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**Original Research**

# Determinants of Neonatal Mortality in a Neonatology Unit in a Referral Hospital of Douala

## *Déterminants de la mortalité néonatale dans une unité de néonatologie d'un hôpital de référence à Douala*

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## ABSTRACT

**Objective.** To determine the frequency and risk factors of neonatal mortality at the Douala Gynaeco-Obstetric and Pediatric Hospital (DGOPH) since its inception. **Population and Methods.** This was a case-control study with retrospective collection of newborns admitted to the neonatal unit (NNU) of DGOPH from 1 August 2016 to 31 December 2019. Cases were defined as any neonate hospitalized during the study period who died during the neonatal period. Controls were defined as any newborn admitted after their matched case, discharged alive, and of the same gestational age. Data were collected using a questionnaire. Analysis was performed using SPSS version 26.0 software. The rib ratio and its 95% confidence interval were used to assess the degree of association of these variables with the risk of neonatal death. The value of p <0.05 was considered significant. **Results.** During the study period, 1454 newborns were admitted to the NNU, of whom 294 died (20.2%). Independent risk factors for neonatal mortality were: gestational age between 28 and 32 weeks, low birth weight, Apgar score <7 at 5 minutes, number of antenatal visits less than 4, altered consciousness at admission and congenital malformations. The etiologies associated with death were: prematurity (43.5%), neonatal infections (23.9%) and neonatal asphyxia (15.3%). **Conclusion.** Neonatal mortality remains high in our context. Apart from the usual causes of neonatal mortality, birth in health facilities other than HGOPED was an additional cause of mortality in our study

## RÉSUMÉ

**Objectif.** Déterminer la fréquence et les facteurs de risque de la mortalité néonatale à l'Hôpital Gynéco-Obstétrique et Pédiatrique de Douala (HGOPED) depuis sa création. **Population et Méthodes.** Il s'agissait d'une étude cas-témoins avec recueil rétrospectif des nouveau-nés admis à l'unité néonatale (UN) du 1er août 2016 au 31 décembre 2019. Les cas étaient définis comme tout nouveau-né hospitalisé pendant la période d'étude et décédé pendant la période néonatale. Les témoins ont été définis comme tout nouveau-né admis après leur cas apparié, sorti vivant et du même âge gestationnel. Les données ont été recueillies à l'aide d'un questionnaire. L'analyse a été effectuée à l'aide du logiciel SPSS version 26.0. Le rapport rib et son intervalle de confiance à 95% ont été utilisés pour évaluer le degré d'association de ces variables avec le risque de décès néonatal. La valeur de p <0,05 a été considérée comme significative. **Résultats.** Pendant la période d'étude, 1454 nouveau-nés ont été admis à l'UN, dont 294 sont décédés (20,2%). Les facteurs de risque indépendants de mortalité néonatale étaient: âge gestationnel entre 28 et 32 semaines, faible poids de naissance, score d'Apgar <7 à 5 minutes, nombre de visites prénatales inférieur à 4, altération de la conscience à l'admission et malformations congénitales. Les étiologies associées au décès étaient : prématurité (43,5%), infections néonatales (23,9%) et asphyxie néonatale (15,3%). **Conclusion.** La mortalité néonatale reste élevée dans notre contexte. En dehors des causes habituelles de mortalité néonatale, la naissance dans des établissements de santé autres que l'HGOPED était une cause supplémentaire de mortalité dans notre étude.

## INTRODUCTION

Nearly 99% of newborn deaths occur in developing countries, including countries in sub-Saharan Africa. In Cameroon, neonatal mortality remains a major public health problem, and its evolution from 1991 to 2018 showed a slight regression(2). In the 2018 Multiple Cluster Indicator /Demographic and Health Survey (EDS-MICS) I Cameroon reported a neonatal mortality rate of 28 ‰ from 33‰ in 1991, indicating a slight decrease of 15%. This is closely related to maternal health conditions and the course of pregnancy and childbirth, which are still major problems(2). In Cameroon, studies have been carried out in hospitals of a similar category on the causes

and determinants of neonatal mortality (3,4). It seemed appropriate to conduct a study at Douala Gynaeco-Obstetric and Pediatric Hospital (DGOPH), a 3rd (third) level referral hospital created in 2015 in order to determine the prevalence and determinants of neonatal mortality, with the aim of proposing measures to reduce neonatal mortality in order to achieve the third sustainable development objective (SDO) relating to the reduction of under-five mortality by 2030.

