Cross-sectional Study

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Capabilities of perinatal healthcare institutions in primary and tertiary care of low birth weight infants in the Federation of Bosnia and Herzegovina: a cross-sectional multicentric study

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Introduction: Providing adequate healthcare for premature infants is an important issue in perinatal medicine. The aim of this study is to assess the level of the perinatal healthcare institution (PHI) where the newborns were delivered and the possibilities of transporting them to the cantons of the Federation of Bosnia and Herzegovina. The authors also aimed to examine the overall survival of low birth-weight infants (LBWI) in the Federation of Bosnia and Herzegovina and to compare the survival of newborns according to the PHI where they were born and the PHI where they were treated.

Materials and methods: This cross-sectional study included newborns of both sexes that were born in the maternity wards in 10 cantons of the Federation of Bosnia and Herzegovina with a gestational age between 22 and 42 weeks, and a birth weight less than 2500 g.

Result: From the PHI of the first and second level, 159 newborns were referred to the third level. A total of 159/669 (23.7%) were referred from a second level PHI to a third level PHI, and 127/669 (l8.9%) LBWI were definitely taken care of. A total of 513/669 (76.8%) LBWI were definitely taken care of in the third level PHI. Out of a total of 159 LBWI referred from other PHI, only 31 (19.5%) LBWI were transported in less than 4 h, and 128 (80.5%) newborns were admitted to the third level PHI within 4 h of birth ($P < 0.0001$). In second level PHI, most LBWI died in the first 12 h after birth, while in third level PHI, 69.2% of LBWI died after 1 week of life.

Conclusion: Based on world experience and assessment of the situation in Federation of Bosnia and Herzegovina, it is necessary to take measures to improve perinatal care and its regional organization.

Keywords: low birth weight, neonatology, perinatal care

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HIGHLIGHTS

- 23.7% of newborns were referred from a second to a third level perinatal healthcare institutions (PHI).
- In second level PHI, most low birth weight infants died in the first 12 h after birth.
- 69.2% of low birth weight infants died after 1 week of life in third-level PHI.
- It is necessary to take measures to improve perinatal care and its regional organization in the Federation of Bosnia and Herzegovina.

Introduction

Providing adequate healthcare for premature infants is an important issue of perinatal medicine[1,2]. In order to provide fast and adequate treatment of preterm infants and low birth weight infants (LBWI), perinatal regionalization of newborns is organized in three levels of perinatal healthcare[3,4].

The first level of perinatal healthcare institutions (PHI) is offered by neonatal healthcare for healthy term newborns. The second level of PHI has two subgroups: level IIa provides health care for premature infants older than 32 weeks of gestation and

Table 1

Distribution of low birth weight infants by levels of perinatal healthcare institutions in the Federation of Bosnia and Herzegovina.

Level of prenatal healthcare institution	Total number of newborns *N* (%)	Number of LBWI cared for at the same institution *N* (%)
I	1651 (7.3)	29 (4.4)
II	9490 (41.6)	286 (42.7)
III	11666 (51.1)	513 (76.7)
Total	22807 (100)	669 (100)

weight more than 1500 g, and level IIb offers short-term mechanical ventilation for children with respiratory distress syndrome. Finally, the Neonatal Intensive Care Units (NICU) are at the third level of PHI which provide healthcare to very immature preterm infants and to any newborn who needs long-term ventilatory support[1–7]. About 80% of pregnancies are monitored and completed in a first level PHI. Obstetricians recognize the risky ones among the supervised pregnant women and refer them to a second level PHI according to the severity of the pathology. This accounts for nearly 16% of pregnancies. On the other hand, only 4% of pregnancies are referred to a third level PHI. These usually tend to have the most severe perinatal pathologies[2–7]. Unfortunately, it is not always possible to predict the birth of a high-risk newborn and refer the pregnant woman to a perinatal institution of the appropriate organizational level (i.e. 'in utero' transport of the fetus) before birth. If high-risk newborns are born in maternity hospitals that do not have an NICU, they are postnatally referred to neonatal institutions of the appropriate organizational level according to the severity of the disease[3,4].

