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Cost of Initial Care for Preterm Infants at Bolgatanga Regional Hospital, Ghana

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Abstract

Preterm birth is an important public health problem due to its medical, economic, and social impact and constitutes about 10% of annual global births. To improve access and equity to health care delivery of preterm infants, identification of major cost areas and strategies to improve efficiency in those areas must be prioritized. This study estimated the health system cost of neonatal intensive care unit (NICU) services for preterm babies in the Regional Hospital, Bolgatanga (RHB). A costing study based on health system perspective designed to estimate cost of initial hospital care for preterm babies was carried out in RHB. Participants were selected based on systematic sampling procedure of preterm babies admitted at the facility from January 2019 to December 2019. The health system and cost estimates of NICU services were done using both top-to-bottom and micro-costing approaches. Preterm births constituted 30% of NICU admissions in 2019. Most preterm infants were of low birth weight (LBW). The total cost for providing initial hospital care for preterm infants in 2019 was GH₵212,776.96 ($35,462.83). The major cost component was shared cost making up 59.20%, especially staff salaries. Direct medical cost constituted 40.80% of the total cost. The RHB would have saved GH₵212,776.96 ($35,462.83) in 2019 if preterm births were eliminated. Prioritizing efficient use of shared resources would save cost for increase access to preterm care.

Keywords: *Cost of initial hospital care, LBW, NICU, Preterm birth, Prevalence, Direct medical cost, shared cost, RHB.*

Introduction

Every year, 15 million babies are born preterm and in 2014 preterm births constituted 10.6% of global births and 12 million (81.1%) of these occurred in Asia and Sub-Saharan Africa [1, 2]. Preterm birth is birth before 37 completed weeks of gestation [3-7]. A preterm birth may arise either spontaneously or provider initiated because of either maternal or fetal indication [3, 4, 8-12]. It is an important obstetric and pediatric problem because of its association with enormous medical, economic, and social impact.

Preterm birth is of public health importance due to its contribution to neonatal mortality. These infants are prone to complications responsible for 35% of deaths among newborns because of prematurity [3, 4].

Preterm birth is the most important determinant of newborn outcomes in terms of survival and quality of life. Among the complications associated with preterm infants are impaired respiration, feeding difficulties, poor body temperature regulation, and high risk of infection. Globally, preterm birth remains the leading cause of adverse perinatal outcomes;

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neonatal morbidity and mortality, [5] which is a key index of health standard in a country [13].

With improvement in technology and medication, preterm infants that would have died in the past are now surviving. Survival is however associated with long hospital stays, use of specialized equipment and medications resulting in increased costs compared to term birth infants.

These costs are borne by both the health system, families, and society at large. Knowing the cost of providing care and areas to improve efficiency will assist the health system to save costs for other critical areas of health care delivery.

This is particularly important for health facilities in developing countries which are already underfunded. High-cost interventions such as preterm infant care which is resource intensive can lead to poor quality care.

In Ghana, newborn deaths account for 65% and 40% of infant and under 5 mortalities, respectively [14]. Geographical access, financial constraints and socio-cultural factors remain major barriers to facility-based maternal and newborn care. To increase financial access, the government of Ghana in 2008 introduced free antenatal, delivery and postnatal care as part of social health insurance to help achieve the Millennium Development Goals (MDGs) [15, 16].

A 5-year newborn Health Strategy and Action Plan was developed and launched in 2014, as policy guide to improving newborn outcomes in Ghana [14, 17-21]. In RHB, the proportion of preterm births among LBW infants is about 60% (2019 annual projections). These infants need special care for survival. The RHB with support from UNICEF has a NICU where special care is given to LBW and other sick neonates. This unit has improved survival of preterm neonates supported by available evidence (unpublished data).

This study is to estimate the health system cost of caring for preterm newborns at the NICU of the RHB. The study perspective is the health system.