## POPULATION AND METHODS

Douala is the economic capital of Cameroon, situated along its costal borders. With a population of 3.7 million inhabitants and a birth rate of 36, 8 per 1000 inhabitants, it is one of the two largest cities in the country with Yaounde as the political capital. The study was conducted in the neonatology units of the Gynaeco-Obstetric and Pediatric Hospital of Douala (DGOPH).

The DGOPH was created in 2015, and the neonatology department has been operational since August 1st, 2016 with 02 neonatology units: internal (for newborns born at DGOPH) and external (for newborns born out of DGOPH). During this study, the newborns admitted to the service came from both the maternity of DGOPH, and other health structures in the city of Douala and the rest of the country. The unit has 17 incubators, 2 radiant tables, a tunnel and ramps for phototherapy, electric syringes, 2 transport mechanical ventilators, one Continuous Positive Airway Pressure therapy (CPAP) machine. The medical staff is composed of one paediatricic neonatologist, one neuropaediatrician, four paediatricians and two general practitioners. The paramedical staff is composed of seventeen nurses. The ethical clearance for this study was obtained from the Ethics Committee of the Faculty of Medicine and Biomedical Sciences of the University of Yaounde I and the research authorization was obtained from the Institutional Committee of Ethics and Research for Human Health (ICERHH) of DGOPH.

This was a retrospective case-control study. We used the records of all newborns admitted to the neonatal unit of DGOPH since its opening on August 1st, 2016, until December 31st, 2019; a period of 41 months. Newborn was defined as a living subject with at least 28 days of life. Neonatal period was the period from birth to 28 days of life. It was divided into three periods:

- Very early neonatal period (from birth to the first 24 hours of life);
- Early neonatal period (covering the first 7 days of life)
- Late neonatal period (from the 8th to the 28th day of life)

The **criteria for inclusion** were:

*Case Group*: All newborns admitted in the NNU of DGOPH, during the study period and died during hospitalization.

*Control Group*: All newborns admitted to the DGOPH NNU during the study period and discharged alive during the neonatal period after hospitalization. The selected controls had the same gestational age as their respective cases ± one week.. The singletons' controls were singletons and the twins' controls were twins.

The **exclusion criteria** were: Newborns admitted during the study period and deceased beyond the neonatal period, all newborns admitted during the study period but left alive after 28 days of life and incomplete files.

The next step was to carefully collect the desired information using the medical records of the patients who were enrolled in our study. The information was recorded on fact sheets/questionnaires.

The data was collected using a previously established data sheet that we filled out ourselves. The data were entered into the CSPro 7.2 software and analyzed with IBM SPSS STATISTICS Version 26 (IBM SPSS Inc, CHICAGO Illinois USA).

The results of our study is presented in the form of tables and figures.

Quantitative variables were expressed as a mean (standard deviation) or median (interquartile range) and qualitative variables were expressed as a frequency (proportion).

We performed bivariate and multivariate analyses of these data with logistic regression.

The Odds Ratio and its 95% confidence interval were used to establish the risk relationship.

The P value was calculated by the Fisher's test (or corrected chi-square test) and was be used to compare the proportions. The significance threshold was defined for $P<0.05$.

## RESULTS

During the study period, 1454 newborns were admitted to the neonatal ward with 294 deaths.50 files of deceased newborns could not be processed. 244 cases and 340 controls were identified. Amongst the 240 cases identified, 127 were excluded from the study and 117 were retained. Out of the 340 controls, 239 were retained. Cases were excluded based on exclusion criteria. **(Figure 1)**.

