Assessment of Neonatal Mortality and Associated Hospital-Related Factors in Healthcare Facilities Within Sunyani and Sunyani West Municipal Assemblies in Bono Region, Ghana

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ABSTRACT

OBJECTIVES: Ghana's quest to reduce neonatal mortality, in hospital facilities and communities, continues to be a nightmare. The pursuit of achieving healthy lives and well-being for neonates as enshrined in Sustainable Development Goal three lingered in challenging hospital facilities and communities. Notwithstanding that, there have been increasing efforts in that direction. This study examines the contributing factors that hinder the fight against neonatal mortality in all hospital facilities in the Sunyani and Sunyani West Municipal Assemblies in Bono Region, Ghana.

METHODS: The study utilized neonatal mortality data consisting of neonatal deaths, structural facility related variables, medical human resources, types of hospital facilities and natal care. The data was collected longitudinally from 2014 to 2019. These variables were analysed using the negative binomial hurdle regression (NBH) model to determine factors that contribute to this menace at the facility level. Cause-specific deaths were obtained to determine the leading causes of neonatal deaths within health facilities in the two municipal assemblies.

RESULTS: The study established that the leading causes of neonatal mortality in these districts are birth asphyxia (46%), premature birth (33%), neonatal sepsis (11%) and neonatal jaundice (7%). The NBH showed that neonatal mortality in hospital facilities depend on the number of incubators, monitoring equipment, hand washing facilities, CPAP[b] machines, radiant warmers, physiotherapy machines, midwives, paediatric doctors and paediatric nurses in the hospital facility.

CONCLUSIONS: Early management of neonatal sepsis, birth asphyxia, premature birth and neonatal infections is required to reduce neonatal deaths. The government and all stakeholders in the health sector should provide all hospital facilities with the essential equipment and the medical human resources necessary to eradicate the menace. This will make the realization of Sustainable Development Goal three, which calls for healthy lives and well-being for all, a reality.

KEYWORDS: Sustainable Development Goal three, hospital records, neonatal mortality, mixture models, infections, hospital facilities, government, health

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Introduction

Children in sub-Saharan Africa (SSA) have an increased chance of dying in their first month of birth, according to the World Health Organization (WHO).[1] Roughly 4 million deaths of children under 5 years of age are believed to have occurred in low- and middle-income nations. This figure represents approximately 99% of these deaths, with approximately 60% of this number related to neonatal death. Ghana did not meet any of the two Millennium Development Goals (MDGs) four or five due to the slow development rate in reducing the death rate of children under 5 years of age. Sixty-eight percent of neonatal deaths and 48% of deaths in children under 5 years of age are attributed to neonatal mortality.[1] Ghana's neonatal death rate was predicted to be 25 per 1000 live births in the WHO Ghana Annual Report 2019. Despite this, Ghana has made impressive strides in the fight against neonatal and under-5 mortalities.[2]

Nwokoro et al.[3] revealed that children dying below 5 years are an important indicator of health and an indispensable development measure for countries. Globally, under-5 and neonatal mortality rates have drastically decreased to 39 deaths per 1000 live births from 93 deaths per 1000 live births from

1990 to 2018.[1] These feats were not observed in all countries due to disparities in child survival rates from birth to 59 months compared to resource inequalities among countries.[4,5] The SSA region is associated with sky-high rates of under-5 and neonatal mortality rates across the world.[6,7] Intrinsically, the SSA region recorded 1 death for every 13 live births compared to 1 death for every 199 live births in developed countries.[1]

In most cases, significant causes of deaths related to under-5 years have been shown throughout the world. Most neonatal deaths have been attributed to pneumonia, diarrhea, pregnancy complications and malaria, as well as neonatal sepsis.[8,9] Several studies have further linked death of children under-5 years in SSA to preventable intermediaries such as maternal age at birth, where delivery occurred, place of residence, weight of child at birth, count of antenatal care attendance and access to assistance during delivery.[9,10]

Bogdewic et al.[11] revealed that systematically strengthening hospital facilities with essential human resources and medical equipment can potentially reduce neonatal mortality. Again, Owen et al.[12] identified critical gap in postnatal care education that must be addressed seriously. They stressed that these identifiable problems can be diagnosed by well-resourced health facilities and serious complications can be prevented. Owen et al.[12] were of the view that pre-discharge counselling must be improved in Ghana so that neonates will have better survival chances in critical periods.

