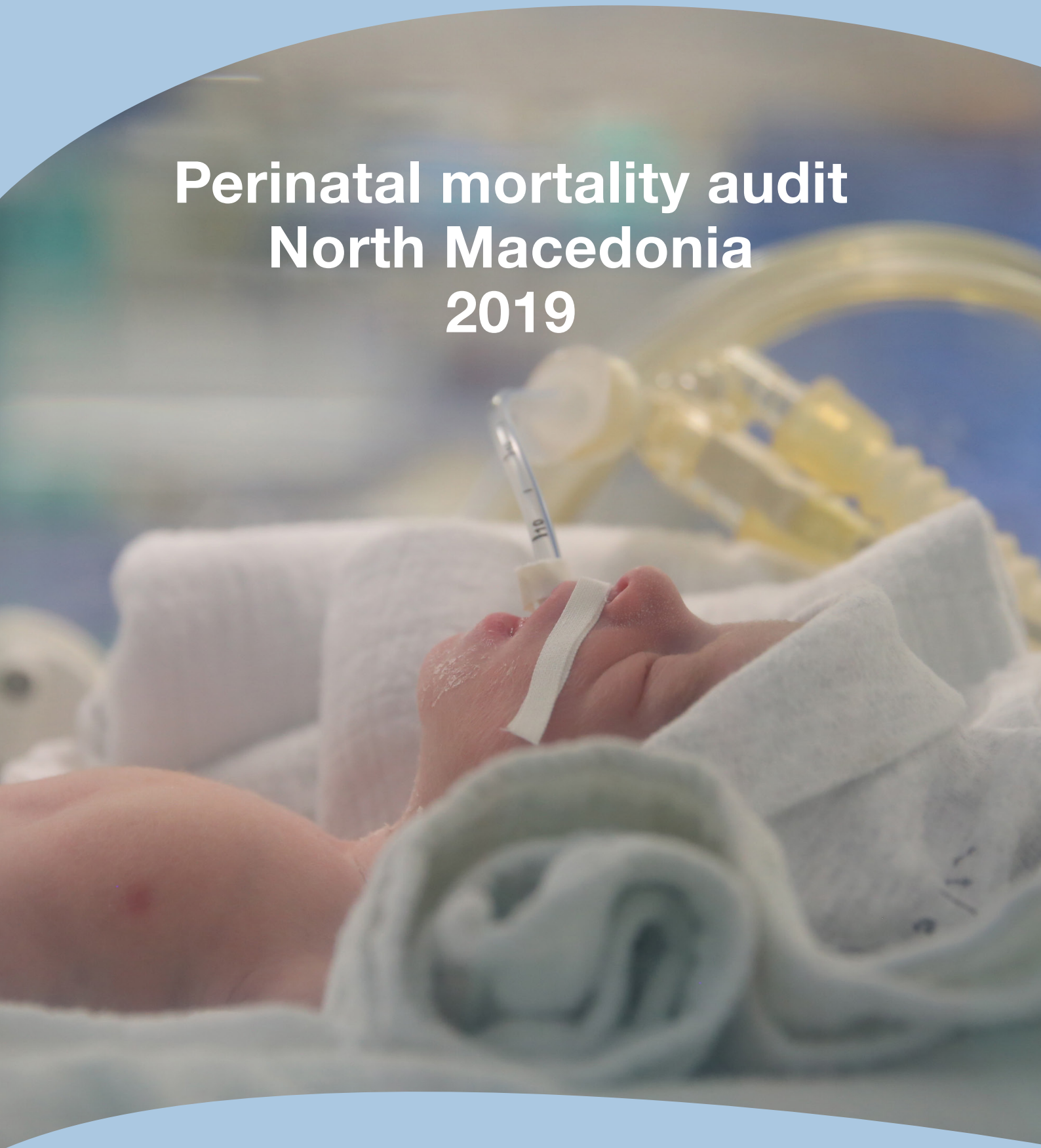
Perinatal mortality audit North Macedonia 2019



World Health Organization
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Ministry of Health

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Abstract

Many stillbirths and neonatal deaths can be prevented through evidence-based and timely interventions. In 2019, with the support of the WHO Regional Office for Europe and the United Nations Children's Fund (UNICEF), the Ministry of Health of North Macedonia established the Perinatal Mortality Review Committee and analysed all perinatal deaths that occurred in the country during 2019. The purpose of the review was to assign a cause of death, to ascertain the factors that contributed to the death and to identify any systemic issues that could be addressed to prevent future similar deaths.

