

Clinical and Biological Profile of Early Bacterial Neonatal Infections in Kisangani

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Abstract

Introduction: Infections are a preventable cause of neonatal morbidity and mortality, but clinicians are still concerned about their diagnosis and management. The aim of this study is to describe the clinical and biological profile and clinical outcome of early bacterial neonatal infections in hospitals in Kisangani. **Methods:** This was a multicentre, cross-sectional descriptive study carried out between 28 June 2023 and 15 July 2024. All symptomatic and asymptomatic newborns presenting at least one antenatal infectious risk according to ANAES were included. Data was analysed using R software version 4.4.2. The Chi² exact test and the Fisher exact test were used with a positivity threshold of 5%. **Results:** Of the 871 newborns admitted 190 were selected for INBP, *i.e.*, a frequency of 21.8%. 123 blood cultures were taken with 5 positive cases, *i.e.*, a frequency of confirmed early neonatal infection of 4.1%. The male-to-female sex ratio was 1.2. Meconium amniotic fluid and the duration of opening of the water sac ≥ 18 h were the most important risk factors; thermoregulatory disorders including fever and hypothermia (70.4%) followed by respiratory disorders (44.8%) were the most frequent clinical manifestations. The median PCT was higher in deceased neonates above the threshold of 50 ng/ml than in neonates with improved clinical status, with a significant difference $p < 0.0001$. Progression was favourable in most cases and the death rate was 4%. **Conclusion:** The incidence of INBP remains high in Kisangani, requiring early diagnosis. Fever and respiratory problems are the most common symptoms, and most newborns have a favourable outcome.

Keywords

Early Neonatal Bacterial Infection, Clinical, Biological, Kisangani

1. Introduction

Neonatal infection (NCI) remains a major public health problem due to its high mortality rate. Indeed, the World Health Organization (WHO) estimates that 2.8 million neonatal deaths occurred globally in 2015, 47.6% of which were due to NIN [1]. Half of these deaths occurred in sub-Saharan Africa (SSA) in 2019 [2], while the early neonatal mortality rate is estimated at 28 per 1000 live births [3]. In the Democratic Republic of Congo (DRC), 15.6% of neonatal deaths are caused by neonatal septicaemia [4]. The incidence of neonatal infections, their characteristics, and their consequences depend on the time of onset and the context in which they occur, particularly at a gestational age [5]. The incidence of NIN has fallen significantly in industrialised countries but remains high in countries with limited resources. An incidence of 0.8 per 1000 births has been found in the United States and Europe [6]. Studies carried out in Africa have shown a frequency of 96.8% in Cameroon (1) and 6.2% in Morocco [7]. Early onset neonatal infection (EONI) refers to an infection occurring within the first 72 hours after birth [6] [8]. Neonatal infections are divided into 2 categories: early neonatal infection when signs occur within 72 hours of life and late neonatal infection when signs occur after the 3rd day of life [9]. EBNI are the consequence of vertical bacterial transmission from mother to newborn [5]. Clinical manifestations are polymorphous and non-specific [10] in response to sepsis [11]. Because of the difficulty of diagnosis, especially during the first 72 hours after birth, and the fact that the symptoms of neonatal sepsis are non-specific, empirical antibiotic therapy can lead to the treatment of up to 30 uninfected newborns for just one who is probably diagnosed as infected [12]. Blood culture, which is the gold standard, is often not available and cannot produce immediate results [13]. Biomarkers are, therefore, becoming an alternative for the early identification of sick newborns [5]. An evidence-based approach combining anamnestic, clinical and biological data is a better strategy, especially in resource-limited countries [14]. The aim of this study was to determine the clinical and biological characteristics and outcomes of newborns suspected of having EONI in a hospital setting in Kisangani.

2. Material and Methods

2.1. Framework and Type of Study

We conducted a multi-centre descriptive cross-sectional study in six health care facilities (HCFs) caring for children and all belonging to the bacteraemia surveillance network during the period from 28 June 2023 to 15 July 2024 in the city of Kisangani, capital of the Tshopo Province in the north-eastern region of the DRC. Five of these SSEs are state-run (Department of Paediatrics at the University Clinics, Kabondo General Referral Hospital, Makiso-Kisangani General Referral Hospital, Cinquantenaire Hospital, ALABUL Health Centre) and only one, the Centre Hospitalier Nouveau Village de Pédiatrie, is private.