Materials and Methods

Study Design and Study Population

This was a costing study designed to estimate the cost of initial hospital care for preterm babies at the newborn care unit of RHB. The Drummond's Guidelines for economic evaluation was used in this costing study [22]. The study perspective was the health system. The study took a retrospective reference period from 1st January 2019 to 31st December 2019. The RHB is a secondary referral facility with a 220-bed capacity providing medical, surgical, obstetric, gynecological, pediatric, and newborn care services.

The hospital serves a population of over 1.2 million people [14]. The study population was preterm babies admitted into the NICU of the hospital. Out of a total of 1,171 patients admitted to the unit within the reference period, 352 were preterm babies.

Sampling Strategy

Using systematic sampling procedure, a sample of 150 preterm babies were selected for study. Medical records of these infants were retrieved, and data abstracted. The information retrieved was on socio-demographic characteristics of parents, newborn characteristics and resources consumed in the course of care.

Classification of Preterm Birth and Low Birth Weight

In this study, preterm births were diagnosed using the gestational age at time of birth. Preterm births were accordingly classified as late preterm (34 - <37 weeks), moderate preterm (32 -33 weeks), very preterm (28-31 weeks) and extreme preterm (< 28 weeks).

The infants were also categorized according to birth weight as normal birth weight (≥2500 gm), LBW (1500 – 2499 gm), very LBW (1000 – 1499 gm) and extremely LBW (<1000 gm).

Data Analysis and Cost Calculations of Preterm Care

Two approaches were used to identify, quantify and estimate monetary value of the resources used in providing initial hospital care. These were the top-to-bottom approach and the micro-costing approach. The cost estimates were limited to resources used directly by the NICU and as such, the general hospital resources such as administrative and management staff resources of the hospital not directly involved with service delivery at the unit were excluded from the estimates. A top-to-bottom approach was used for shared cost resources such as staff, equipment, and utilities. A micro-costing approach was used for direct medical costing of resources by documenting and quantifying resources consumed by each of the 150 preterm infants from their medical records. The hospital fees based on national health insurance tariffs were used to cost resources consumed by each preterm infant. Staff salaries were obtained from the payroll and equipment cost from the assets register. Utility costs were obtained from bills submitted by utility companies as well as estimates for cleaning and accommodation. The costs were estimated per capita expenditure for preterm infants for initial hospitalization. The cost of equipment was discounted using straight-line depreciation method [23] to obtain annualized cost based on the assumption of average useful life of the equipment. In this study, the average useful life of all the equipment was assumed to be 10 years. Sensitivity analysis was done by varying the number of useful life of equipment.

Variables Used in Costing Preterm Care

The dependent variable was the total cost of initial preterm hospitalization. The independent variables investigated were educational level of parents, employment status of parents, gestational age, sex of baby, birth weight, type of preterm complications, type of laboratory investigations, type of medications consumed, type of NICU service and outcome of care. The main costs studied were the direct cost of delivering the initial intensive care service to preterm infants.

Results

Socio-demographic Characteristics of Parents

Approximately 50% of the mothers with preterm infants were aged 20-29 years. Mothers under 20 years constitute about a quarter (24.6%) and 26.6% were above 30 years. Fathers had higher educational status than mothers. Similarly, 83.3% of fathers were gainfully employed compared to 54.5% of mothers. The majority (82.4%) of parents were married (Table 1).