The Ghana Health Service (GHS) launched the Make Every Baby Count Initiative (MEBCI) in 2013 on a 5-year basis. This initiative was based on a curriculum from the American Academy of Paediatrics Helping Babies Breathe and Essential Care for Every Baby programme with the inclusion of prevention of infections. The programme trained 3688 health workers from the Brong Ahafo Region (now Bono, Bono East and Ahafo Regions), Volta Region (now Volta and Oti Regions), Eastern Region and Ashanti Region on resuscitation, essential neonates care and infection treatment.[13] Though this programme made a great impact, there are still bottlenecks in this fight for the survival of neonates.

There is a higher risk of neonates dying in their early stages.[14] Abdul-Mumin et al.[15] observed that the majority of neonatal deaths in these early stages are from preventable causes. Moreover, Aheto[16] indicated that the Northern Region (now Northern, North East and Savanna Regions), the Upper East Region, the Upper West Region and the Brong Ahafo Region (now Bono, Bono East and Ahafo Regions) have the highest mortality for children under 5 years of age among all regions in Ghana. This is not surprising because there exist great disparities and inequalities in access and distribution of maternal and child care services in rural-urban communities.[17] Forestalling deaths by asphyxia and infections should be focused, while essential post-delivery care and wellbeing of neonates prioritized.[18]

Existing studies conducted in Ghana on neonatal mortality and its related dynamics are mainly exploratory.[14,19-21] These studies did not include structural facility-related variables, medical human resources, hospital facility types and natal care at the same time. Addressing neonatal mortality requires proper maternal and child health care services.[22,23] This is lacking in most Ghanaian hospital facilities, especially in the Bono Region of Ghana. Ghana continues to fight against neonatal mortality in hospital facilities and communities throughout the country. However, efforts by the government and its stakeholders have not yielded the needed results. It is against this backdrop that this study is carried out in two municipal assemblies to identify areas where the government and its stakeholders can channel their efforts to achieve the Sustainable Development Goal three (SDG 3) which aims to ensure the end of avoidable deaths of neonates and children under-5 years of age.

This paper seeks to assess the impact of structural facility-related variables, medical human resources, types of hospital facility and natal care on neonatal mortality in the Bono region of Ghana. The study used data from health facilities within the Sunyani and Sunyani West municipal assemblies. This assessment will help the government and its stakeholders provide the necessary intervention to ensure the survival of all neonates. The hurdle model was applied to the neonatal mortality data due to the excessive number of zeros in the facility-level data.[24-28] Cause-specific neonatal deaths as documented by medical professionals were also ascertained and reported.

Materials and Methods

Data

We used Sunyani and Sunyani West Municipal Assemblies in the Bono Region of Ghana as our study area, since most of the prominent hospital facilities in the Bono Region are located in these assemblies. Furthermore, the two districts account for most of the health facilities in the entire region.

Retrospective neonatal mortality data was collected longitudinally from hospital records and reports in all hospital facilities in the two municipalities. For the study, factors associated with healthcare facilities and cause-specific deaths were used with the official permission of health facility heads and administrators, as well as regional and district health directorates. The Human Research and Ethics Committee of the University of Energy and Natural Resources provided ethical approval for the study and waived all consent.

The dependent variable in the data is the number of neonatal deaths per year in all health facilities in the two assemblies. The independent variables included can be classified into four main parts: structural facility-related variables, medical human resources, hospital facility types and natal care. Structural facility-related variables included the existence of a neonatal intensive care unit (NICU), the number of hand washing facilities (HW), the existence of emergency obstetric care (EOC), the existence of a planned parental clinic/family planning center (PPC / FPC), the number of radiant warmers (RM), the number of monitoring equipment (ME), the number of blood gases (BG), the number of incubators (I), the number of bassinets (COTS), the number of haematocrit equipment (HE), the number of ventilators (V), the number of CPAP[b] machines and the number of phototherapy machines (PM). The medical human resources included the number of paediatric nurses (PN), the total number of midwives (MW) and the total number of paediatric doctors (PD) in the health facility. The types of hospital facilities included hospitals and clinics. Health centres, community health planning service compound (CHPS), maternity homes and similar health facilities were classified as clinics. In total, four hospitals and nineteen clinics participated in the study. The 23 health facilities included in the study were the major health facilities in the 2 municipal assemblies. Natal care involved the number of antenatal visits exceeding 4 and the number of postnatal visits exceeding 4.