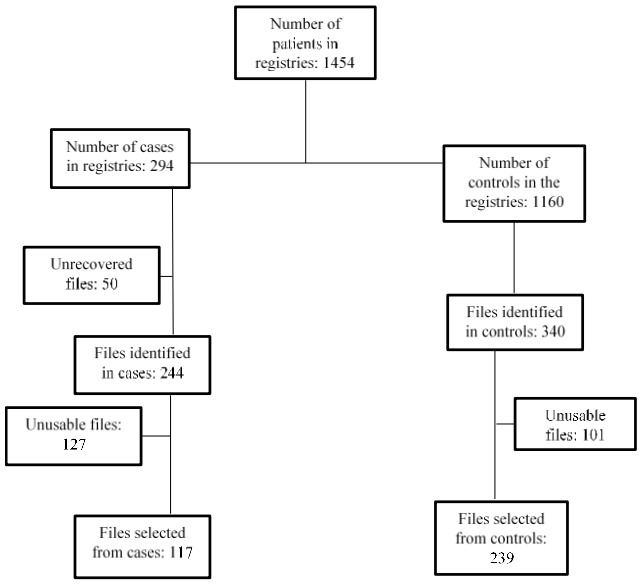


**Figure 1.** Case and Witness Recruitment Diagram

### *Neonatal mortality rate*

One thousand four hundred fifty four (1454) newborns were admitted to the neonatal department of DGOPH, out

of which 294 died, with an estimated neonatal mortality rate of 20.22%. The frequency of mortality in the neonatology unit since its inauguration in 2016, has been increasing with a highest frequency (22.8%) in 2019 (**Table I**)

**Table I. Evolution of newborn mortality by year**

| | Admitted | Deceased | Mortality rate | IC at 95% | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| **Global** | 1454 | 294 | 20,2% | 18.2 | 22.4 |
| **2016** | 338 | 52 | 15,4% | 11.7 | 19.7 |
| **2017** | 409 | 83 | 20,3% | 16.5 | 24.5 |
| **2018** | 370 | 82 | 22,2% | 18.0 | 26.7 |
| **2019** | 337 | 77 | 22,8% | 18.5 | 27.7 |

***Characteristics of the study population***

Females made up the majority of the the deceased newborns 59(50.4%) with an estimated sex ratio of 1.03. More than half of the deaths were outborn 65(55.6%). The majority of newborns died in the first week of life, with preterm babies, low birth weight babies, and babies from other health facilities predominating (**Table II**).

**Table II. Socio-demographic profile of newborns**

| **Variables** | **Total=356 n(%)** | **Deceased = 117 n(%)** | **Alive = 239 n(%)** |
|---|---|---|---|
| **Sex** Male | 192(53.9) | 58(49,6) | 134(56,1) |
| Female | 164(46.157) | 59(50,4) | 105(43,9) |
| **Age at admission (in days)** | | | |
| < 7 days | 337(94.7) | 116(99.1) | 221(92.5) |
| >7 days | 19(5.3) | 1(0.9) | 18(7.5) |
| **Gestational age (WA)** | | | **(GA)** |
| < 28 | 10(2.8) | 10(8.5) | 0 (0) |
| [28-32] | 61(17.1) | 44(37.6) | 17(7.1) |
| [33-37[ | 84(23.6) | 25(21.4) | 59(24.7) |
| [37-42] | 201(56.5) | 38(32.5) | 163(68.2) |
| **Birth weight (in grams)** | | | |
| <2500gr | 153(43.0) | 81(69.2) | 72(30.1) |
| 2500-4000gr | 189(53.1) | 34(29.1) | 155(64.9) |
| >4000gr | 14(3.9) | 2(1.7) | 12(5.0) |
| **Residence** | | | |
| urbain | 353(99.2) | 115(98.3) | 238(99.6) |
| rural | 3(0.8) | 2(1.7) | 1(0.4) |
| **Origin** | | | |
| DGOPH | 192(53.9) | 52(44.4) | 140(58.6) |
| Others * | 164(46.1) | 65(55.6) | 99(41.4) |

Others=referral hospitals, other health facilities, home, taxi
DGOPH=Douala Gynaeco-Obstetric and Pediatric Hospital
GA= Gestational age

***Factors associated with newborn deaths***

***Maternal risk factors***

The risk of neonatal death was increased in single mothers (OR=1.94; CI95 (1.24-3.04); P=0.004) (**Table III**).

