basic or advanced newborn care. This study assessed post-discharge survival and postnatal care utilization among newborns discharged from selected hospitals in Addis Ababa and Oromia Region, Ethiopia.

Methods

We conducted a prospective cohort study among 896 postpartum mother-newborn pairs discharged from four hospitals in Ethiopia between December 2017 and March 2019. The cohort included newborns discharged from advanced newborn care units, defined as neonatal intensive care units, kangaroo mother care units, or special newborn care units, and newborns discharged from basic newborn care units without admission to advanced care. Data were collected through medical record abstraction and maternal interviews at enrollment, followed by post-discharge contacts at approximately 7, 29, and 59 days after discharge. The primary outcomes were post-discharge mortality during 60 days of follow-up and utilization of postnatal care, including at least one postnatal care visit and completion of all three recommended postnatal care contacts. Modified Poisson regression with robust variance was used to identify factors associated with postnatal care utilization.

Results

Among 896 newborns included in the final analysis, three verified deaths occurred during 60 days of post-discharge follow-up, corresponding to a post-discharge mortality rate of 3.3 deaths per 1,000 followed newborns. One additional infant was recorded as having died before or at discharge and was not included in the post-discharge mortality numerator. Because mortality events were rare, multivariable analysis of mortality predictors was not feasible. Overall, 68.1% of newborns had at least one postnatal care visit after discharge, but only 16.1% completed all three recommended postnatal care contacts. Newborns enrolled in Oromia Region had lower utilization of at least one postnatal care visit and all three postnatal care contacts compared with those enrolled in Addis Ababa. Completion of all three postnatal care contacts was associated with facility stay of at least 24 hours after birth (aRR 1.92, 95% CI 1.21–3.05), maternal awareness of newborn danger signs at discharge (aRR 1.66, 95% CI 1.21–2.28), and maternal awareness of the timing of newborn follow-up visits (aRR 1.39, 95% CI 1.01–1.92).

Conclusions

Post-discharge survival was very high among newborns discharged from the study hospitals, including those who had received advanced newborn care. However, completion of the full postnatal care continuum remained low, and rural-urban differences in follow-up care were substantial. The findings suggest that survival after discharge can be favorable when newborns reach and are discharged from hospital-based care, but continuity of care after discharge remains incomplete. Strengthening discharge counseling, ensuring at least 24 hours of facility observation after birth, reinforcing maternal awareness of newborn danger signs and follow-up timing, and improving community-based postnatal follow-up may help sustain survival gains and improve post-discharge newborn care.

Introduction

The postnatal period is a critical window for newborn survival, growth, and early identification of illness. Globally, the first days and weeks after birth carry substantial risk, particularly for newborns who are born preterm, low birth weight, or sick. The World Health Organization recommends that every newborn delivered in a health facility should receive appropriate care before discharge, including at least 24 hours of observation after birth, and that mothers and newborns should receive additional postnatal care contacts after discharge: around 48–72 hours, between days 7 and 14, and at approximately six weeks after birth [1]. These contacts are intended to support feeding, thermal care, immunization, recognition of newborn danger signs, referral, and timely care-seeking when illness occurs.

Despite the importance of postnatal care, the period after discharge remains one of the weakest points in the maternal and newborn care continuum in many low- and middle-income countries. Newborns may leave health facilities before adequate observation, mothers may not receive sufficient counseling on danger signs or follow-up timing, and linkages between hospitals, primary health care facilities, and community-based providers are often weak. These challenges are particularly consequential for newborns discharged from neonatal intensive care units, kangaroo mother care units, or special newborn care units, because survival after discharge depends not only on inpatient care but also on the family's ability to recognize danger signs, access follow-up care, and return rapidly when complications arise [2–5].

In Ethiopia, national efforts have expanded facility-based delivery, neonatal care, kangaroo mother care, and referral services for preterm, low-birth-weight, and sick newborns. However, postnatal care utilization remains low, and national estimates have shown limited coverage of early postnatal contacts for newborns and mothers [10]. Existing evidence also suggests that access to postnatal care is shaped by residence, distance to facilities, maternal education, household resources, quality of discharge counseling, and the availability of functioning referral and community follow-up systems [6–8]. These factors may be especially important after discharge from hospital-based newborn care, where infants may remain clinically vulnerable even after surviving the immediate neonatal illness episode.