The perinatal mortality audit process in 2019 provided important insights and evidence-based recommendations that can be used both to address system errors and barriers and to identify and praise points of strength. The aim is to provide recommendations for better care for mothers and their infants during pregnancy, childbirth and the neonatal period and improve the quality of care provided throughout the health system.

Keywords
DEATH REVIEW
PERINATAL AUDIT
NEONATAL DEATH
STILLBIRTH
QUALITY OF CARE
ANTENATAL CARE
NEONATAL CARE

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Contents

Foreword

Maternal and neonatal health is among the key priorities for North Macedonia. In the last three years, we have put in place a series of interventions that have contributed to achieving better pregnancy outcomes and saving babies' lives, including practical on-the-job training for effective perinatal care and rapid assessment of delivery facilities according to WHO's curricula and recommendations. We have introduced standardized procedures and provided equipment to delivery and neonatal facilities.

Nevertheless, the work continues to ensure high-quality care for mothers and their infants during pregnancy, childbirth and the neonatal period. For this reason, we established the National Working Group for Neonatal Mortality Audit, and I am very pleased to introduce the results of the first perinatal mortality audit in North Macedonia for the year 2019. This newly launched national report takes a deep dive into the data to provide important insights and evidence-based recommendations that will both help when dealing with system errors and barriers wherever they emerge and reinforce areas of strength. By counting the number of stillbirths and neonatal deaths, gathering information on where and why these deaths occurred and trying to understand the underlying contributory causes and avoidable factors, health care providers, programme managers, administrators and policy-makers can help to prevent future deaths and improve the quality of care provided throughout the health system.

We are grateful to have the continuous support and contribution of many national stakeholders and international partners in these efforts. In particular, we thank WHO, the United Nations Children's Fund and United Nations Population Fund, nongovernmental organizations, professional associations and health clinics and centres for their technical support.

We will keep working together to acquire more expertise and resources and to achieve our goal to end preventable maternal and perinatal deaths, no matter where mothers and newborns live. Our strong health workforce engagement, civil society, media and research institutions all play a role in creating and sustaining a social movement for prevention of maternal and newborn mortality.

Dr Venko Filipche, Minister of Health of North Macedonia

Acknowledgements

This report would not have been possible without the commitment and collaboration of many individuals, health institutions and organizations. In particular, the support of the Ministry of Health of North Macedonia, the United Nations Children's Fund, the Perinatal Mortality Review Committee and the WHO Regional Office for Europe is gratefully acknowledged.

Dr Nino Berdzuli, WHO Regional Office for Europe, coordinated and led the project. This included liaising with the Ministry of Health and promoting the importance of high-quality national data collection on stillbirths and neonatal deaths to identify the bottlenecks and gaps in the information and health care system in order to improve care via focused intervention and a subsequent reduction in perinatal mortality. She also led the technical discussions with national and the international consultants and guided the analysis, provided the necessary tools and technical guidelines, reviewed the report and the recommendations and made available all necessary resources for the process to be finalized.

The Minister of Health of North Macedonia, Dr Venko Filipche, and his colleagues at the Ministry of Health were crucial to the decision to start the process of perinatal mortality audit by forming the Perinatal Mortality Steering Committee, and for the leadership in making perinatal mortality data a cornerstone in improvement of the health care system to decrease the number of stillbirths and neonatal deaths in in the North Macedonia.