The data was thoroughly cleaned before further analysis was performed. Stepwise deletion in R was used to remove all independent variables that do not greatly influence neonatal deaths during data cleaning and preliminary analysis. As a result, few variables related to structural facilities (HW, I, PH, HW, ME, PM, COTS, RM and CPAP[b]) and all medical human resources were included. The type of health facilities and natal care were excluded from further analysis. Data on cause-specific deaths verified by doctors were obtained to determine the leading cause of neonatal deaths in the facilities.

The summary statistics of the number of Poisson counts of neonatal death are presented in Table 1. Clearly, overdispersion is observed in the data (variance [254.53] > mean [3.40]). This is an indication that NB is preferable to P. Figure 1 indicates that zeros account for a greater proportion (about 86.96%) of the data. This signifies that the data have excessive zeros, an indication of the need to consider analytical methods that handle data inflated with zeros.[24–26] As such, extensions to the traditional NB that simultaneously capture overdispersion and zero-inflation as well as other sources of heterogeneity was considered.[29,30]

Table 1. Descriptive statistics of the number of neonatal deaths.

STATISTIC	VALUE
Minimum	0
Maximum	122
First quartile	0
Median	0
Third quartile	0
Mean	3.40
Variance	254.53
Skewness	5.49
Kurtosis	34.06
No. of observations	138

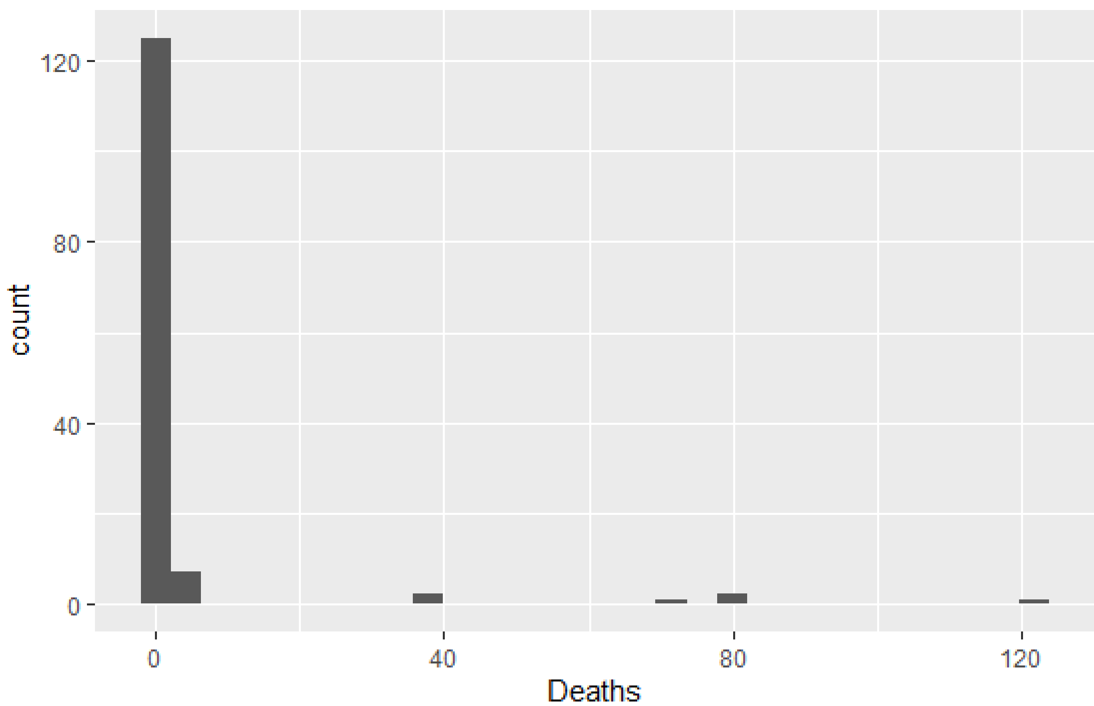

Figure 1. Histogram of neonatal death counts in all hospital facilities.

Table 2. AIC and BIC of models fitted.