This manuscript is part of a broader implementation research effort on care for preterm, low-birth-weight, and sick newborns in Ethiopia. Three companion qualitative papers from the same broader study examined health system readiness, referral linkage, and quality of care for this population [13–15]. Those papers documented important system-level barriers, including gaps in facility readiness, referral communication, continuity of care, human resources, essential supplies, and quality of inpatient newborn care. Together, those findings highlighted that improving newborn survival requires more than facility admission alone; it also requires a functioning continuum that links pregnancy, delivery, inpatient newborn care, discharge preparation, referral, community follow-up, and timely postnatal care.

However, while these qualitative studies provided important insight into health system constraints, less is known about what happens to newborns after discharge from hospital-based care. In particular, there is limited evidence from Ethiopia on post-discharge survival among newborns who received advanced newborn care and on whether newborns discharged from basic or advanced care complete the recommended postnatal care continuum. Understanding post-discharge survival and follow-up care is essential for identifying whether hospital-based newborn care is followed by adequate continuity of care, and whether discharge counseling and system linkages are sufficient to support newborns and families after they return home.

This prospective cohort study therefore assessed post-discharge survival and postnatal care utilization among newborns discharged from selected hospitals in Addis Ababa and Oromia Region, Ethiopia. Specifically, the study aimed to estimate post-discharge mortality during 60 days of follow-up; determine the proportion of newborns receiving at least one and all three recommended postnatal care contacts after discharge; compare postnatal care utilization by level of newborn care and facility location; and identify factors associated with completion of recommended postnatal care. By linking survival and service utilization after discharge, the study contributes evidence on both the outcomes and the remaining gaps in the postnatal care continuum for newborns discharged from hospital-based care in Ethiopia.

Methods

Study design and setting

We conducted a prospective cohort study among postpartum mother-newborn pairs discharged from selected hospitals in Ethiopia. Data were collected from December 2017 through March 2019 in three specialized hospitals in Addis Ababa - St. Paul's Hospital Millennium Medical College, Gandhi Memorial Hospital, and Yekatit 12 Hospital - and one hospital in Oromia Region, Goba Hospital. The Addis Ababa facilities represent large urban referral and specialized hospitals, while Goba Hospital serves a more rural catchment population in Oromia Region.

The study was designed to assess post-discharge survival and postnatal care utilization among newborns discharged from hospital-based newborn care, including both newborns who received

advanced newborn care and those discharged from basic newborn care without admission to advanced care.

Study population

The study population included postpartum mothers and their newborns who were discharged from the study hospitals and were expected to remain within the study catchment area during the 60-day follow-up period after discharge.

Two cohorts of newborns were enrolled. The advanced care cohort included newborns admitted to and discharged from advanced newborn care units, defined as neonatal intensive care units, kangaroo mother care units, or special newborn care units. The basic care cohort included newborns delivered in or receiving care from labor, delivery, or postnatal care units and discharged home without admission to advanced newborn care units in the study facility or another facility.

Newborns were eligible if they were less than 72 hours old at presentation to the study facility, were discharged alive from the facility, and their mothers or guardians provided informed consent. Newborns born in the study facilities and newborns born elsewhere, including at home or in another facility, and subsequently transferred, referred, or self-referred to the study facilities were eligible if they met the study criteria.

Mothers were excluded if they were unavailable, incapacitated, unwilling or unable to provide informed consent, or younger than 18 years and unable or unwilling to obtain consent from a parent or guardian in addition to self-consent.

Sampling and recruitment

Study staff worked with ward staff and facility registers to identify potentially eligible newborns during the study enrollment period. Each day, research staff reviewed unit registers and approached eligible mothers before discharge. After screening, eligible mothers were invited to participate and provided written informed consent before enrollment.

Because the number of newborns discharged from basic care units exceeded the number that could be screened and enrolled each day, a subset of newborns discharged from basic care units was selected on the same days and during similar times as newborns discharged from advanced care units. A stratified systematic sampling approach was used to enroll newborns from the two care-level groups.

Sample size

The original study was designed to estimate post-discharge mortality among newborns discharged from advanced newborn care. The sample size calculation assumed a 95% confidence level, 5% margin of

error, an estimated national neonatal mortality rate of 29 deaths per 1,000 live births, and a higher expected mortality risk among preterm newborns based on published evidence [10, 11]. Allowing for an estimated 10% loss to follow-up, the target sample size was 520 newborns discharged from advanced care units in the urban facilities. The rural site was included to provide exploratory evidence on post-discharge outcomes in a less urban setting, although the study was not powered to provide a precise mortality estimate for the rural site.

Data collection

Data were collected using medical record abstraction and maternal interviews at enrollment, followed by post-discharge follow-up contacts. At enrollment, trained study staff abstracted information from medical records and facility registers and administered a standardized questionnaire to mothers.