2.2. Study Population and Sampling

To calculate our sample size, we used Epi info software version 7.2.5.0 with a theo-

retical frequency of early neonatal sepsis of 22.7% found by Mulinganya *et al.* in Bukavu, DRC [4], a population size of 48,452 at the 5% significance level, and a minimum sample size of 295.

Newborns with risk factors for BPN and clinical signs of infection according to the criteria of the Agence Nationale d'Accréditation et d'Evaluation en Santé (ANAES) [15] were included in the study.

Antenatal risk factors for INBP

1) Major criteria

- Maternal colonisation with group B Streptococcus (GBS) during the current pregnancy (vaginal and/or GBS bacteriuria)
- Duration of water break > 18 hours
- Maternal fever > 38.0°C intrapartum (or within 2 hours of delivery)
- picture suggestive of chorio
- Premature rupture of the membranes (PMR) before 37 weeks' amenorrhoea (SA)
- Twin with maternal-foetal infection
- Spontaneous prematurity < 35 SA

2) Minor criteria

- Prolonged opening of the water bag > 12 h but < 18 h
- Spontaneous prematurity between 35 SA and 37 SA
- Fetal heart rhythm abnormalities or unexplained fetal asphyxia
- Stained or meconium amniotic fluid

Clinical signs

- General signs: fever (temperature $\geq 38.0^{\circ}\text{C}$) or hypothermia (temperature < 36.0°C)
- Respiratory signs: respiratory distress (whining, nasal flaring, signs of retraction), tachypnoea (FR > 60/min), and apnoea
- Haemodynamic signs: tachycardia (>160 bpm) or bradycardia (<80 bpm), signs of shock (increased skin recolouration time, pallor, arterial hypotension, oliguria)
- Neurological signs: drowsiness, irritability, hypotonia, convulsions, disturbed consciousness
- Digestive signs: refusal to drink, vomiting
- Skin signs: purpura, petechiae, rashes of various types, early jaundice before 24 hours

Malformed polyyps, those who had previously received antibiotics prior to transfer to the selected EHSs and those whose parents had not consented to the study were excluded.

2.3. Conduct of the Study

Using a pre-established form, we prospectively collected sociodemographic data on newborns (age and sex) and their mothers (age, town of residence, level of education, marital status, occupation, antenatal consultation follow-up, mode of de-

livery) as well as clinical data on newborns (Apgar at 5th minute, risk factors for infection, birth weight, head circumference, height, symptoms and management data). The newborns were examined by trained doctors who were able to make a diagnosis of suspected EONI. A 1 - 2 ml blood sample was taken using a clean vacutainer tube and sent to the laboratory for PCT and blood culture.

2.4. Laboratory Analysis

A trained laboratory technician performed a quantitative PCT assay on blood samples from neonates following the standard operating procedure for the test (Fluore Care PCT Kit, China). This is a diagnostic immuno-chromatographic test used to detect the concentration of PCT in serum using the double antibody sandwich method. The technique involved collecting half a millilitre to one millilitre of blood in a clean, dry, impermeable vacutainer tube and sending it to the laboratory. After centrifugation at 2500 rpm, 20 µL of blood sample was added to the 180 µL diluent solution tube and mixed for 2 minutes. Seventy microlitres of this mixture were applied to the card, which was placed at room temperature for 15 minutes before insertion into the analyser's test card holder. A few seconds later, the result was automatically displayed on the screen. The diagnostic kit's reference value range for PCT was 0.5 ng/ml.

For blood cultures, neonatal blood samples (1 - 2 ml) were collected by aseptic peripheral venipuncture [4]. The indications for blood culture collection in newborns were the presence of one or more risk factors for bacterial infection and/or clinical signs.

Neonatal blood samples were added to Bio Mériex BACT/ALERT*FP paediatric blood culture bottles, after which the bottles were kept at room temperature. The blood culture bottles were transported at room temperature from the sampling site to the laboratory in the paediatric department of the Kisangani University clinics in a "Bac".

Culture was carried out after incubation for a maximum of 7 days, with the positive (virulent) flasks inoculated onto two Petri dishes, one made from fresh blood agar (FBA) and the other from Mac Conkey medium (PVX), after direct examination and Gram staining. Positive grams were isolated on GSF and Salt Agar Medium (SAM) while negative grams were isolated on GSF and Mac Conkey.

The bacteria were identified 24 to 48 hours later, by comparing the various biochemical characteristics of the Api galleries. We considered the following germs to be contaminants: *Bacillus spp*, *Micrococcus spsp* and coagulase-negative Staphylococci (CNS). The test result was recorded in the patient file and communicated to the mother as part of the child's care. All the blood for both tests was obtained in a single sample.