MODEL	AIC	BIC
P	462.9293	498.0563
NB	415.1600	456.1464
ZINB	251.1800	268.7400
NBH	132.7200	168.4700

Methods

The main finding of the study is the number of neonatal deaths in health facilities. Such count data are often modelled using the Poisson regression. Let Y_i represent the dependent variable. Since Y_i is count, we assume $Y_i \sim Poisson(\lambda_i)$ and $E(Y_i) = var(Y_i) = \lambda_i$. The frequent relationship among independent and dependent variables is $\lambda_i = \exp(X_i \Phi_i)$. Where X_i is a matrix with covariates and Φ_i represents a vector of coefficients that are estimable.

The strict mean-variance relationship of the Poisson regression model (P) is usually violated due to unobserved heterogeneity or clustering.[29,30] This unobserved heterogeneity or clustering results from repeated measurements that lead to overdispersion (variance greater than the mean in a Poisson regression model).[29,30] In such a situation, the negative binomial regression model (NB) becomes more appropriate. Assume $Y_i \sim Negative\ Binomial\ (\mu_i)$ with $E(Y_i) = \mu_i$ and $var(Y_i) = \mu_i(1 + k\mu_i) > \mu_i$.[28] The interrelation among the independent and dependent variables is $\mu_i = \exp(W_i \varphi_i)$. Where W_i is a matrix of independent variables, φ_i is a vector of estimable coefficients and k is the dispersion parameter.

In essence, neonates at risk at a particular health facility are transported to others due to adequate infrastructure, equipment and human resources. This leads to a higher number of zeros being recorded in the clinics. The presence of structural zeros and overdispersion in the data required the use of the negative binomial hurdle regression (NBH) model to determine the related factors within the facilities.[29,30] The use of the NBH requires a 1 step at a time procedure.[24-26] The NBH assumes the zeros come from a single source.[27,28] The detailed model estimation procedure has been included as a Supplemental file.

Statistical analysis

The fitting of the model was done using the *MASS, pscl, sandwich* and *nonnest2* packages in R. The suitability of NBH was based on the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and the Vuong test.[31-35] The AIC, BIC and Vuong tests are presented in Tables 2 and 3, respectively. The results of the NBH is presented in Table 4. The proportion of cause-specific neonatal death is presented in Figure 2.

Table 3. Results of the Vuong non-nested test statistic.

TEST ITEM	VUONG Z-STATISTIC	*P*-VALUE
Raw	4.91	<.0001
AIC-corrected	3.97	<.0001
BIC-corrected	4.53	<.0001

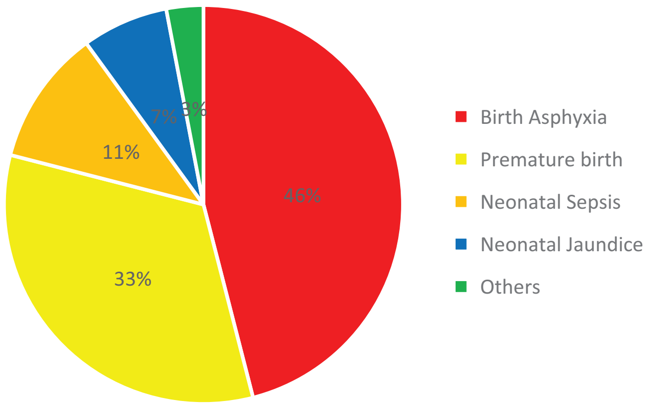

Figure 2. Major causes of neonatal deaths.

Results

The proportion of cause-specific neonatal death in Figure 2 shows that the majority of neonates in the two municipal assemblies died of asphyxia (46%), premature birth (33%), neonatal sepsis (11%) and neonatal jaundice (7%). Furthermore, birth asphyxia and birth immaturity account for nearly 80% of all neonatal deaths in the study area. The estimated rate of neonatal mortality is 9.24 per 1000 live births.

Table 4 presents the estimates of the parameters and their standard errors for the NBH. From the table, the dispersion parameter is statistically significant at a 0.05 level of significance. Considering the count model coefficient, the intercept had a significant estimate of 0.840 (P-value < .05). This suggests an estimated expected number of neonatal deaths count of 2.32 per year when there is a constant number of midwives, incubators, paediatric doctors, bassinets, phototherapy machines, paediatric nurses, radiant warmers and CPAP[b] machines in a hospital facility. Therefore, the expected number of neonatal deaths will be extremely high in health facilities due to the lack of essential medical human resources and equipment to care for neonates in critical conditions.