Enrollment data included maternal sociodemographic characteristics, antenatal care attendance, delivery characteristics, place and mode of delivery, parity, birth type, newborn sex, newborn feeding, level of newborn care received, length of facility stay before discharge, discharge status, and maternal awareness of newborn immunization, danger signs, and timing of recommended newborn follow-up visits.

Follow-up data were collected at approximately 7, 29, and 59 days after discharge. Follow-up was conducted by telephone whenever possible. When telephone contact was unsuccessful and prior permission had been obtained, study staff conducted in-person follow-up in the community. Follow-up interviews assessed newborn vital status, illness or danger signs, postnatal care utilization, care-seeking, and receipt of follow-up services.

Data collectors and supervisors received training on the study protocol, informed consent, abstraction procedures, questionnaire administration, privacy, and respectful communication with mothers. Study tools were pretested and revised before implementation.

Outcome variables

The primary outcome was post-discharge survival during 60 days of follow-up. Post-discharge mortality was defined as a verified death occurring after discharge from the study facility and before completion of the final follow-up contact at approximately 59 days post-discharge. Deaths recorded before or at discharge were not included in the post-discharge mortality numerator.

The secondary outcomes were postnatal care utilization after discharge. Two postnatal care outcomes were assessed: receipt of at least one postnatal care visit during the 60-day follow-up period and completion of all three recommended postnatal care contacts after discharge. Completion of all three contacts was defined as having postnatal care contacts corresponding to the follow-up schedule recommended for mothers and newborns after facility discharge: around 48–72 hours, between days 7 and 14, and at approximately six weeks after birth [1].

Additional descriptive outcomes included reported newborn danger signs during follow-up, home visits by Health Extension Workers in the first week after birth, and postnatal care utilization by level of newborn care and facility location.

Explanatory variables

Potential explanatory variables were selected based on prior literature and programmatic relevance. These included facility location, level of newborn care, maternal age, maternal education, paternal occupation, newborn sex, parity, birth type, delivery mode, antenatal care attendance, length of facility stay before discharge, infant feeding type, maternal awareness of newborn immunization, maternal awareness of newborn danger signs, and maternal awareness of timing for newborn follow-up visits.

Facility location was categorized as Addis Ababa or Oromia Region. Level of newborn care was categorized as basic care or advanced care. Length of facility stay was categorized as less than 24 hours or at least 24 hours before discharge.

Data analysis

The final analysis included newborns with complete outcome data. Data were analyzed using Stata statistical software (StataCorp LLC, College Station, TX, USA). Descriptive statistics were used to summarize maternal, newborn, delivery, and discharge characteristics. Frequencies and percentages were calculated for categorical variables.

Post-discharge mortality was calculated as the number of verified deaths during 60 days after discharge divided by the number of newborns included in the final analysis and expressed per 1,000 followed newborns. Deaths recorded before or at discharge were not included in the post-discharge mortality numerator. Because verified post-discharge deaths were rare, multivariable analysis of mortality predictors was not conducted.

Postnatal care utilization was summarized as the proportion of newborns who received at least one postnatal care visit and the proportion who completed all three recommended postnatal care contacts. These outcomes were described overall and by level of newborn care and facility location.

Modified Poisson regression with robust variance was used to estimate adjusted risk ratios (aRRs) and 95% confidence intervals for factors associated with receiving at least one postnatal care visit and completing all three recommended postnatal care contacts. Variables were included based on conceptual relevance, prior evidence, and availability in the dataset. Statistical significance was assessed at $p < 0.05$.

Ethical considerations

Ethical approval

was obtained from the Institutional Review Boards of St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia (IRB No. PM23/111), and Project Concern International (IRB No. 25). Letters of support were secured from relevant institutions and offices where data were collected.

Written informed consent was obtained from eligible and interested mothers in their preferred language. Mothers were informed that participation was voluntary and that refusal to participate would not affect the care they or their newborns received. Mothers were given the option to read or hear the consent form according to their literacy level. No financial incentives were provided.

In-person and telephone interviews were conducted in a manner that protected privacy and confidentiality. When community-based follow-up was needed, it was conducted only if mothers had given prior permission. Data were kept securely, and identifying information was separated from study data. Study staff were trained to interact respectfully and compassionately with participants and to refer mothers to available local support services when needed.

Results

Participant flow and baseline characteristics

A total of 1,185 women were approached to participate in the study. Of these, 1,040 consented and were enrolled at baseline, and 896 mother-newborn pairs had complete outcome data and were included in the final analysis (Fig. 1).