Table 1. Socio-demographic Characteristics of Parents

Variable	n (%)
Maternal age (years)	
<20	37 (24.6)
20 - 29	73 (48.7)
30 - 34	26 (17.3)
>35	14 (9.3)
Educational status of mother	
None	75 (50.0)
Primary	15 (10.0)
Secondary	30 (20.0)
Tertiary	30 (20.0)
Educational status of father	

None	30 (20.0)
Primary	30 (20.0)
Secondary	30 (20.0)
Tertiary	60 (40.0)
Employment status of mother	
Unemployed	68 (45.5)
Self-employed	55 (36.4)
Public service	27 (18.1)
Employment status of father	
Unemployed	25 (16.7)
Self-employed	100 (66.7)
Public service	25 (16.6)
Marital status	
Married	124 (82.4)
Single	26 (17.7)

Characteristics of Preterm Infants

A total of 1,171 babies were admitted at the NICU of the hospital in 2019 and 352 of these were preterm babies giving preterm admission rate of 30% (Figure 1). Majority of preterm infants (54.6%) were females and 72.9% were singleton births. LBW infants constitute the majority (62.4%) followed by very LBW (30.3%) and then 5.5% were of normal birth weight. Only 1.8% were of the extremely LBW category. A higher proportion of preterm infants (68.6%) were on admission for a week, whereas 29.7% were on admission for about 2 weeks. Only 1.7% stayed on admission for more than 2 weeks. On outcome after initial hospital care, 91.8% were discharged home, 2.7% died and 5.5% referred for more advance care at a tertiary institution (Table 2).

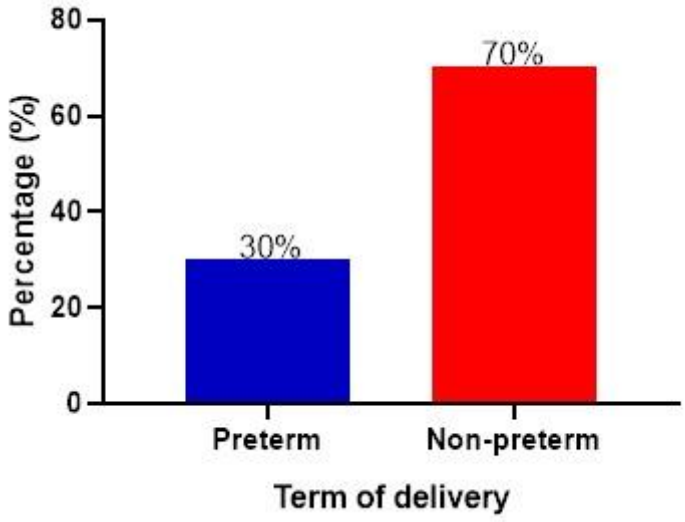

Figure 1. Preterm Babies Admission Rate in 2019

Table 2. Characteristics of Preterm Infants

Variables	**n (%)**
Gestational age	
extremely preterm (<28 weeks)	12 (7.8)
very preterm (28-32 weeks)	60 (40)
moderate preterm (32-33 weeks)	76 (50.4)
late preterm (34-<37 weeks)	2 (1.7)
Sex of baby	
Female	82 (54.6)
Male	68 (45.4)
Multiple birth	
No	109 (72.9)
Yes	41 (27.1)
Birth weight (gm)	
ELBW (<1000)	3 (1.8)
VLBW (1000 – 1499)	45 (30.3)
LBW (1,500 - 2,499)	94 (62.4)
NBW (≥2,500)	8 (5.5)
Length of stay on admission (days)	
0 -7	103 (68.6)
8 -14	45 (29.7)
>14	2 (1.7)
Outcome of baby	
Discharged home	138 (91.8)
Died	4 (2.7)
Referred for tertiary care	8 (5.5)
NBW: normal birth weight, LBW: low birth weight, VLBW: very low birth weight, ELBW: extremely low birth weight	

Direct Medical Costs

The cost items under direct medical costs included NICU service fees, laboratory investigations and cost of medicines. The highest cost item was intensive care service fees, followed by medicines and then laboratory services. The median cost with interquartile range for various categories of LBW were computed (Table 3). The median NICU service cost under direct medical cost by sex was higher in females than in males whereas the medicines and laboratory services costs were similar in both genders (Table 4).