This work would not have been possible without the support of two international consultants. Dr Khatuna Lomauri, Neonatologist, Tbilisi State Medical University, Georgia, devoted her time to guiding the Perinatal Mortality Review Committee through the process of correct data collection and analysis. She also provided special education about the most important steps in the in-depth analysis and about coding causes of death using the International Statistical Classification of Diseases and Related Health Problems, 10th revision, and WHO's application of this classification to deaths during the perinatal period. Her role as an experienced neonatologist was crucial in transferring knowledge about the latest evidence-based medicine guidelines and protocols for analysis of early and late neonatal deaths and improving clinical care routines and processes in neonatal intensive care units to the members of the Perinatal Mortality Review Committee. Dr Nathalie Roos, Karolinska Institute, Stockholm, Sweden, contributed to the creation of the database for collecting the relevant information on each perinatal death, conducted the main analyses and wrote this report.

The offices of WHO and the United Nations Children's Fund and their representatives and coordinators Dr Jihanne Tawilah, Dr Margarita Spasenovska, Dr Patrizia di Giovanni and Dr Danche Gudeva are gratefully acknowledged for coordinating the process of introducing perinatal mortality audit nationally.

The Perinatal Mortality Steering Committee and the Perinatal Mortality Review Committee merit particular recognition for their time devoted to learning the process of perinatal data collection and the in-depth analyses of the selected data, as well as reviewing the report.

The members of the Perinatal Mortality Review Committee are Associate Professor Gligor Tofoski, Associate Professor Ana Daneva, Professor Katerina Stavric, Dr Tamara Voinovska, Dr Renata Dimitrievska, Associate Professor Elena Dzikova, Nagip Rufati, Associate Professor Florin Besimi, Dr Vlatko Girevski, Dr Sanja Ivanovska, Dr Mejlinda Azemi.

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- Clinical Hospital Tetovo
- Specialist Obstetrics Hospital “Mother Theresa”
- University Institute of Pathology
- Ministry of Health
- Agency for Accreditation of Health Institutions
- United Nations Children’s Fund
- United Nations Population Fund
- WHO Country Office in North Macedonia

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WHO Regional Office for Europe
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Abbreviations

AGA	appropriate for gestational age
ANC	antenatal care
BMI	body mass index
C-section	caesarean section
CRVS	civil registration and vital statistics
EU	European Union
EU13	the 13 countries joining the EU since 2004
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th revision
ICD-PM	WHO application of ICD-10 to deaths during the perinatal period
IUGR	intrauterine growth restriction
LGA	large for gestational age
NICU	neonatal intensive care unit
SGA	small for gestational age
SSO	State Statistical Office
UI	uncertainty interval
UNICEF	United Nations Children's Fund

Executive summary

The burden of stillbirths and neonatal deaths remains unacceptably high worldwide; a large proportion are preventable with the provision of high-quality, evidence-based and timely interventions. Knowing the true burden of deaths is important to create awareness of the problem, and to allow analysis of missed opportunities within health care systems and beyond. Analysing perinatal deaths may provide important insights and evidence-based recommendations to address system errors and barriers to receiving lifesaving interventions and high-quality care for mothers and their babies during pregnancy, childbirth and the neonatal period.

North Macedonia took an important step towards this goal in 2019. The process started by forming the Perinatal Mortality Steering Committee at the Ministry of Health. The decision was made to develop a mortality audit system by using the globally accepted methodology and tools for analysis of perinatal deaths set out by WHO guidance. Providing the available data and capturing the chain of events that led to a perinatal death, from both the maternal and perinatal sides, delivered valuable information; this will have a strong impact on the creation of future health programmes addressing needs for improving perinatal health. A network and database were established to obtain medical histories of all stillbirths and neonatal deaths in the country, as well as demographic factors and data on quality of care, antenatal interventions, the referral system, continuity of care and evidence-based medical interventions performed in the neonatal intensive care unit.

The analyses of the perinatal deaths identified and reviewed showed that quality of care in North Macedonia is suboptimal for pregnant women and during childbirth, postnatal and neonatal care. Information was lacking among providers of antenatal care on screening for several important maternal conditions, which is crucial to be able to formulate any strategies to improve outcomes. In addition, poor intrapartum care and birth asphyxia may be the reason for a large proportion of the term neonatal deaths. A relatively large proportion of stillbirths were delivered by caesarean section, and even by elective caesarean section. Reducing this number could improve outcomes for subsequent pregnancies in these women. The majority of the preterm cases before 32 weeks of gestation did not receive corticosteroids for lung maturation, and only one case received magnesium sulfate for protection of the brain against intraventricular haemorrhage. Providing corticosteroids and magnesium sulfate to pregnant women at high risk could substantially improve neonatal outcomes.