Among the 896 newborns included in the final analysis, 802 (90.0%) were enrolled from Addis Ababa and 94 (10.0%) from Oromia Region. Overall, 386 newborns (43.1%) had received advanced newborn care and 510 (56.9%) had received basic care. Most mothers were 25–34 years old (59.9%), married (99.1%), and had attended at least one antenatal care visit (98.2%). More than half were primiparous (55.5%), and most newborns were singleton births (95.9%). Approximately one-quarter of newborns were discharged before 24 hours after birth (25.3%). At discharge, 45.0% of mothers were not aware of important newborn danger signs and 57.7% were not aware of the timing of recommended newborn follow-up visits (Table 1).

Table 1
Respondents' characteristics according to number of postnatal care visits post-discharge.

Variable	Category	Sample % (N = 896)	At least 1 PNC n (%) (n = 610)	All 3 PNC n (%) (n = 144)
Facility region/location	Addis Ababa	802 (90.0)	580 (72.3)	139 (17.3)
	Oromia	94 (10.0)	30 (31.9)	5 (5.3)
Level of newborn care	Basic	510 (56.9)	377 (73.9)	83 (16.3)
	Advanced	386 (43.1)	233 (60.4)	61 (15.8)
Maternal age (years)	≤ 24	276 (30.8)	193 (69.9)	47 (17.0)
	25–34	537 (59.9)	356 (66.3)	85 (15.8)
	35+	83 (9.3)	61 (73.5)	12 (14.5)
Paternal employment	Unemployed	12 (1.3)	10 (83.3)	2 (16.7)
	Farmer	28 (3.1)	13 (46.4)	2 (7.1)
	Employed	402 (44.9)	272 (67.7)	49 (12.2)
	Self-employed	454 (50.7)	315 (69.4)	91 (20.0)
Maternal education	No education	67 (7.5)	48 (71.6)	10 (14.9)
	Primary	350 (39.1)	251 (71.7)	66 (18.9)
	Secondary	232 (25.9)	155 (66.8)	38 (16.4)
	Tertiary	247 (27.6)	156 (63.2)	30 (12.2)
Newborn sex	Female	388 (43.3)	273 (70.4)	63 (16.2)
	Male	508 (56.7)	337 (66.3)	81 (15.9)
Marital status	Married	888 (99.1)	605 (68.1)	144 (16.2)
	Unmarried	8 (0.9)	5 (62.5)	0 (0.0)
Parity	First birth	497 (55.5)	343 (69.0)	86 (17.3)
	2–3 births	335 (37.4)	224 (66.9)	51 (15.2)
	4 + births	64 (7.1)	43 (67.2)	7 (10.9)
Birth type	Multiple	37 (4.1)	29 (78.4)	10 (27.0)
	Single	859 (95.9)	581 (67.6)	134 (15.6)
Delivery mode	Cesarean section	260 (29.0)	186 (71.5)	42 (16.2)
	Instrumental	57 (6.4)	35 (61.4)	5 (8.8)

Variable	Category	Sample % (N = 896)	At least 1 PNC n (%) (n = 610)	All 3 PNC n (%) (n = 144)
	Spontaneous vaginal	579 (64.6)	389 (67.2)	97 (16.8)
ANC attendance	Not attended	16 (1.8)	12 (75.0)	5 (31.3)
	Attended ≥ 1	880 (98.2)	598 (68.0)	139 (15.8)
Length of hospital stay	< 24 hours	227 (25.3)	138 (60.8)	23 (10.1)
	≥ 24 hours	669 (74.7)	472 (70.6)	121 (18.1)
Infant feeding type	Breastfed only	786 (87.7)	536 (68.2)	128 (16.3)
	Formula-fed only	25 (2.8)	18 (72.0)	5 (20.0)
	Both	85 (9.5)	56 (65.9)	11 (12.9)
Mother aware of newborn immunization	No	100 (11.2)	46 (46.0)	8 (8.0)
	Yes	796 (88.8)	564 (70.9)	136 (17.1)
Mother aware of important newborn danger signs	No	403 (45.0)	285 (70.7)	51 (12.7)
	Yes	493 (55.0)	325 (65.9)	93 (18.9)
Mother aware of newborn follow-up visit timing	No	517 (57.7)	331 (64.0)	71 (13.4)
	Yes	379 (42.3)	279 (73.6)	73 (19.3)

Post-discharge survival during 60 days of follow-up

Among the 896 newborns included in the final analysis, three verified deaths were recorded during the 60-day post-discharge follow-up period, corresponding to a post-discharge mortality rate of 3.3 deaths per 1,000 followed newborns. This indicates that post-discharge survival was very high among newborns discharged from the study hospitals, including those who had received advanced newborn care.