**Table III. Socio-demographic factors associated with neonatal death**

| Variables | Total =356 n(%) | Deceased =117 n(%) | Living= 239 n(%) | OR (95% CI) | P-value |
|---|---|---|---|---|---|
| **Age (in years)** | | | | | |
| <20 | 11(3.1) | 6 (5.1) | 5(2.1) | 0.40 (0.12-1.32) | 0.132 |
| ≥20 | 345(96.9) | 111(94.9) | 234(97.9) | 2.53 (0.76-8.47) | 0.132 |
| **Residence** | | | | | |
| Urban | 353(99.2) | 115(98.3) | 238(99.6) | 4.14 (0.37-46.12) | 0.248 |
| Rural | 3(0.8) | 2(1.7) | 1(0.4) | 0.24 (0.02-2.69) | 0.248 |
| **Marital statut** | | | | | |
| Married | 207(58.1) | 56(47.9) | 151(63.2) | 0.54 (0.34-0.84) | 0.008 |
| Single | 147(41.3) | 61(52.1) | 86(36.0) | **1.94 (1.24-3.04)** | **0.004** |
| Others* | 2(0.6) | 0 (0) | 2(0.8) | - | 1.000 |
| **Profession** | | | | | |
| Household | 143(40.3) | 50(42.7) | 94(39.3) | 1.15 (0.72-1.83) | 0.556 |
| Having an occupation * | 213(59.7) | 67(57.3) | 145(60.7) | 0.87 (0.55-1.38) | 0.556 |
| **Level of education** | | | | | |
| Elementary and secondary | 26(21.3) | 4(12.1) | 22(24.7) | 0.42 (0.13-1.32) | 0.139 |
| Superior | 96(98.7) | 29(87.9) | 67(75.3) | 2.38 (0.75-7.52) | 0.139 |

Having an occupation (private sector, students, shopkeepers, doctor, civil servant) . Others= cohabitation; OR=Odds ratio; IC=Confidence Interval. *: Fisher's exact test used

The number of Antenatal consultations (ANC) less than 4 (OR=3.99. IC95 (2.14-7.47); P=0.000) and ANC visits done outside the DGOPH (OR=3.42; IC95 (1.89-6.17); P=0.000) increased the risk of neonatal death (**Table IV**).

**Table IV. Obstetrical Determinants of Neonatal Deaths**

| Variables | Total = 356 n(%) | Deceased = 117 n(%) | Alive =239 n(%) | OR (95% CI) | P-value |
|---|---|---|---|---|---|
| **Parity** | | | | | |
| Primipare | 82(23.0) | 21(17.9) | 61(25.5) | 0.64 (0.37-1.11) | 0.113 |
| Others | 274 (77.0) | 96(82.1) | 178 (74.5) | 1.57 (0.90-2.73) | 0.113 |
| **Number of ANC < 4** | 49(13.8) | 30(25.6) | 19(7.9) | **3.99 (2.14-7.47)** | **0.000** |
| ≥4 | 307 (86.2) | 87(74.4) | 220 (92.1) | 0.25 (0.12-0.47) | 0.000 |
| **Location of ANC** | | | | | |
| DGOPH | 100 (28.1) | 16 (13.7) | 84 (35.1) | 0.29 (0.16-0.52) | 0.000 |
| Excluding DGOPH | 256 (71.9) | 101 (86.3) | 155 (64.9) | **3.42 (1.89-6.17)** | **0.000** |

DGOPH: Gynaeco-Obstetric and Pediatric Hospital of Douala.
ANC: Antenatal consultations.

Among maternal conditions, high blood pressure increased the risk of neonatal death, but this was not statistically significant. No relationship was found between labor, delivery and newborn death.

***Neonatal risk factors***

The risk of death increased with : Out-born (OR=1.76; IC95 (1.13-2.76) ;P=0.012), gestational age below 37 weeks (OR=4.46; IC95 (2.78- 7.16); P=0.000), low birth weight (OR=5. 21; IC95 (3.23 - 8.44); P=0.000), apgar score less than 7/10 at the 5th minute (OR=8.00; IC95 (4.54-14.11) ;P=000), and abnormal intra uterine growth (OR=1.83; IC95 (1.11-3.03) ;P= 0.002. (**Table V**).