INBP has been defined as an infection occurring within the first 72 hours of life. [13]

Newborns suspected of having a neonatal infection are those with an antenatal

risk factor or clinical sign.

Low birth weight was defined as a birth weight of less than 2500 g, and neonatal asphyxia as an APGAR score of less than 7 at five minutes. [10]

2.5. Statistical Analysis

The data were recorded using Epi Info version 7.2.2.6 and the statistical analyses were carried out using R software version 4.4.2. For the descriptive analysis, the categorical data were described in terms of numbers and percentages, while the quantitative data were presented, in terms of their statistical distribution, in terms of mean and standard deviation or median and interquartile range. For bivariate analysis, comparisons of proportions were made using Pearson's Chi-square test or Fisher's exact test. Where the distribution of quantitative data was not normal, medians were calculated. Comparisons of medians were made using the Wilcoxon Mann-Whitney test. For all statistical tests, the significance threshold was 5% ($p < 0.05$).

2.6. Ethical Considerations

The study protocol was approved by the ethics committee of the University of Kisangani (N° UNIKIS/CER/015/2023). In addition, we obtained permission from the administration of each SSE. Written or oral informed consent was obtained from each mother prior to inclusion of the neonate in the study.

3. Results

Of the 871 newborns admitted, 190 were selected for INBP, a frequency of 21.8%. The average age of the newborns was 48.6 hours, and the sex ratio was 1.2 (165 boys and 132 girls). Low birth weight was found in 15.5% of newborns and neonatal asphyxia in 20.2% of cases (Table 1). The average age of the mothers was 26, and most of them (80%) were housewives and well-educated. The most important antenatal risk factors were meconium amniotic fluid (12.1%), duration of water sac opening ≥ 18 h (10.8%) and maternal temperature $\geq 38^\circ\text{C}$ (8.1%), which was statistically significant ($p < 0.039$). The most frequent clinical manifestations were disorders of thermal regulation including fever and hypothermia (70.4%) followed by respiratory disorders (44.8%) significant ($p < 0.018$) and neurological signs (26.3%) (Table 2). Of the 297 newborns aged < 72 hours, blood cultures were taken in 123 and came back positive in 5 newborns, giving a confirmed hospital incidence of INBP of 4.1%. The germs isolated were as follows: two blood cultures were positive for *Enterobacter spp*, two for *Staphylococcus spp* and one for *Serratia spp*. PCT was positive in 86 newborns, including the 5 with a positive blood culture. The median PCT of blood culture-positive neonates was higher than that of blood culture-negative neonates (Table 3). Regarding the clinical outcome of neonates, the median PCT was higher in neonates who died at 22.4 [3.7 - 50.0] compared with neonates with improved clinical status 0.8 [0.3 - 3.3] with a significant difference (Table 4). The outcome was favourable in most cases (96%) and the death rate was 4%.

Table 1. General characteristics of newborns.

Variables	N	N = 297 ¹
Age of newborns (in hours)		
Average age	297	48.6 (19.9)
Brackets	297	
<24		34 (11.4%)
24 - 48		117 (39.4%)
>48		146 (49.2%)
Gender	297	
Male		165 (55.6%)
Female		132 (44.4%)
Apgar score at 5th minute	297	
≥7		233 (78.5%)
<7		60 (20.2%)
Data not available		4 (1.3%)
Birth weight (g)	297	
<2500		46 (15.5%)
2500 - 4000		239 (80.5%)
>4000		12 (4.0%)

¹n (%); Mean (SD).**Table 2.** Clinical manifestations of neonates and variations in PCT

Clinical signs	PCT		Total N = 297 ¹	p-value
	Positive N = 190 ¹	Negative N = 107 ¹		
Fever	120 (63.2%)	78 (72.9%)	198 (66.7%)	0.087 ²
Incessant crying	31 (16.3%)	29 (27.1%)	60 (20.2%)	0.026²
Dyspnoea	33 (17.4%)	8 (7.5%)	41 (13.8%)	0.018²
Refusal to feed	26 (13.7%)	10 (9.3%)	36 (12.1%)	0.3 ²
No cries at birth	18 (9.5%)	10 (9.3%)	28 (9.4%)	>0.9 ²
Convulsions	1 (0.5%)	1 (0.9%)	2 (0.7%)	>0.9 ³
Premature birth	6 (3.2%)	1 (0.9%)	7 (2.4%)	0.4 ³
Vomiting	9 (4.7%)	1 (0.9%)	10 (3.4%)	0.10 ³
Respiratory distress	23 (12.1%)	4 (3.7%)	27 (9.1%)	0.016²
Whining	13 (6.8%)	4 (3.7%)	17 (5.7%)	0.3 ²
Tachypnea	10 (5.3%)	0 (0.0%)	10 (3.4%)	0.016³