One additional infant was recorded as having died before or at discharge and was therefore not included in the post-discharge mortality numerator. Because the number of verified post-discharge deaths was very small, multivariable analysis to identify predictors of mortality was not feasible. In a sensitivity estimate, if the additional record marked as died at discharge were included as a post-discharge death, the mortality rate would be 4.5 deaths per 1,000 followed newborns. However, the primary analysis was restricted to deaths verified during the 60-day post-discharge follow-up period (Table 2).

Table 2
Headline survival and postnatal care findings.

Indicator	Estimate
Newborns included in final analysis	896
Verified post-discharge deaths during 60 days	3
Post-discharge mortality rate	3.3 deaths per 1,000 followed newborns
Sensitivity estimate including ambiguous at-discharge death	4.5 deaths per 1,000 followed newborns
At least one PNC visit	610/896 (68.1%)
All three recommended PNC contacts	144/896 (16.1%)
HEW home visit in first week among full PNC users	Approximately 1%

Postnatal care utilization after discharge

Overall, 610 newborns (68.1%) had at least one postnatal care visit after discharge, while 144 newborns (16.1%) completed all three recommended postnatal care contacts. Utilization differed substantially by location. In Addis Ababa, 580 of 802 newborns (72.3%) had at least one postnatal care visit and 139 (17.3%) completed all three visits. In Oromia Region, 30 of 94 newborns (31.9%) had at least one visit and 5 (5.3%) completed all three visits.

Newborns who received basic care had higher use of at least one postnatal care visit than newborns who received advanced care (73.9% vs. 60.4%). Completion of all three recommended contacts was similar between the basic care and advanced care groups (16.3% vs. 15.8%) (Table 1).

WHO-recommended postnatal care components and danger signs

Among newborns who completed all three recommended postnatal care contacts, most had stayed at least 24 hours in the facility before discharge. This included 72.3% of basic care recipients and 100.0% of advanced care recipients. However, home visits by Health Extension Workers in the first week after birth were rare: 0.9% among basic care recipients, 1.2% among advanced care recipients, and none among newborns from Oromia Region.

Exclusive breastfeeding was common among newborns who completed all three postnatal care contacts. Reported danger signs during postnatal care included fast breathing, feeding difficulty, fever, coldness of the body, and jaundice. Several danger signs were more frequent among newborns who had received advanced care than among those who had received basic care, including fast breathing, feeding difficulty, coldness of body, and jaundice (Table 3).

Table 3

Coverage of WHO-recommended postnatal care among newborns completing all three visits and danger signs observed at postnatal care visits.

WHO recommendation / danger sign	Basic care (n = 83)	Advanced care (n = 61)	Addis Ababa (n = 139)	Oromia (n = 5)
Received 24 + hours of care prior to discharge	72.3	100.0	84.2	80.0
Home visits in the first week after birth	0.9	1.2	1.1	0.0
Exclusively breastfed	90.4	86.9	88.5	100.0
Fast breathing	3.6	13.1	7.9	0.0
Convulsions	0.0	2.5	0.9	0.0
Lethargy	1.2	3.3	2.2	0.0
Feeding difficulty	1.2	13.1	5.8	20.0
Severe chest indrawing	0.0	3.3	2.6	0.0
No movement	5.0	0.0	1.3	0.0
Fever	7.2	6.6	5.8	40.0
Coldness of body	5.0	11.5	10.4	0.0
Jaundice	6.0	9.8	7.2	20.0

Factors associated with postnatal care utilization

In adjusted analysis, newborns enrolled in Oromia Region had lower utilization of postnatal care compared with newborns enrolled in Addis Ababa. Newborns in Oromia had a lower likelihood of receiving at least one postnatal care visit (aRR 0.48, 95% CI 0.36–0.66) and completing all three visits (aRR 0.41, 95% CI 0.17–0.99).

Newborns who received advanced care had lower likelihood of at least one postnatal care visit compared with those receiving basic care (aRR 0.77, 95% CI 0.70–0.84), although completion of all three recommended postnatal care contacts did not differ significantly by level of newborn care (aRR 0.91, 95% CI 0.65–1.26).

Completion of all three postnatal care contacts was associated with staying at least 24 hours in the facility after birth (aRR 1.92, 95% CI 1.21–3.05), maternal awareness of newborn danger signs (aRR 1.66, 95% CI 1.21–2.28), and maternal awareness of the timing of newborn follow-up visits (aRR 1.39, 95% CI 1.01–1.92). Maternal awareness of newborn immunization was associated with receipt of at least one postnatal care visit (aRR 1.36, 95% CI 1.11–1.67) (Table 4).