**Table V. Newborn determinants associated with neonatal death**

| Variables | Total = 356 n(%) | Cases = 117 n(%) | Controls = 239 n(%) | OR (95% CI) | P-value |
|---|---|---|---|---|---|
| **Source** | | | | | |
| DGOPH | 192 (53.9) | 52 (44.4) | 140 (58.6) | 0.57 (0.36-0.88) | 0.012 |
| Out of DGOPH | 164 (46.1) | 65 (55.6) | 99 (41.4) | **1.76 (1.13-2.76)** | **0.012** |
| Sex Male | 192 (53.9) | 58 (49.6) | 134 (56.1) | 0.77 (0.49-1.20) | 0.248 |
| Female | 164 (46.1) | 59 (50.4) | 105 (43.9) | 1.29 (0.83-2.02) | 0.248 |
| Gestational age < 37 (weeks) | 155 (43.55) | 79 (67.5) | 76 (31.8) | **4.46 (2.78-7.16)** | **0.000** |
| ≥ 37 | 201 (56.5) | 38 (32.5) | 163 (68.2) | 0.22 (0.14-0.36) | 0.000 |
| Birth weight(g) | | | | | |
| < 2500 | 153 (43.0) | 81 (69.2) | 72 (30.1) | **5.21 (3.23-8.44)** | **0.000** |
| ≥ 2500 | 203 (57.0) | 36 (30.8) | 167 (69.9) | 0.192 (0.12-0.31) | 0.000 |
| Apgar score at the 5th minute | | | | | |
| < 7 | 75 (21.1) | 52 (44.4) | 23 (9.6) | **7.73 (4.38-13.6)** | **0.000** |
| ≥ 7 | 281 (78.9) | 65 (55.6) | 216 (90.4) | 0.13 (0.07-0.23) | 0.000 |
| Intra uterine growth | | | | | |
| normal | 271 (76.1) | 80 (68.3) | 191 (79.9) | 0.55 (0.33-0.90) | 0.017 |
| abnormal | 85 (23.9) | 37 (31.6) | 48 (20.1) | **1.83 (1.11-3.03)** | **0.017** |
| Resuscitated Yes | 116 (32.5) | 61 (57.0) | 51 (21.4) | **4.60 (2.85-7.43)** | **0.000** |
| No | 240 (67.5) | 46 (43.0) | 188 (78.6) | 0.21 (0.13-0.33) | 0.000 |

***:** Fisher's exact test used
CI= confidence interval; OR=Odds ratio

Altered consciousness (OR=12.47; IC95 (5.31-29.33); P=0.000) and hypothermia (OR=5.37; IC 95 (3.18-9.01); P=0.000) on admission were significantly associated with neonatal deaths.

***Causes of deaths***

Prematurity and its complications were the leading cause of death in (43.5%) of cases. This was followed by neonatal infection (23.9%), neonatal asphyxia (15.3%), congenital malformations (12.8%) and finally other pathologies at (4.2%).

***Timing of neonatal death***

The majority of newborns in our sample died in the early neonatal period, 73.4% as compared to 26.4% in the late neonatal period and 14.5% in the very early newborn period. The mean age of death was 4 days.

***Multivariate analysis of risk factors for neonatal death***

Variables associated with neonatal mortality at cut-off p<0.05 in the bi-variate analysis were included in a logistic regression model to determine independent factors. The independent risk factors for neonatal mortality were : Gestational age between [28-32] weeks (OR=3.20; CI95 (1.30-7.87); P=0.011), birth weight < 2500g (OR=6.28; CI 95(2.31 -16.67); P=0.000), outborns (OR=0.02; IC95 (1.44-5.39); P=0.002), unmarried (OR=2.79; IC95 (1.44-5.39); P=0. 049); number of ANC< 4 (OR=2.66; IC95 (1.16-6.08); P=0.000), apgar score less than 7 at the 5th minute (OR=10.95; IC95 (4. 93-24-31); P=0.000), altered consciousness (OR=9.49; IC95(3.36-26.83); P=0.000) and congenital malformations (OR=6.21; IC95 (2.21-17.40); P=0.000) (**Table VI**).