Table 3. Direct NICU Medical Cost Categorized into NICU Service Cost, Laboratory Cost and Medicine Cost

Birthweight (gm)	**Total Cost (GH₵)**	**Median Cost (GH₵)**	**IQR (GH₵)**
NICU service cost			
ELBW (<1000)	624.50	312.50	178.50-446.00
VLBW (1000-1499)	9384.50	245.50	172.50-1168.00
LBW (1500-2499)	19832.00	233.90	132.80-887.50
NBW (≥2500)	1159.00	241.50	166.50-257.00

Sub-Total	33,785.31	246.00	0.00-1174.00
Laboratory cost			
ELBW (<1000)	24.00	12.00	7.00-17.00
VLBW (1000-1499)	384.00	7.00	7.00-97.00
LBW (1500-2499)	840.00	7.00	7.00-64.50
NBW ≥2500	97.00	9.50	7.00-32.00
Sub-Total	1,490.00	7.00	7.00-97.00
Medicine cost			
ELBW (<1000)	330.50	165.30	71.50-259.00
VLBW (1000-1499)	5394.50	134.00	65.50-1056.00
LBW (1500-2499)	12888.00	125.50	48.80-1061.50
NBW (≥2500)	462.00	33.00	125.00-54.50
Sub-Total	16,740.00	117.00	32.00-1067.00
Total	**52,015.31**		
NICU: neonatal intensive care unit, NBW: normal birth weight, LBW: low birth weight, VLBW: very low birth weight, ELBW: extremely low birth weight			

Table 4. Direct Medical Cost Stratified according to Sex of Neonate

Cost category: Median (IQR)	**Male**	**Female**
NICU service fees	185.50(100.00-600.97)	242.50(162.50-1174.00)
Laboratory cost	7.00(7.00-52.00)	7.00(7.00-97.00)
Medicine cost	117.00(32.00-1056.00)	117.00(55.50-1067.00)
NICU: neonatal intensive care unit, IQR: interquartile range		

Shared Costs

Shared cost items considered were staff salaries, equipment, and utilities. These items were specific to the newborn care unit. The total gross annual NICU staff salaries were GH₵280,761.96 and constitute the highest cost item. The total initial cost of the NICU equipment was GH₵882,000.00. We assumed the average useful life of equipment was 10 years. The total annual cost of NICU utilities was GH₵49,920. Utilities were made up of water, electricity, generator use, detergents, and accommodation (Table 6).

Table 5. Annualized Cost of NICU Equipment by Straight-Line Depreciation

Total Cost of Equipment GH₵)	**Average Useful Life of Equipment (Years)**	**Annualized Cost (GH₵)**
882,000.000	10	88,200.00

Table 6. Shared NICU Costs for the Year 2019

Cost Category	**Annual Cost (GH₵)**	**Cost Per Capita of NICU Admissions (GH₵)**	**Total Shared Cost for 150 Preterm Infants (GH₵)**
Staff salaries	280,761.96	239.76	35,964.00
Equipment (discounted)	88,200	75.32	11,298.00
Utilities	49,920	42.63	6,394.50
Total	418,881.96	357.71	53,656.50

Grand total (direct medical cost + shared cost)	418,881.96 + 52,015.31 = 470,897.27 ($78,482.88)

Total NICU admissions for 2019 =1,171

Sensitivity Analysis

The main assumption in this study was the average number of useful life of the equipment. In performing sensitivity analysis, the useful life of the equipment was varied to 5 years, 8 years, 12 years, and 15 years. The corresponding annual cost and cost per capita were in Table 8. Total cost from the median 10 years of average useful life of the equipment to 5 years vary by 12% and to 15 years by 2%. Figure 2 showed variation in total cost of initial hospital care for preterm infants as the average number of useful life of the equipment changes.