Table 4. Multivariable modified Poisson regression of factors associated with postnatal care utilization.

Variable	Category	At least 1 PNC aRR (95% CI)	All 3 PNC aRR (95% CI)
Location of hospital	Addis Ababa (ref)		
	Oromia	0.48 (0.36-0.66)*	0.41 (0.17-0.99)*
Newborn level of care	Basic care (ref)		
	Advanced	0.77 (0.70-0.84)*	0.91 (0.65-1.26)
Maternal age	≤24 years (ref)		
	25-34 years	0.95 (0.87-1.04)	1.00 (0.72-1.38)
	35+ years	1.04 (0.90-1.20)	0.88 (0.50-1.53)
Newborn sex	Female (ref)		
	Male	0.97 (0.89-1.06)	0.97 (0.72-1.31)
Maternal education	None (ref)		
	Primary	1.00 (0.86-1.17)	1.16 (0.66-2.06)
	Secondary	0.97 (0.82-1.15)	1.15 (0.64-2.08)
	Tertiary	0.86 (0.72-1.02)	0.84 (0.45-1.55)
Paternal occupation	No job (ref)		
	Farmer	0.81 (0.55-1.21)	0.93 (0.15-5.93)
	Employee	0.86 (0.72-1.02)	1.04 (0.29-3.77)
	Self-employed	0.81 (0.68-0.96)*	1.49 (0.42-5.29)
Delivery mode	Cesarean (ref)		
	Instrumental	0.97 (0.78-1.20)	0.69 (0.29-1.62)
	Spontaneous vaginal	1.01 (0.91-1.10)	1.22 (0.87-1.70)
Length of hospital stay	<24 hours (ref)		
	≥24 hours	1.28 (1.13-1.44)*	1.92 (1.21-3.05)*
Infant feeding type	Breastfed (ref)		
	Formula	1.11 (0.88-1.40)	1.14 (0.50-2.57)
	Both	0.95 (0.81-1.12)	0.70 (0.39-1.25)
ANC attendance	None (ref)		
	Attended ≥1	0.95 (0.72-1.26)	0.48 (0.23-1.00)

Variable	Category	At least 1 PNC aRR (95% CI)	All 3 PNC aRR (95% CI)
Awareness of newborn immunization	No (ref)		
	Yes	1.36 (1.11-1.67)*	1.83 (0.93-3.63)
Awareness of newborn danger signs	No (ref)		
	Yes	0.94 (0.86-1.03)	1.66 (1.21-2.28)*
Awareness of newborn follow-up visit timing	No (ref)		
	Yes	1.06 (0.96-1.16)	1.39 (1.01-1.92)*

Abbreviations: aRR, adjusted risk ratio; CI, confidence interval; PNC, postnatal care. * Statistically significant at $p < 0.05$.

Discussion

This prospective cohort study assessed post-discharge survival and postnatal care utilization among newborns discharged from hospital-based newborn care in Ethiopia. The most striking finding was the very high survival during 60 days after discharge. Only three verified post-discharge deaths occurred among 896 followed newborns, corresponding to 3.3 deaths per 1,000 followed newborns. This low mortality was observed despite inclusion of newborns who had required advanced care in NICU, KMC, or special newborn care units. Because mortality events were rare, the study could not identify predictors of post-discharge mortality; the finding should therefore be interpreted as reassuring but exploratory.

The low post-discharge mortality observed in this cohort should be interpreted cautiously. It is not directly comparable to national neonatal mortality estimates because this study followed newborns who had already reached hospital-based care and survived to discharge. The cohort was also predominantly urban, with 90% of participants enrolled in Addis Ababa, where geographic access to facilities and specialized services is likely better than in many rural settings. Nevertheless, the finding is important because post-discharge survival among preterm, low-birth-weight, and sick newborns is often assumed to be poor in low-resource settings, yet this cohort suggests that newborns discharged from these study hospitals had favorable short-term survival after returning home.

The second important finding was the contrast between relatively high use of at least one postnatal care contact and low completion of the full recommended continuum. More than two-thirds of newborns had at least one postnatal care visit after discharge, which is higher than many previously reported estimates from Ethiopia and other settings [16-20]. However, only 16.1% completed all three recommended contacts. This suggests that many families reconnected with care after discharge, but the system did not reliably support completion of the full postnatal follow-up schedule. For newborns discharged after

illness or advanced care, this incomplete continuum represents a missed opportunity for early detection of deterioration, feeding problems, infection, thermal instability, and other danger signs.