**Table VI. Results of multivariate analysis with logistic regression**

| Variables | OR (95% CI) | p-value | AOR (95% CI) | p-value |
|---|---|---|---|---|
| Age at admission <7 days | 9.45 (1.25-71.66) | 0.998 | - | - |
| Birth weight <2500 | **5.21 (3.23-8.44)** | **0.000** | **6.28 (2.31-16.67)** | **0.000** |
| Source outside DGOPH | **1.76 (1.13-2.76)** | **0.012** | **2.79 (1.44-5.39)** | **0.002** |
| Single status | **1.94 (1.24-3.04)** | **0.004** | **2.79 (1.44-5.39)** | **0.050** |
| ANC <4 | **3.99 (2.14-7.47)** | **0.000** | **2.66 (1.16-6.08)** | **0.021** |
| Gestational age [28-32] weeks | **8.16 (4.40-15.14)** | **0.000** | **3.20 (1.30-7.87)** | **0.011** |
| Gestational age <37weeks | 4.46 (2.78-7.16) | 0.000 | 1.97 (0.78-4.96) | 0.150 |
| Apgar score <7 at 5th minute | **7.73 (4.38-13.63)** | **0.000** | **10.95 (4.93-24.31)** | **0.000** |
| Newborns resuscitated | 4.60 (2.85-7.43) | 0.000 | 1.23 (0.51-2.95) | 0.632 |
| Impaired consciousness | **12.47 (5.31-29.33)** | **0.000** | **9.49 (3.36-26.83)** | **0.000** |
| Neonatal infection | 2.03 (1.23-3.35) | 0.006 | 1.17 (0.56-2.42) | 0.668 |
| Birth defects | **2.72 (1.32-5.60)** | **0.006** | **6.21 (2.21-17.40)** | **0.001** |

Fisher's exact test used
CI= confidence interval; OR=Odds ratio

## DISCUSSION

***Mortality rate in neonatology***

Neonatal mortality in our study was 20.2%. This rate is significantly higher than the 9.83% reported by Chiabi et al. in 2012 at Yaounde Gyneco-Obstetric and Pediatric Hospital(YGOPH), and that of Ndombo et al. at the Bamenda Regional Hospital (BRH) in 2016 estimated 15.7% (3,5). In contrast, our result is similar to that found

by Kedy et al. in 2014 at the Bonassama District Hospital(BDH) in the same city estimated at 20,3% (4). These differences in neonatal mortality rates could be explained by the setting of our study in an urban area, the fact that DGOPH is a referral center for other health facilities, where high-risk pregnancies or deliveries are transferred, and lastly because of the high proportion of preterm infants in our study. On the African continent, contrary to the studies carried out in Algeria in 2012 (5,3%) (6) and in Ethiopia in 2017 (16,5%) (7) where rates were lower than ours, other authors found rates higher than those in our study: 85,72% in Niger in 2013 (8) . On the other hand, in 2014, in Ghana, the rate was similar to ours, i.e. 20,2% (9). These data corroborate the WHO's conclusions that neonatal mortality rates remain very high in developing countries (10). In general, it remains high where maternal mortality is also high, and where most deliveries take place in precarious conditions out of health facilities, without care during labor, delivery and the first week of life.

In our study, the evolution of neonatal mortality has increased since the opening of the neonatology unit. This could be explained by the fact that consultations in this newly created structure were initially low in 2016. In addition to the neonatologists who are trained in the care of newborns, nursing, support and hygiene staff limited in number, qualification and dedicated expertise could be an answer. Furthermore, in the following years, consultations increased with multiple referrals of newborns and in utero transfers for the follow-up of high-risk pregnancies and deliveries, as well as other very sick newborns requiring specialist care that is not always provided in primary health care facilities.

***Factors associated with newborn deaths***

***Maternal risk factors***

In our study, the independent maternal risk factors for neonatal mortality were: single mother status and number of ANC visits less than 4. The correlation between single mother status and neonatal mortality had been observed (P=0.049), reinforcing the importance of a spouse in the organization of life activities in general. These findings are identical to those of Kedy et al. at BDH and Ndombo et al. at BRH (4,5). This could be related to the fact that married women in couples generally receive financial and psycho-emotional support from their spouses, which can lead to timely and good decisions, which is not always the case for single women. In contrast, in Brazil, Zanini et al. found no association between marital status and neonatal mortality (11). Among the obstetrical variables analyzed, the number and place of ANC significantly influenced neonatal deaths, and only the number of ANC less than 4 persisted in the multivariate analysis. Our results are consistent with those of Souza et al. in Brazil (12), where newborns from mothers who did not have ANC, or who had insufficient number of ANC, were more likely to die. However, the association between poor pregnancy monitoring and neonatal mortality was not found by Chiabi et al. at YGOPH (13). This discrepancy could be explained by the importance of the quality of ANC, rather than by the number of ANC.

***Neonatal risk factors***

Independent Neonatal risk factors of mortality in our study were: low birth weight, born out of DGOPH, Apgar score less than 7/10 at 5 minutes, altered consciousness and congenital malformations.