Continued

Breathing pauses	1 (0.5%)	0 (0.0%)	1 (0.3%)	>0.9 ³
Inter- and subcostal retraction	28 (14.7%)	3 (2.8%)	31 (10.4%)	0.001²
Xiphoid Depression	5 (2.6%)	1 (0.9%)	6 (2.0%)	0.4 ³
Vomiting	19 (10.0%)	1 (0.9%)	20 (6.7%)	0.003²
Abdominal bloating	4 (2.1%)	0 (0.0%)	4 (1.3%)	0.3 ³

¹n (%); ²Chi-square test of independence; ³Fisher's exact test.

Table 3. Blood culture and PCT results for the group of 123.

Variables	HEMOCULTURE			p-value
	Positive N = 5 ¹	Negative N = 118 ¹	Total N = 123 ¹	
PCT (ng/ml)	5.7 [3.1 - 9.4]	1.1 [0.4 - 5.6]	1.3 [0.4 - 6.6]	0.0631 ²
PCT				0.3209 ³
Positive	5 (100.0%)	81 (68.6%)	86 (69.9%)	
Negative	0 (0.0%)	37 (31.4%)	37 (30.1%)	

¹Median [EI]; n (%); ²Wilcoxon-Mann-Whitney test; ³Fisher's exact test.

Table 4. Clinical outcome of neonates and variations in PCT threshold.

Variables	Improvement N = 285 ¹	Deaths N = 12 ¹	Total N = 297 ¹	p-value
PCT (ng/ml)	0.8 [0.3 - 3.3]	22.4 [3.7 - 50.0]	0.9 [0.4 - 4.0]	<0.0001 ²
PCT				0.0050 ³
Positive	178 (62.5%)	12 (100.0%)	190 (64.0%)	
Negative	107 (37.5%)	0 (0.0%)	107 (36.0%)	

¹Median [EI]; n (%); ²Wilcoxon-Mann-Whitney test; ³Fisher's exact test.

4. Discussion

INBP remains a major cause of neonatal morbidity and mortality in both developed and developing countries [16] and in the DRC. It remains a concern for clinicians because of its non-specific symptoms and diagnostic difficulties. In our study, the frequency of infection was 21.8%, higher than that found by Chemsu *et al.* [7] (6.2% in Casablanca, Morocco), by Kamaye *et al.* [10] (5.4% in Niger) and by Konaté *et al.* [17] (11% in Mali). This frequency was lower than that found by Kemeze *et al.* [1] of 96.8% in Cameroon.

The average age of the newborns was 48.6 hours, and only 11.6% were symptomatic within 24 hours of birth. The youngest was 7 hours old. The sex ratio was 1.2, the Apgar score at 5 minutes was <7 in 20.2% and 15.5% of newborns had a low birth weight. The lack of unified criteria for diagnosing neonatal sepsis means that

clinicians in resource-limited settings with no access to blood cultures must rely on a range of clinical arguments. [18] The risk factors found in our series were meconium amniotic fluid, opening of the water sac ≥ 18 h and maternal temperature $\geq 38^{\circ}\text{C}$, which was significant. This result is different from the premature rupture of membranes significantly associated with the risk of neonatal sepsis found by Adarate *et al.* in Ghana [19]. The most frequent clinical manifestations were fever, respiratory disorders (with a significant difference) and neurological disorders. The same result was found by Nyenga *et al.* [20] in Lubumbashi in the DRC and Berhane *et al.* in Ethiopia. However, the symptomatology found by Tran *et al.* in Vietnam [21] and Maamouri *et al.* in Iran [22] is different from our series represented by respiratory distress and difficulty in eating, respectively. Blood culture, which is the gold standard, diagnosed only 5 positive cases. A negative blood culture does not always rule out neonatal infection, as low blood volume and low bacteremia may be the cause. This result is similar to that found by Oeser *et al.* [23] in England, who also found a low rate of blood culture in EONI. With regard to the clinical outcome of neonates, the median PCT was higher in neonates who died above the 50 ng/ml threshold than in neonates with improved clinical status, with a significant difference of $p < 0.0001$ making PCT a prognostic marker for neonatal sepsis. The outcome was favourable in most cases (96%) and the death rate was 4%.