Regarding the variable of the structural facility, the number of bassinets was not significant. However, it had a decreasing effect on the number of neonates who died in health facilities. The number of phototherapy machines, incubators, radiant warmers, monitoring equipment, CPAP[b] machines and handwashing facilities were statistically significant (P-value < 0.05). A unit increase in the number of phototherapy machines in a health facility reduces the expected neonatal mortality per year by 38% when all other variables remain constant. Additionally,

Table 4. Parameter estimates and standard errors (S.E.) for the HBH model.

NBH		
COEFFICIENTS	ESTIMATE (S.E.)	PR (>I Z I)
Count model		
Intercept	0.840 (0.281)	0.0028
Midwives	−0.011(0.020)	0.5752
Paediatric doctors	−0.686 (0.105)	<0.0001
Incubators	−0.254 (0.243)	0.0044
Bassinets	−0.216 (0.115)	0.0604
Phototherapy machines	−0.470 (0.199)	0.0175
Radiant warmers	−0.944 (0.134)	<0.0001
Paediatric nurses	0.123 (0.098)	<0.0001
Monitoring equipment	0.257 (0.130)	0.0485
CPAP[b]	−2.113 (0.456)	<0.0001
Handwashing facilities	−0.542 (0.159)	<0.0001
Zero hurdle model		
Intercept	−8.841 (1.023)	0.0035
Midwives	−0.083 (0.319)	0.0093
Paediatric doctors	−0.656 (0.212)	0.0083
Incubators	−0.928 (0.396)	0.0192
Bassinets	0.457 (0.203)	0.1996
Phototherapy machines	0.002 (0.001)	0.0070
Dispersion parameter		
Log*k*	3.970 (1.213)	0.0011

a unit increase in the number of incubators reduces the number of neonates who die per year by 22%. Increasing the number of radiant warmers results in a reduction in neonatal deaths by 61%. CPAP[b] machines and hand washing facilities in the labour ward reduce neonatal deaths by 88% and 41%, respectively, for each additional added. The number of monitoring equipment in health facilities results in an increase in recorded neonatal deaths. This requires further interrogation. Most clinics lack these essential facilities.

For medical human resources, the number of midwives was not significant. However, it had a decreasing effect on neonatal mortality in the hospital. The number of paediatric doctors and paediatric nurses was statistically significant (P-value < .05). The estimate of the number of paediatric doctors indicate that increasing the number of paediatric doctors per unit results in decreasing the expected number of neonatal deaths per year by approximately 50% when all other factors remain constant. An increase in the number of paediatric nurses in health facilities results in an increase in recorded neonatal deaths. Hospitals have doctors, physician assistants, nurses and midwives, while clinics have physician assistants, nurses and midwives. This in relation to the lack of EOC in most clinics is responsible for the transfer of all complicated neonatal cases from clinics to hospitals.

The zero-hurdle model had an intercept of −8.841 (P-value < .05) which translates into a reduction of 99.99% in the expected odds of neonatal death per year when there is a constant number of midwives, incubators, paediatric doctors, bassinets and phototherapy machines in the health facility. Here, the number of bassinets was not statistically significant (P-value > .05). The number of phototherapy machines increases the expected odds of neonatal mortality by 0.02%, while the number of incubators reduces the expected odds of neonates dying by 60.47%. Again, the number of midwives and paediatric doctors were significant (P-value < .05). When a midwife is added to the number of midwives in a health facility, the expected odds of neonatal death will decrease by 8.00% when all other factors remain constant. For every paediatric doctor added to the number of paediatric doctors in a health facility, the expected odds of neonatal death will decrease by 48.11% in the facility. This points to the fact that the increase of medical human resources with inexperienced ones greatly influence neonatal deaths in these facilities. As much as the medical human resource is unlikely to remain the same over years, the experienced must be maintained while the inexperienced ones are added.