Gestational age significantly influenced neonatal mortality; newborns with a gestational age below 37SA had a 4-fold increased risk of death in bivariate analysis, a result identical to that of Mah et al. at YGOPH in 2014(13). Our results are comparable in different proportions to the findings of Noria et al. in Algeria (6), Chelo et al. in Cameroon(14), and discordant with studies by Kedy et al, Adetola et al. where the majority of deaths occurred in term newborns (4,15). However, after detailed analysis of the gestational age groups in our series, the high proportion of deaths was between [28-32] weeks of amenorrhea with a statistically significant difference. Indeed, the very premature infant has a multi-systemic immaturity that exposes it to multiple complications leading to very early death.

The majority (55.6%) of newborn deaths occurred in out-born babies. We found a strong positive association between the newborns born out of outside DGOPH and mortality. These findings are identical to those of Ndombo et al. in 2016 (5) , and of Ravikumar et al. in India (16), who demonstrated that internal transfer was a protective factor. The importance of neonatal deaths from outside the hospital could be explained by the poor conditions of transport of the newborn to the receiving facility, increasing the risk of hypothermia, hypoglycemia, and infection, which are the causes of death. For example, Monebenimp et al (17) showed that a newborn referred from a peripheral center to a specialized care unit had a higher risk of mortality than one transferred from the same center. According to them, newborns referred from peripheral centers to the referral center were at high risk of colds and adequate time to care, with adverse consequences for their survival.

Low birth weight was strongly associated with neonatal mortality, with a five-fold higher risk of death than normal weight newborns. This result corroborates to those of some authors in Africa (3,5,7) and that of Ravikumar et al. in India(16). This statistical difference could be explained by the high proportion of low birth weight (52.9%) among deceased newborns. Indeed, the low weight newborn is subject to a lack of reserves, especially energy reserves necessary for growth, and a lack of brown fat to maintain its temperature within normal limits on its own. Hence the promotion of adequate nutrition for the mother, the prevention and management of infection during pregnancy and the use of kangaroo methods in low birth weight babies (15).

An Apgar score below 7 at the $5^{th}$ minute was strongly associated with neonatal mortality (18). Our finding is similar to those of some authors in Cameroon and Niger (3,5,8). During asphyxia the newborn is exposed to poor cellular oxygenation, leading to multisystem lesions (renal, cerebral, and cardiac) that will alter the vital prognosis while precipitating death. Similarly, in the Souza et al. series in Brazil, an Apgar score below 7 at both the first and second minute was a risk factor for neonatal mortality (12).

We found a very strong association between altered consciousness of the newborn on admission and increased risk of death. Altered consciousness increases the risk of death by a factor of twelve. This is consistent with the study carried out by Garba et al. in Niger, where the risk of death was multiplied by one hundred(8). Impaired consciousness in newborns can be due to infections, metabolic disorders and asphyxia, during which there is a production of free radicals and an acceleration of anaerobic metabolism (energy deficiency), contributing immediately to death.

Birth defects significantly influenced neonatal death, as shown in 2016 by Souza et al. in Brazil (12). In our context, this may be justified by the lack of antenatal diagnosis and the delay in immediate management at birth due to lack of material and human resources for the immediate correction of these defects.

***Causes of death***

From our analysis, the main causes of death, in decreasing order, are: prematurity and its complications, infections, neonatal asphyxia, and congenital malformations. Overall, our results are consistent with those of other authors, but with varying degrees of predominance (3,13).

***Limits***

Our work has the weaknesses of a retrospective study, represented by missing data: Unusable medical records, incomplete anamnestic data, absent or incomplete neonatal transfer sheets, lack of homogeneity in the taking of medical observations and follow-up of newborns, discharge or death reports that are often absent or incomplete. Nevertheless, our sample was large enough to give acceptable results.

## CONCLUSION

Neonatal mortality was influenced by less than 4 prenatal; very extreme prematurity, low birth weight, Asphyxia, out-born, and congenital malformations. Neonatal mortality is still high in our environment due to poor monitoring of pregnancies. Several lines of research on in utero transfers, transfers of newborns, the training of medical personnel in the delivery room on neonatal resuscitation should help to bring down neonatal deaths in the near future in this context.

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**Disclosure of interest**

The authors declare that they have no competing interest.

**Author contributions**

DNN, DE and GNK designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. YDP, CMT, MCB, and SRWT designed the data collection instruments, collected the data, and reviewed and revised the manuscript. EMM and AC designed the study, coordinated, and supervised data collection, and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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