5. Conclusion

Our study shows that INBP is still common in hospitals in our context. The clinical picture is dominated by fever, as well as respiratory and neurological disorders. Progression is favourable in most cases, but the median PCT is very high in neonates who die, making it a prognostic marker in resource-limited settings.

6. Limits of the Study

The limitation of this study is the low positivity of the blood culture. This did not allow us to establish the bacterial ecology of INBP in our environment. Studies on larger cohorts of newborns should be considered in the future.

Authors' Contributions

The clinical examination of newborns suspected of having INBP and the collection of data were carried out by the following authors: H. M. V., G. B. M., V. M. K., B. B. L. and D. G. M.: H. M. V., G. B. M., V. M. K., B. B. L. and D. G. M. Correction of the study protocol and manuscript were provided by B. M. M., D. F. S., E. T. K. and J. P. A. O.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Kemeze, S., Moudze, B., Chiabi, A., Eposse, C., Kaya, A., Mbangue, M., *et al.* (2016)

- Clinical and Bacteriological Profile of Neonatal Bacterial Infections at Laquintinie Hospital, Douala, Cameroon. *Pan African Medical Journal*, **23**, Article 97. <https://doi.org/10.11604/pamj.2016.23.97.8523>
- [2] Velaphi, S.C., Westercamp, M., Moleleki, M., Pondo, T., Dangor, Z., Wolter, N., et al. (2019) Surveillance for Incidence and Etiology of Early-Onset Neonatal Sepsis in Soweto, South Africa. *PLOS ONE*, **14**, e0214077. <https://doi.org/10.1371/journal.pone.0214077>
 - [3] Berhane, M., Gidi, N.W., Eshetu, B., Gashaw, M., Tesfaw, G., Wieser, A., et al. (2021) Clinical Profile of Neonates Admitted with Sepsis to Neonatal Intensive Care Unit of Jimma Medical Center, a Tertiary Hospital in Ethiopia. *Ethiopian Journal of Health Sciences*, **31**, 485-494. <https://doi.org/10.4314/ejhs.v31i3.5>
 - [4] Mulinganya, G.M., Claeys, M., Balolebwami, S.Z., Bamuleke, B.A., Mongane, J.I., Boelens, J., et al. (2021) Etiology of Early-Onset Neonatal Sepsis and Antibiotic Resistance in Bukavu, Democratic Republic of the Congo. *Clinical Infectious Diseases*, **73**, e976-e980. <https://doi.org/10.1093/cid/ciab114>
 - [5] Letouzey, M., Boileau, P. and Foix-L'Hélias, L. (2022) Early and Late Neonatal Bacterial Infections. *Journal de Pédiatrie et de Puériculture*, **35**, 284-292. <https://doi.org/10.1016/j.jpp.2022.09.003>
 - [6] Puopolo, K.M., Mukhopadhyay, S., Frymoyer, A. and Benitz, W.E. (2021) The Term Newborn: Early-Onset Sepsis. *Clinics in Perinatology*, **48**, 471-484. <https://doi.org/10.1016/j.clp.2021.05.003>
 - [7] Chemsî, M. and Benomar, S. (2015) Early Neonatal Bacterial Infections. *Journal de Pédiatrie et de Puériculture*, **28**, 29-37. <https://doi.org/10.1016/j.jpp.2014.10.005>
 - [8] El-Amin Abdalla, E.O., Salih, F.A.M., Salih, H.F., Elamin, O.E., Gamaleldin, M.A. and Mustafa, B.M. (2017) Procalcitonin in the Diagnosis of Early-Onset Neonatal Infection in Resource-Limited Settings. *Cogent Medicine*, **4**, Article 1283085. <https://doi.org/10.1080/2331205x.2017.1283085>
 - [9] Shane, A.L., Sánchez, P.J. and Stoll, B.J. (2017) Neonatal Sepsis. *The Lancet*, **390**, 1770-1780. [https://doi.org/10.1016/s0140-6736\(17\)31002-4](https://doi.org/10.1016/s0140-6736(17)31002-4)
 - [10] Kamaye, M. and Al, E. (2022) Diagnostic, Therapeutic and Prognostic Aspects of Early Bacterial Neonatal Infections at the Issaka Gazobi Maternity Hospital in Niamey. *Revue Malienne d'Infectiologie et de Microbiologie*, **16**, 93-96. <https://doi.org/10.53597/remim.v16i3.2038>
 - [11] Cantey, J.B. and Lee, J.H. (2021) Biomarkers for the Diagnosis of Neonatal Sepsis. *Clinics in Perinatology*, **48**, 215-227. <https://doi.org/10.1016/j.clp.2021.03.012>
 - [12] Bunduki, G.K. and Adu-Sarkodie, Y. (2020) The Usefulness of C-Reactive Protein as a Biomarker in Predicting Neonatal Sepsis in a Sub-Saharan African Region. *BMC Research Notes*, **13**, Article No. 194. <https://doi.org/10.1186/s13104-020-05033-1>
 - [13] Yadav, P. and Kumar Yadav, S. (2022) Progress in Diagnosis and Treatment of Neonatal Sepsis: A Review Article. *Journal of Nepal Medical Association*, **60**, 318-324. <https://doi.org/10.31729/jnma.7324>
 - [14] Guen, C.G., Launay, É., Boscher, C. and Caillon, J. (2016) Update on Neonatal Infections. *Bulletin de l'Académie Nationale de Médecine*, **200**, 81-90. [https://doi.org/10.1016/s0001-4079\(19\)30789-7](https://doi.org/10.1016/s0001-4079(19)30789-7)
 - [15] Agency National Accreditation and Evaluation in Health (ANAES) (2003) Diagnosis and treatment curative of the infection bacterial early newborn development. Recommendations for practice. <http://has-santé.fr>
 - [16] Dain, C., Rozé, J.-C., Caillon, J., Flamant, C., Muller, J.-B., Boscher, C., et al. (2020)