Rural-urban differences were substantial. Newborns enrolled in Oromia Region were much less likely than newborns in Addis Ababa to receive at least one postnatal care visit or complete all three recommended contacts. This finding is consistent with broader evidence that urban residence, geographic proximity, service availability, and access to information influence utilization of maternal and newborn health services [18, 21]. The small size of the Oromia cohort limits precision, but the difference remains programmatically important. Strengthening post-discharge care in rural settings will likely require stronger linkage between hospitals, primary health care units, Health Extension Workers, and families before the newborn leaves the hospital.

Discharge-related factors were strongly associated with completion of recommended postnatal care. Newborns who stayed at least 24 hours in the facility after birth were nearly twice as likely to complete all three postnatal care contacts. This supports WHO guidance recommending at least 24 hours of facility-based care after birth [1] and reinforces the importance of using the immediate postnatal period for observation, counseling, and follow-up planning. Early discharge may reduce opportunities for mothers to receive counseling, understand danger signs, and leave the facility with a clear plan for where and when to return.

Maternal awareness also mattered. Mothers who were aware of newborn danger signs and the timing of follow-up visits at discharge were more likely to complete all three postnatal care contacts. These findings are consistent with evidence from Uganda, Ghana, and Ethiopia showing that maternal knowledge of danger signs and postnatal care recommendations influences care-seeking [21-23]. They also point to a modifiable intervention: structured discharge counseling. A standardized discharge checklist for newborns, especially for those discharged from advanced care, could include danger signs, feeding assessment, thermal care, immunization, follow-up appointment dates, referral instructions, and emergency contact information.

Another important systems finding was the near absence of Health Extension Worker home visits in the first week after birth, even among newborns who completed all three postnatal care visits. This indicates a gap between policy expectations for community-based postnatal follow-up and the reality of post-discharge continuity. For high-risk newborns, hospital discharge should trigger communication to the primary health care unit and community health worker responsible for follow-up. The findings support the need for a more deliberate discharge-to-community linkage mechanism, potentially including phone-based notification, referral slips, family-held discharge cards, and follow-up tracking registers.

This study complements three earlier qualitative publications from the same broader implementation research effort. Those studies documented challenges in facility readiness, referral systems, and quality of care for preterm, low-birth-weight, and sick newborns in Ethiopia [13-15]. The present study adds an outcome and utilization perspective after discharge. Together, the findings suggest that while newborns who reach and survive hospital-based care may have favorable short-term survival, the broader

continuum remains incomplete. Improving newborn outcomes will require connecting inpatient quality, discharge readiness, referral communication, and community-based follow-up into one functioning system.

The study has several limitations. First, the cohort was drawn from selected hospitals and was predominantly urban, limiting generalizability to rural settings and facilities with less specialized newborn care capacity. Second, the study was not powered to examine predictors of mortality, and the small number of deaths prevented multivariable mortality analysis. Third, postnatal care utilization and danger signs were collected through maternal follow-up interviews and may be affected by recall or reporting bias. Fourth, some participants enrolled at baseline did not have complete outcome data and were excluded from the final analysis. Fifth, the observational design does not allow causal attribution of survival or postnatal care utilization to the level of care received. Finally, the study followed newborns for 60 days after discharge and therefore does not capture longer-term readmission, morbidity, growth, neurodevelopmental outcomes, or mortality after the follow-up period.

Despite these limitations, the study provides useful evidence on a poorly documented period in newborn care: the transition from hospital discharge to home and follow-up care. The findings suggest that survival after discharge can be high among newborns discharged from hospital-based care, but the postnatal care continuum remains incomplete. Programmatic interventions should focus on discharge counseling, follow-up scheduling, referral linkage, and community-based follow-up, particularly for high-risk newborns and families living outside major urban centers.

Conclusions

Post-discharge survival was very high among newborns discharged from the study hospitals, including those who had received advanced newborn care. However, completion of all three recommended postnatal care contacts remained low, and rural-urban differences in post-discharge follow-up were substantial. Staying at least 24 hours in the facility after birth, maternal awareness of newborn danger signs, and maternal awareness of follow-up timing were associated with completion of the recommended postnatal care continuum. Strengthening discharge preparation, counseling, referral linkage, and community-based postnatal follow-up may help sustain survival gains and improve continuity of care after newborns return home.