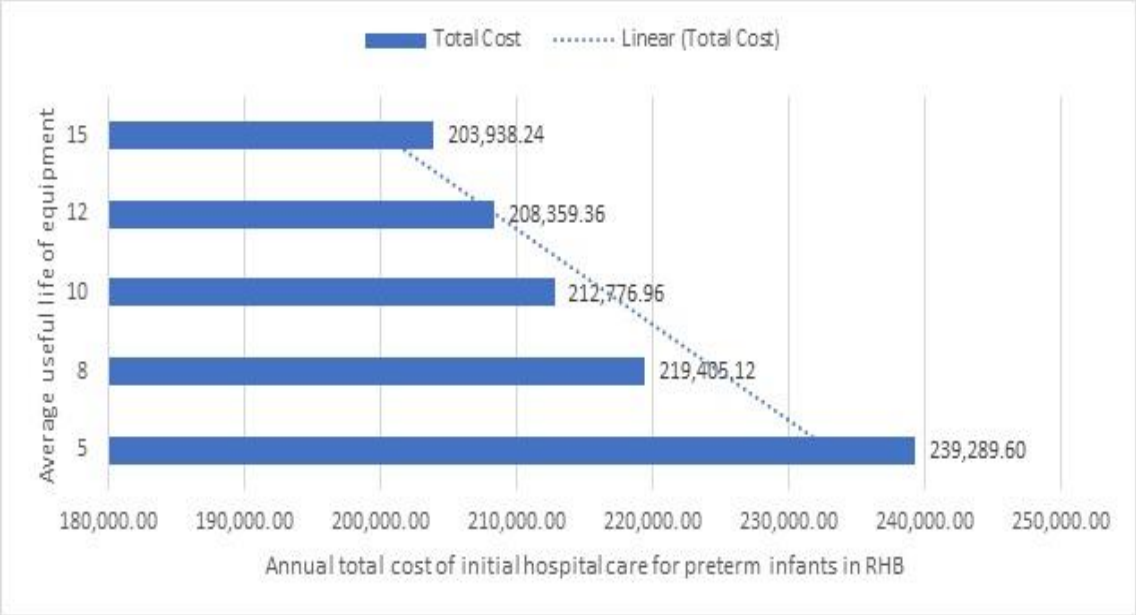

Figure 2. Sensitivity Analysis based on Useful Life of Equipment

Table 7. Summary Cost

Variable	**Direct Medical Cost (GH₵)**			**Shared Costs (GH₵)**			**Total**
Resource Item	NICU service	Laboratory	Medicine	Staff salaries	Equipment	Utilities	
Cost per capita	225.24	9.93	11.60	239.76	75.32	42.63	604.48
Total cost for 150 preterm	33,786	1,489.50	1,740	35,964	11,298	6,394.50	90,672
Total cost for all 352 preterm in 2019	79,284.48	3,495.36	4,083.20	84,395.52	26,512.64	15,005.76	212,776.96
Shared cost constituted 59.2% of total cost of initial preterm care whereas direct medical cost was 40.8%. NICU: neonatal intensive care unit							

Table 8. Annualization of Equipment Cost Per Capita

Total cost of equipment (GH₵)	882,000.000	882,000.00	882,000	882,000	882,000
Average useful life of equipment (Years)	10	5	8	12	15
Annualized cost (GH₵)	88,200.00	176,400	110,250	73,500	58,800
Annual cost per capita (Total admission =1171)	75.32	150.64	94.15	62.77	50.21

GH₵6.00 = 1USD

Table 9. Sensitivity Analysis

Average useful life of equipment (years)	**Direct medical cost per capita**	**Shared cost (Salaries and utilities only) per capita**	**Shared cost (Equipment only) per capita**	**Total cost for 150 preterm babies**	**Total cost for 352 preterm babies**
5	246.77	282.39	150.64	101,970.00	239,289.60
8	246.77	282.39	94.15	93,496.50	219,405.12
10	246.77	282.39	75.32	90,672.00	212,776.96
12	246.77	282.39	62.77	88,789.50	208,359.36
15	246.77	282.39	50.21	86,905.50	203,938.24

Discussion

The proportion of preterm infants admitted at the NICU of RHB in 2019 was 30%. This means the greater burden of care on the unit was from other patients other than preterm infants. This finding is at variance with the study in Malaysia where the majority (75%) of neonatal intensive care admissions were due to preterm babies [13]. LBW neonates (62.4%), were most of the preterm babies followed by very LBW neonates (30.3%) and extremely LBW babies which constituted only 1.8%. This finding is consistent with other studies [13, 24] which also reported the bulk of their preterm babies as being of the LBW category.