Antenatal 'in utero' transport is an indispensable part of the regionalization of perinatal care, which means sending a pregnant woman and her fetus to an institution whose treatment options are better[3,4]. Transporting a newborn with a life-threatening condition is a critical procedure that carry a lot of risks on the health of the newborn when a low level of care is implemented. 'In utero' transport and postnatal transport of newborns are indispensable parts of regionally organized perinatal care and serve to achieve the ultimate goals, which is treating every pregnant woman and newborn in a particular region or country in an institution of optimal organizational level, according to severity of their conditions or diseases[8–10]. Several studies have examined the capabilities of various neonatal institutions in the treatment of newborns with a birth weight of less than 1500 g. It has been shown that the results of such comparisons obtained on the basis of birth weight change after adjusting the studied populations to the severity of the disease. Therefore, most authors suggest that studies comparing the capabilities of neonatal facilities should use cumulative disease severity systems to overcome the variation in disease severity of individual groups of subjects[3,4,9]. Neonatal survival as well as mortality by time periods are some of the measures of the quality of neonatal healthcare[3,4,9]. Among other criteria, the success of a neonatal institution is most often measured by the mortality or survival of the patient. In order to be able to compare the outcomes of treatment of patients between individual neonatal institutions, it is necessary to stratify the severity of the diseases of patients treated in these institutions. Only then, it is possible to compare the capabilities of neonatal institutions according to the outcome of such stratified patients[3,4,9].

The aim of this study is to determine the level of the PHI where the newborns were born and the possibility of transporting them to the cantons of the Federation of Bosnia and Herzegovina (FBiH). We also aimed to examine the overall survival of LBWI in the FBiH and to compare the survival of newborns according to the PHI where they were born and the PHI where they were treated.

Materials and methods

This cross-sectional study included newborns of both sexes that were born in the maternity wards in 10 cantons of the FBiH with a gestational age between 22 and 42 weeks, and a birth weight less than 2500 g. This study confirms the Declaration of Helsinki and in line with the guidelines of the Committee on Publications Ethics (COPE). This study was conducted in accordance with the Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement[11], which is available through the Enhancing the Quality and Transparency of Health Research (EQUATOR) network (www.equator-network.org). The study protocol was revised and approved by an independent institutional review board (IRB Approval ID: 02-09/2-77/20). This study was written in accordance with the STROCCS guidelines[12]. Each patient signed informed consent for the procedures, as well as data collection and analysis for research purposes.

Data on the course of pregnancy and childbirth were collected from the available medical records and included the place of delivery (inside or outside the maternity wards). The maternity wards were divided based on a 1-year number of deliveries to this study (first level 1–500 births, second level 501–2000, and third level >2000 childbirths in 1 year)[3,4].

Data of the LBWIs in the FBiH were collected from the available medical documentation, including canton of the childbirth, date and hour of birth, birth weight (in grams), birth length (in centimeters), gestational age (completed weeks of gestation), Apgar score (AS) at the first and fifth min, date, and hour of transfer to the neonatal facility, and PHI where the newborn was transferred to. The analysis covers the duration of hospitalization and the outcomes of the newborns.

For the purposes of this research, the levels of the PHI were defined according to the diagnostic and therapeutic possibilities, and according to the definition of the Association of Neonatologists of the FBiH from 2000[3]. The regional distribution of

Table 2

Number of births of low birth weight infants in first level of perinatal health care institution (PHI).

Live low birth weight infants *N* (%)	Not referred *N* (%)	Referred to 2nd level institution *N* (%)	Referred to 3rd level institution *N* (%)	Total referrals *N* (%)
102 (6.1)	29 (28.4)	73 (71.6)	27 (36.9)	100 (98)

Table 3

Number of births of low birth weight infants in second level of perinatal health care institution (PHI), primary and definitive care, and referred to third level PHI.

Live low birth weight infants *N* (%)	Primary care *N* (%)	Definitive care *N* (%)	Referred to 3rd level institution *N* (%)	Total referrals *N* (%)
213 (2.2)	186 (87.3)	127 (59.6)	59 (27.7)	86 (40.4)

maternity and neonatal units respected the current status of the organization and usual postnatal transport practice. In some cantons, there was only a maternity hospital without a neonatal institution, so that the place of birth and care for LBWIs were referred to a PHI by levels. The preferred time of transport was considered to be 4 h since birth[3,4].

Descriptive statistics, mean, SD, and coefficient of variation (CV) were used in the statistical analysis. Quantitative data were compared with the Mann–Whitney *U* test, and qualitative data were compared with the χ^2 test and the Fisher's exact test. A multiple regression analysis was used to compare the two dependent on one independent variable. Statistical significance was determined at the level of the difference of 0.05.