- Epidemiology of Invasive Early-Onset Neonatal Infection in a French Administrative District: A 10-Year Population-Based Study. *Archives de Pédiatrie*, **27**, 356-361. <https://doi.org/10.1016/j.arcped.2020.07.011>
- [17] Konaté, D., Coulibaly, O., Sidibe, L.N., Diallo, O., Diall, H., Diakité, F.L., *et al.* (2019) Infection néonatale bactérienne précoce en 2016 au CHU Gabriel Touré de Bamako. *Revue Malienne d'Infectiologie et de Microbiologie*, **14**, 62-67. <https://doi.org/10.53597/remim.v14i2.1373>
- [18] Rees, C.A., Lim, J., Westbrook, A.L., El Helou, R., Schmid, A., Rubin-Smith, J., *et al.* (2023) Systematic Review and Meta-Analysis of the Diagnostic Value of Four Biomarkers in Detecting Neonatal Sepsis in Low- and Middle-Income Countries. *BMJ Paediatrics Open*, **7**, e001627. <https://doi.org/10.1136/bmjpo-2022-001627>
- [19] Adatara, P., Afaya, A., Salia, S.M., Afaya, R.A., Konlan, K.D., Agyabeng-Fandoh, E., *et al.* (2019) Risk Factors Associated with Neonatal Sepsis: A Case Study at a Specialist Hospital in Ghana. *The Scientific World Journal*, **2019**, Article ID: 9369051. <https://doi.org/10.1155/2019/9369051>
- [20] Nyenga, A.M., Mukuku, O., Mutombo, A.K., Luboya, O.N. and Wembonyama, S.O. (2021) Epidemiology of Neonatal Sepsis in Lubumbashi, Democratic Republic of Congo. *Journal of Medicine, Public Health and Policy Research*, **1**, 6-13. <http://pugoma.com/index.php/IMPHPR/article/view/40>
- [21] Tran, L.U., Giang, T.P.L. and Nguyen, T.T. (2024) Validity of Umbilical Cord Blood Procalcitonin in the Diagnosis of Early-Onset Neonatal Infection. *Cureus*, **16**, e59887. <https://doi.org/10.7759/cureus.59887>
- [22] Maamouri, G., Boskabadi, H., Zghandi, M., Sayedi, J. and Bagheri, F. (2017) The Evaluation of Serum Procalcitonin Levels in Neonatal Infections. *Journal of Pediatric Perspectives*, **5**, 5287-5294. <https://doi.org/10.22038/ijp.2017.23415.1968>
- [23] Oeser, C., Pond, M., Butcher, P., Bedford Russell, A., Henneke, P., Laing, K., *et al.* (2020) PCR for the Detection of Pathogens in Neonatal Early Onset Sepsis. *PLOS ONE*, **15**, e0226817. <https://doi.org/10.1371/journal.pone.0226817>