The majority of the referral cases were among neonates at term, who were referred after birth. This may represent a missed opportunity, as pre-referral stabilization might not be adequate, and transportation time could deteriorate underlying conditions. Early and timely use of surfactant reduces the risk of complications, increases the probability of survival and lowers the risk of complications. A significant proportion did not receive surfactant – in particular, the early neonatal death cases. In critically ill neonates, timely initiation and adequate inotropic support is essential to reduce poor outcomes. The analysis detected that a significant proportion of cases did not receive inotropic support. Essential newborn care is a package of interventions that should be given to all neonates to improve health outcomes; it includes thermal care, screening for temperature and breast feeding. Half of the neonates were not screened for hypothermia. These simple interventions, including thermal control, could be implemented easily and would improve outcomes for neonates.

1. Introduction

Perinatal mortality is an important indicator used in analysis of the functioning of a country's health system. Its value varies, depending on the joint work of several factors and the quantity and quality of health measures taken by authorities. Good and timely planning of health activities by implementing perinatal health strategies and action plans, availability of a network of relevant health institutions with adequate levels of care (equipment, personnel, transportation and so on) and ensuring standardization of health care (implemented and functioning guidelines, procedures and protocols) to ensure that every pregnant woman and every baby receive the best possible care during the sensitive period of pregnancy and early newborn days. This provides the best starting-point to ensure quality of life for the baby and the newly formed family.

North Macedonia took an important step towards providing important insights and evidence-based recommendations to address system errors and barriers to receiving lifesaving interventions and high-quality care for mothers and their babies during pregnancy, childbirth and the neonatal period. The process started by forming the Perinatal Mortality Steering Committee at the Ministry of Health. The decision was made to develop a mortality audit system by using the globally accepted methodology and tools for analysis of perinatal deaths set out by WHO guidance (see Annex 1 for a glossary of terminology used).

A network was established to obtain medical histories of all stillbirths and neonatal deaths in the country. These were needed to determine real numbers of perinatal deaths. They also provided further insight into specific mortality cases, which were used for in-depth analysis of health care interventions.

A database was created, determining several demographic factors and specific data concerning quality of care, antenatal interventions, the referral system, continuity of care and evidence-based medical interventions done in the neonatal intensive care unit, among others, which served as a basis for further analysis.

For the first time, classification of diagnoses and causes of death was undertaken, not only using the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10), but also using the WHO application of this to deaths during the perinatal period. This captures the time of perinatal death, uses a multilayered approach to classification of death and links the death to contributing maternal conditions.

Providing the available data and capturing the chain of events that led to a perinatal death, from both the maternal and perinatal sides, delivered valuable information, which will have a strong impact on the creation of future health programmes addressing needs for improving perinatal health. The process of perinatal mortality audit presented in this report will further help to improve the data collection system and interpretation of the data on perinatal mortality, and provide in-depth analysis of common factors influencing perinatal care.

2. Background

2.1. General background

Worldwide, it is estimated that 2.6 million stillbirths occur every year *(1, 2)* and 2.5 million babies die during their first month of life *(3)*. The burden of stillbirths and neonatal deaths remains unacceptably high; a large proportion are preventable with the provision of high-quality, evidence-based and timely interventions. Knowing the true burden of deaths is important to create awareness of the problem, and to allow analysis of missed opportunities within health care systems and beyond. Analysing perinatal deaths may provide important insights and evidence-based recommendations to address system errors and barriers to receiving lifesaving interventions and high-quality care for mothers and their babies during pregnancy, childbirth and the neonatal period.