Results

During the investigated timeframe, a total of 22 897 offspring were delivered in the Federation of Bosnia and Herzegovina (FBiH), among which 669 infants (2.9%) exhibited a birth weight below 2500 g. Table 1 provides an overview of the overall childbirth percentages across various levels of Primary Health Institutions (PHIs), along with the corresponding proportion of LBWIs delivered and attended to at each level. Notably, 159 neonates from the first and second-level PHIs were referred to the third level. A statistically significant difference in the incidence of LBWI births was observed for both the first and second-level PHIs ($P < 0.0001$) and the second and third-level PHIs ($P < 0.0002$). The care capabilities for LBWI in first-level PHIs are delineated in Table 2, while the options for primary and definitive care of LBWI in second-level PHIs are explicated in Table 3.

Among infants born in second-level PHIs, 12.7% were directed to third-level PHIs, and an additional 59 LBWI experienced a deterioration in health status postprimary care, irrespective of their birth site. Out of the 159 referrals from second-level PHIs to third-level PHIs, 18.9% of LBWI received definitive care, while 23.7% were transferred from second-level to third-level PHIs. The majority of LBWI (76.8%) received definitive care in third-level PHIs (Table 4).

Among the 159 LBWI referred from first and second-level PHIs, only 31 (19.5%) were transported within 4 h, with the remaining 80.5% admitted to the third-level PHI after 4 h since birth (Table 5). This temporal discrepancy was statistically significant ($P < 0.0001$).

Table 4

Number of low birth weight infants that were born in and referred to a third level perinatal healthcare institution.

Live low birth weight infants *N* (%)	Definite care *N* (%)	Definitive care *N* (%)	Total referrals *N* (%)
354 (3.03)	27 (12.7)	132 (61.9)	159 (23.7)

In second-level PHIs, 30.4% of LBWI succumbed within the initial 12 h of life, whereas in third-level PHIs, 69.2% of LBWI passed away after 1 week (168 h) of life. According to our regression model, LBWI treated at third-level PHIs exhibited a 56% lower likelihood of mortality within 28 days of life [OR: 0.436, 95% CI (0.346–0.550), $P < 0.0001$].

Discussion

The majority of the examined studies focused on evaluating the influence of Perinatal Health Index (PHI) levels on birth outcomes, with limited consideration given to the impact on the therapeutic interventions for these patients. Among the scant literature available on the subject, studies that incorporated an examination of postnatal transport in the context of PHI levels and its effect on neonatal survival revealed a noteworthy reduction in mortality rates for transported patients. Notably, Carlo *et al*. conducted a study involving 71 689 newborns, wherein adequate transport was associated with a decrease in early neonatal mortality from 11.5 deaths per 1000 live births to 6.8 deaths per 1000 live births. This underscores the significance of staff training in achieving favorable outcomes[11]. Transportation is often undertaken to facilitate more precise diagnostics, necessitating advanced equipment at higher organizational levels of Perinatal Health Indices (PHIs), alongside enhanced education and expertise among healthcare professionals for specific diagnostic and/or therapeutic procedures[3,4]. The highest incidence of births occurred in the two largest cantons, Sarajevo and Tuzla, with the highest frequency of LBWI. A total of 669 LBWI were born at various levels of PHI in the Federation of Bosnia and Herzegovina (FBiH). At the first PHI level, 1651 (7.3%) newborns were delivered, with 29/669 (4.4%) exhibiting low birth weight. In the second PHI level, 41.6% of FBiH newborns were delivered, with 213 (2.2%) experiencing low birth weight, yet 286/669 (42.7%) received primary care. At the third PHI level, 51.1% of all FBiH newborns were delivered, and 354 exhibited low birth weight, with 513/669 (76.7%) receiving care. Regional disparities within the FBiH were identified, with a predominant proportion of births occurring at the third PHI level in Sarajevo and Tuzla, across all weight categories, except for the

Table 5

Time of transport of low birth weight infants to other perinatal healthcare institutions (PHI) in the Federation of Bosnia and Herzegovina.