Although ELBW babies constituted only 1.8% of the admissions, they had the highest median cost of GHS165.3 ($33), for medicines. This is due to the intensity of care associated with patient management and the longer duration of stay on admission. The long duration of stay increases consumption of resources leading to high cost associated with this category of preterm babies. As expected, the lowest cost of GHS33 ($6.6) was in the management of NBW infants. The cost with respect to laboratory services was similar, the highest median cost of GHS12 ($2.4) was with ELBW babies compared to GHS7 ($1.4) for both LBW and VLBW infants. Also, on NICU service, ELBW infants had the highest median cost of management followed by VLBW infants and NBW neonates. Furthermore, LBW infants had the lowest cost of management. The higher NICU service cost in managing NBW neonates compared to LBW neonates may be due to other life-threatening neonatal complications other than birth weight.

Direct medical cost of managing neonates of female gender was higher than that of the male gender. This may be due to physiological disposition of females making them vulnerable to adverse foetal and neonatal complications. In this study, the total annual cost for the 150 preterm infants managed in 2019 was GH₵90,672.00 ($15,112) giving cost per capita of GH₵604.48 ($100.75) compared to extremely

high cost in high income countries such as United States and Canada [13, 24]. Shared cost constituted 59.2% of total cost and direct medical cost was 40.8%. The major cost items were intensive care service fees, staff salaries, equipment, and utilities. This is consistent with other studies on this subject [13, 24, 25].

Sensitivity analysis performed showed that average useful life of equipment has a marginal inverse linear effect of the total cost of initial care. As the average useful life increased from 5 years to 15 years, the total cost of care reduced with variation from 12% to 2% with respect to the median cost. This implies increasing the life span of NICU equipment through appropriate maintenance practices will culminate in reduction of the total cost of care. The bar chart peaks reduced in height from 5 years to 15 years depicting a linear inverse relationship.

Limitations of the Study

Some of the limitations of this study were poor documentation of some medical records which did not enable accurate capture of some resources. In addition, only resources directly involved in the provision of NICU services were included. The other resources involving the hospital administrative staff and non-direct supervisors of the unit were excluded in this study.

Conclusion

In conclusion, preterm birth constitutes 30% of neonatal care admissions in RHB. The bulk of this preterm babies are of LBW. Total annual cost for initial preterm care on admission at newborn care unit was GH₵604.48 ($100.75) per capita. The major component of the total cost was shared cost. The direct medical cost was 40.80%. The ELBW babies, although were of the lowest proportion, had the highest median direct medical cost for medicines and laboratory services. If preterm birth were eliminated, RHB would have saved GH₵212,776.96 ($35,462.83) for other health care services in 2019. Improving efficiency in the use of shared resources would save cost on initial hospital care for preterm babies for other needy areas of the hospital.

Declarations

Author Contribution Statement

WO conceived and designed the study. WO, BA, JA and ASS conducted the study. BA and WO analyzed and interpreted the data. WO, BA, JA and ASS contributed resources, materials, analysis tools or data. All authors read and revised the manuscript and gave final approval of the manuscript.

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Data Availability Statement

The datasets used and analyzed during the current study are available upon reasonable request.

Ethical Approval

Ethical approval was not needed for this study. However, permission was sought from the study site.

Declaration of Interest Statement

The authors declare that they have no competing interest.

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