Global initiatives such as the United Nations Sustainable Development Goals *(4)* and WHO's Global Strategy for Women's, Children's and Adolescents' Health 2016–2030 *(5)* and Every Newborn Action Plan *(6)* have set ambitious but achievable targets to reduce preventable stillbirths and neonatal deaths worldwide. To assist countries in reducing perinatal mortality by counting and reviewing each perinatal death, WHO developed an important guide outlining methodology and tools for developing a mortality system: *Making every baby count: audit and review of stillbirths and neonatal deaths (7)*.

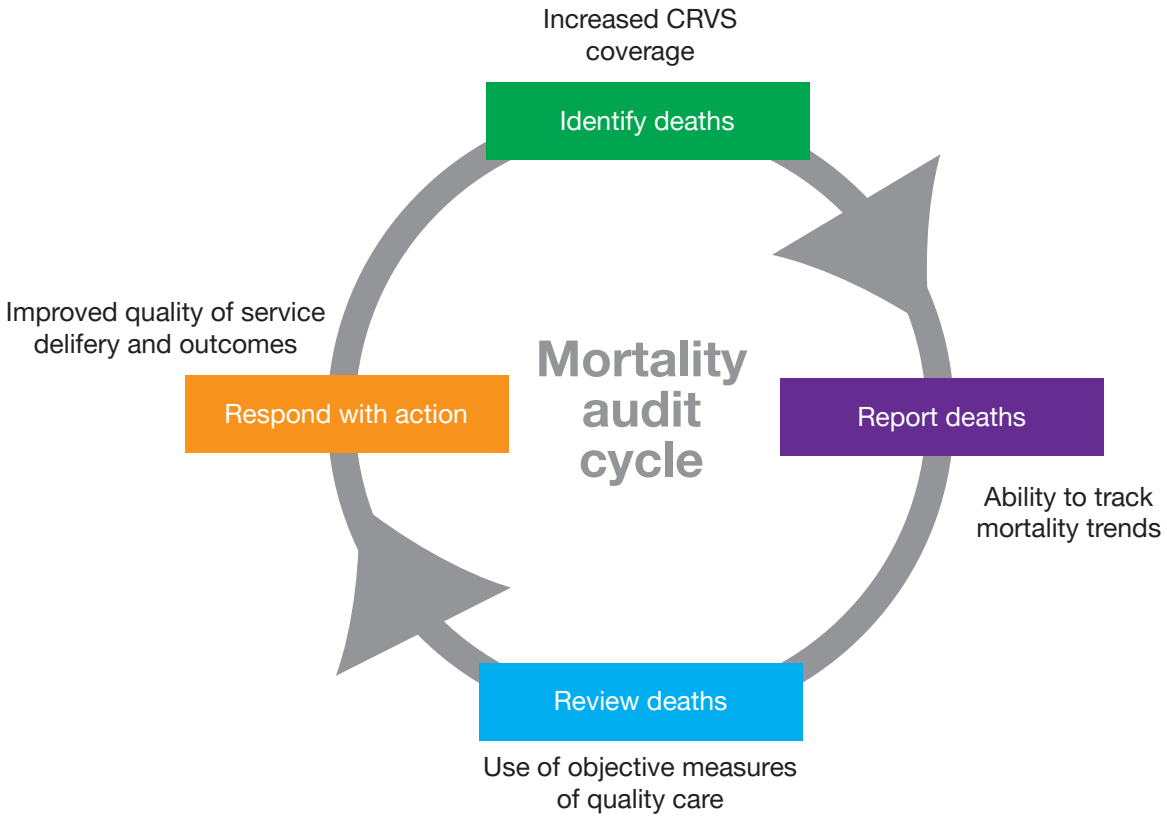
Between 1990 and 2017 the global neonatal mortality rate decreased by 51% (90% uncertainty interval (UI): 46%–54%); from 36.6 (UI: 35.5–37.8) deaths per 1000 live births in 1990 to 18.0 (UI: 17.0–19.9) deaths per 1000 live births in 2017. The estimated number of neonatal deaths during the same period decreased from 5.9 million (UI: 4.9 million–5.2 million) to 2.5 million (UI: 2.4 million–2.8 million). All regions reported reductions in neonatal mortality rates since 1990, and most regions accelerated progress in reducing neonatal mortality in 2000–2017 versus 1990–2000 *(8).*

Counting the numbers more accurately and gaining a better understanding of the causes and contributing factors of death are key to tackling the burden of millions of neonatal deaths and stillbirths. Many resource-poor settings lack effective civil registration and vital statistics (CRVS) systems for counting all births and deaths and assigning causes of death. Half of the world's babies do not currently receive a birth certificate, and most neonatal deaths and almost all stillbirths received no death certificate, let alone information on causes of death and contextual factors contributing to them *(9)*.