Time from birth to admission to another PHI	Second level *N* (%)	Third level *N* (%)	Total
Less than 4 h	16 (59.26)	15 (11.36)	31 (19.5)
More than 4 h	11 (40.74)	117 (88.64)	128 (80.5)
Total	27 (100)	132 (100)	159 (100)

2000–2499 g category, where the majority were born at the second PHI level. Two potential explanations for regional variations in LBWI birth frequencies are posited. The first centers on differences in lifestyle rooted in biological and social distinctions within the region[13]. Secondly, research serves the purpose of identifying regions with notably high or low rates of LBWI[14]. Regrettably, our investigation revealed evidence suggesting that the regionalized system in the Federation of Bosnia and Herzegovina (FBiH) lags behind in structural organization when compared to more developed nations. Within the first month of life, encompassing the neonatal period up to 28 days, our study observed that 385 (57.5%) low birth weight newborns survived, while 284 (42.4%) succumbed. Notably, survival rates were highest in the subgroup receiving treatment at the third level of Perinatal Health Indices (PHI), reaching 43.6%. In contrast, survival rates for LBWI in the second PHI level were 13.9%, and in the first level, no survival was recorded. The observed difference in survival rates attained statistical significance only between LBWI treated in the first PHI level versus those treated in the second and third levels. Importantly, the disparity in survival rates across PHI levels demonstrated statistical significance in the overall sample.

With advancing gestational weeks, there is a corresponding increase in the likelihood of survival for newborns in the second level of Perinatal Health Indices (PHI). Notably, after 30 gestational weeks, the survival rate in the second level of PHI reaches 27.9%, thereby affirming our hypothesis[3].

In a study assessing the impact of perinatal health care regionalization on total perinatal mortality in 1989, Campbell *et al.* substantiated two hypotheses. Firstly, they posited that mortality would decrease more rapidly in smaller maternity hospitals as regionalization progressed. Secondly, perinatal mortality would be highest in large maternity hospitals due to the effects of regionalized perinatal care. Over a 6-year period, the study found that perinatal mortality experienced a more significant reduction in small maternity wards, thereby confirming both hypotheses[15]. Notably, perinatal mortality in large maternity hospitals at the end of the study period was lower than at the beginning but higher than that in small maternity hospitals.

The concept of 'critical mass' accentuates the significance of specialized care expertise for newborns, particularly those with Low Birth Weight (LBW), necessitating delivery in Perinatal Health Institutions (PHIs) equipped with advanced technology and staffed by experienced professionals. However, the establishment of an appropriate number of high-tech centers is contingent upon the healthcare resources available in the country. Therefore, the prenatal referral of infants to a third-level PHI should be closely aligned with their specific needs, mitigating the risk of third-level PHI saturation and associated unnecessary costs[16]. The second level is defined as the tier capable of caring for newborns beyond 32 weeks of gestation or with a birth weight exceeding 1500 g. Contrary to this definition, our findings reveal that some newborns as young as 32 weeks do not necessitate intensive care, provided antenatal mothers have received steroids and do not manifest severe hypertension, antepartum hemorrhage, or infection. Additionally, in Canada, neonatologist presence requirements are uniform across second and third levels, emphasizing the importance of staff maintaining requisite skills at both PHI levels for effective perinatal regionalization. However, it is imperative to acknowledge that 14.6% of infants receiving this level of treatment occasionally require a higher level of care[17].

The significance of perinatal health care regionalization has been underscored in numerous studies, a sentiment affirmed by our own research. Both antenatal transport 'in utero' and postnatal transport of newborns are integral components of perinatal care regionalization.

Conclusions

Based on world experience and assessment of the situation in FBiH, it is necessary to take measures to improve perinatal care and its regional organization. The mortality rate within 12 h in the second level PHI is high and the minority of newborns are referred in less than 4 h. The underlying reasons should be examined and the healthcare quality should be improved. In addition, the 1-week mortality rate in the third level PHI is high. The underlying reasons may be the delayed transfer of newborns from PHI of lower organizational levels or the actual healthcare at those institutions in snot satisfactory. The exact causes should be examined carefully and addressed.

Ethical approval

Ethical approval for this study (Ethical Committee of General Hospital Tešanj, IRB Approval ID: 02-09/2-77/20) was provided by the Ethical Committee of General Hospital Tešanj, Tešanj, Bosnia and Herzegovina on 20 March 2020.

Patient informed consent

Written informed consent was obtained from the patients' parents/legal guardians for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

A.C.: study design, supervision, and drafting of the original manuscript; E.N.: data collection, data analysis, and drafting of the original manuscript; D.H.: data collection, data entry, and drafting of the original manuscript; A.S.L.: supervision and reviewing the drafted manuscript; V.C.: supervision and reviewing the drafted manuscript; A.N.: data analysis and reviewing the drafted manuscript; E.Č., E.C., and R.H.: data collection; T.Z.: study design, supervision, and reviewing the drafted manuscript.

Conflicts of interests disclosures

All the authors declare that they have no conflicts of interest regarding the publication of this research paper.

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Data availability statement

The data are available from the corresponding author upon a reasonable request.

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