Discussion

A significant number of neonates dying in middle- and low-income countries (MLIC), including Ghana, are attributed to inadequate prenatal, intrapartum and postpartum medical care.[15,36-38] Neonatal mortality rates have decreased significantly over the years. It is imperative to continuously assess the progress achieved, as well as the areas that need improvement, to further reduce all forms of neonatal deaths, particularly in low-resource countries. Thus, this study scrutinized and evaluated elements at the health facility level that have the potential to influence neonatal deaths in Sunyani and Sunyani West municipalities, Bono Region, Ghana.

The main and common causes of neonatal death in the current study were birth asphyxia (46 %), preterm (33%), sepsis (11%) and neonatal jaundice (7%). This finding is consistent with the findings observed in Abdul-Mumin et al.[15] in which preterm complications and birth asphyxia accounted for the majority of neonatal deaths in the NICU of the Tamale Teaching Hospital (TTH). Similarly, the findings align with studies in Ethiopia where sepsis, preterm and asphyxia were reported to be the leading causes of neonatal death.[36-38]

Regarding the results of the NBH model, the lack of adequate numbers of midwives, incubators, paediatric nurses and doctors, radiant warmers and CPAP machines at the health facility level contributed significantly to the high risk of neonatal death. This is because neonates in critical condition could be denied essential human resources and equipment related to structural facilities to enhance their survival. In addition, a sufficient number of skilled nurses and midwives is essential to reduce neonatal, infant and perinatal mortality. Findings from Amiri et al.[39] alludes to the significant impact skilled nurses have had on minimizing infant, neonatal and perinatal deaths in some countries within the Organization for Economic Cooperation and Development (OECD), particularly in Japan, Sweden, Iceland, Slovenia and Finland. Also, Nove et al.[40] presented evidence of the possible impact that adequate and skilled midwives have on reducing and preventing more than 2.2 million neonatal and maternal deaths per year by 2035 in MLIC. Nove et al.[40] recommended the need for midwives to be equipped with skills and competencies that align with those of the International Conference of Midwives to provide quality healthcare to neonates and mothers.

The study findings also highlight the important role that well-equipped and resourced neonatal intensive care units (NICUs), in addition to obstetric departments in MLICs, play in reducing and preventing neonatal mortality. According to Cavicchiolo et al.,[41] well-resourced NICU significantly reduced neonatal deaths in Mozambique. This was possible due to an improvement in the quality of interventions for neonates admitted for asphyxia, sepsis and prematurity. The findings of this study support those in which quality and effective interventions within well-resourced neonatal intensive care units reduce neonatal deaths by 30%.[42,43]

When the study's recommendations are put into practice, neonatal survival rates in the two municipal assemblies and throughout Ghana will significantly increase. Notwithstanding this, the study had some limitations. Since the study covered all of the main healthcare facilities, no power analysis for sample size was conducted. The study did not include traditional birth attendants' homes. Despite the fact that hospitals get more neonates than clinics and have access to more medical personnel and resources, weighting for the variables were not factored in our model. The current assessment was carried out between 2020 and 2021 using data from 2014 to 2019.

Conclusion

This study evaluated the link between neonatal death cases and factors at the health facility level in the Sunyani and Sunyani West municipal assemblies in the Bono Region, Ghana. Early management of neonatal sepsis, birth asphyxia, premature birth and neonatal infections should be prioritized to improve neonatal survival. Furthermore, the government and all stakeholders in the health sector should collaborate to provide cost-efficient, reliable and proven structural facility equipment and medical human resources to improve healthcare services for neonates in all health facilities in the two municipal assemblies. The findings of the study have significant implications on public health, particularly efforts to ensure quality health for all, including neonates. This will contribute to the achievement of Sustainable Development Goal three, which calls for an end to avoidable deaths of neonates and children under 5 years of age by 2030.

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Author Contributions

KT, KAA, SI, AAO, IWA, RKA and FKB planned the study. KT and SI suggested the methodology. KT, KAA, RKA and FKB collected the data. KT, SI and KAA performed the statistical analysis and drafted the manuscript. IWA, RKA, FKB, AOA, AAO and EO reviewed the manuscript. All authors read and approved the final manuscript.

Ethical Approval

Ethical approval was provided by the Human Research and Ethics Committee of the University of Energy and Natural Resources with approval number CHRE/AP/05/023.

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Data Availability

The data used in the study is available upon reasonable request from the corresponding author.

SUPPLEMENTAL MATERIAL

Supplemental material for this article is available online.

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