Abbreviations

aRR

adjusted risk ratio

CI

confidence interval

GAPPS

Global Alliance to Prevent Prematurity and Stillbirth

HEW
Health Extension Worker
KMC
kangaroo mother care
LBW
low birth weight
NICU
neonatal intensive care unit
PNC
postnatal care
WHO
World Health Organization.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Institutional Review Boards of St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia (IRB No. PM23/111), and Project Concern International (IRB No. 25). Letters of support were secured from all institutions and offices where data were collected. Written informed consent was obtained from eligible and interested participants in their preferred language.

Consent for publication

Not applicable.

Availability of data and materials

The dataset used for this analysis is not publicly available because it contains participant-level information. De-identified data may be made available from the corresponding author upon reasonable request and with appropriate ethical and institutional approvals.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AMT, WA, EW, WG, TH, JAL, and members of the Every Preemie-SCALE Ethiopia Implementation Research Study Group contributed to the conception, design, implementation, analysis, interpretation, and manuscript development. All authors reviewed and approved the final manuscript.

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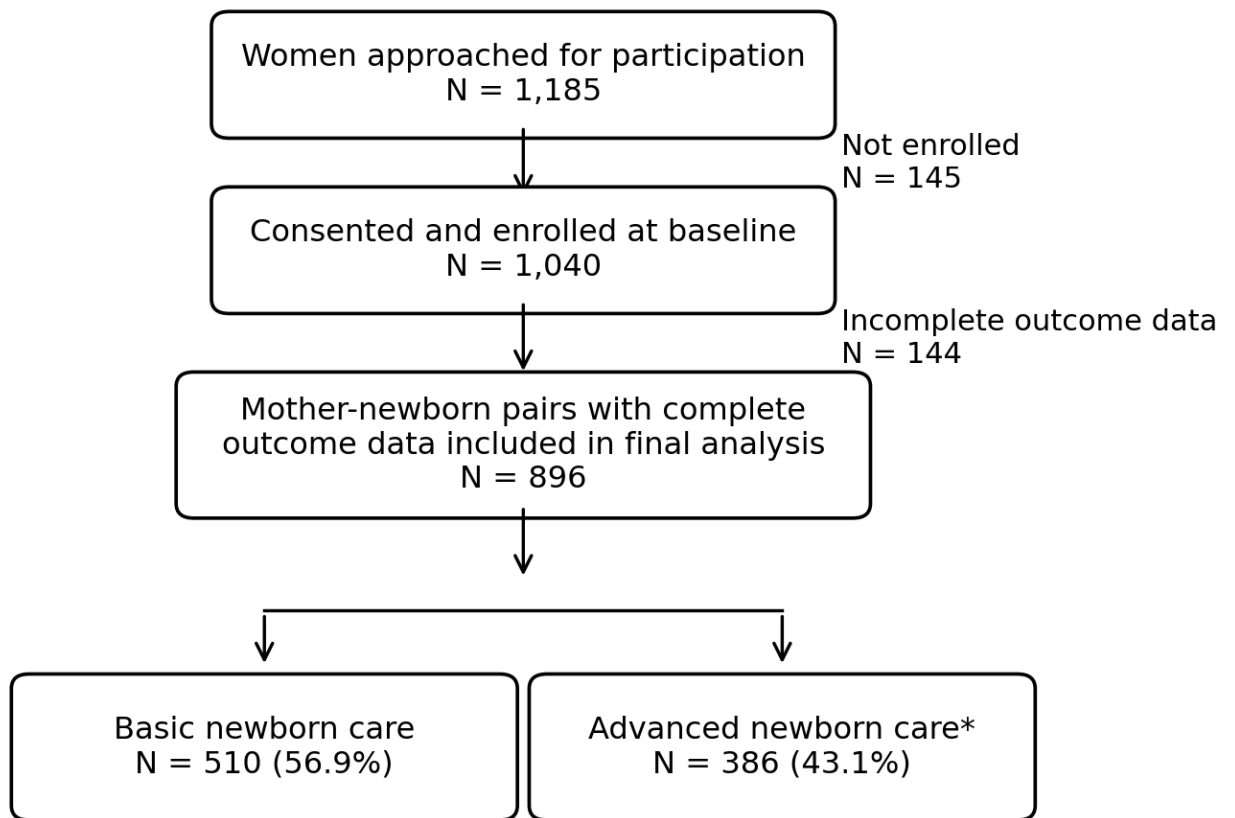
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Figures



* Advanced newborn care included neonatal intensive care, kangaroo mother care, and special newborn care units.

Figure 1

Participant flow diagram. A total of 1,185 women were approached; 1,040 consented and were enrolled at baseline; 896 mother-newborn pairs had complete outcome data and were included in the final analysis.