National estimates of numbers and causes of death are useful, but they do not tell the whole story *(8)*. Examination of individual cases provides underlying reasons why these deaths occurred and information about what needs to be done to prevent similar deaths in the future. The majority of stillbirths – particularly those that occur in the intrapartum period – and three quarters of neonatal deaths are preventable *(10)*.

Applying the audit cycle to the circumstances surrounding deaths can highlight breakdowns in clinical care at the local level, as well as breakdowns in processes at the district or national level, and may ultimately improve the CRVS system and quality of care overall (Fig. 2.1.1).

Fig. 2.1.1. Relationship between perinatal audit and the wider health care system, including CRVS systems and quality of care



Source: WHO *(7)*.

2.2. Perinatal health in North Macedonia

During the last 18 years, reductions in infant and perinatal mortality have varied from year to year in North Macedonia, but the overall trend has been downward. The trends in stillbirth and neonatal mortality reductions in other European country groupings are, however, steeper. Fig. 2.2.1 and Fig. 2.2.2 show the trends in North Macedonia, across the WHO European Region, in all European Union (EU) countries and in the 13 countries joining the EU since 2004 (EU13).

Fig. 2.2.1. Trends in estimates of neonatal mortality in North Macedonia and European country groupings, 1990–2018

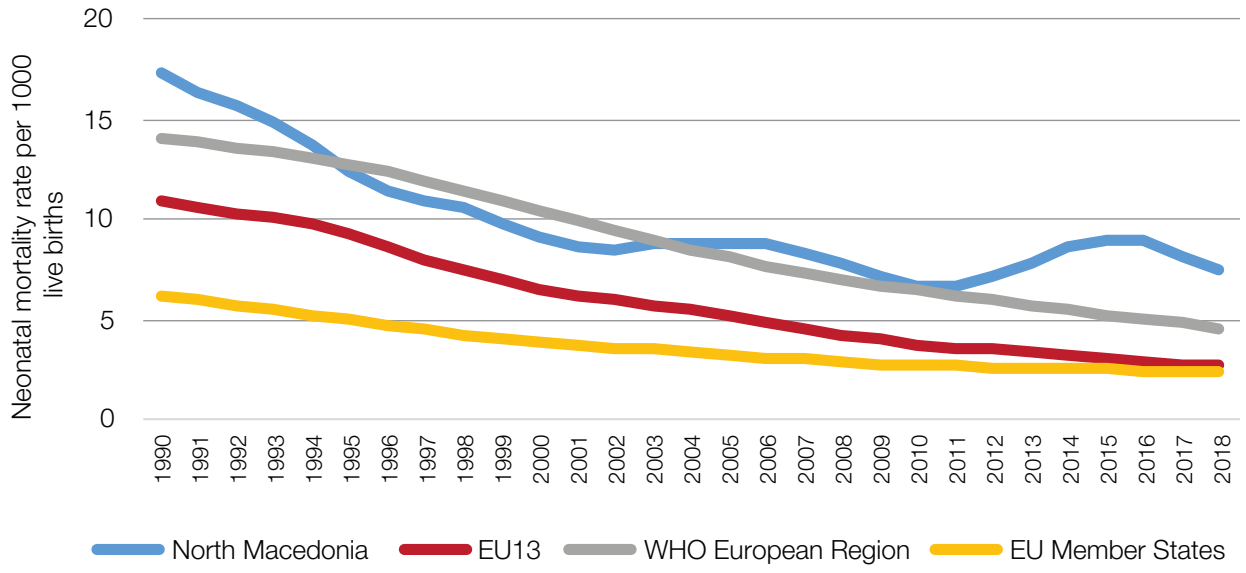
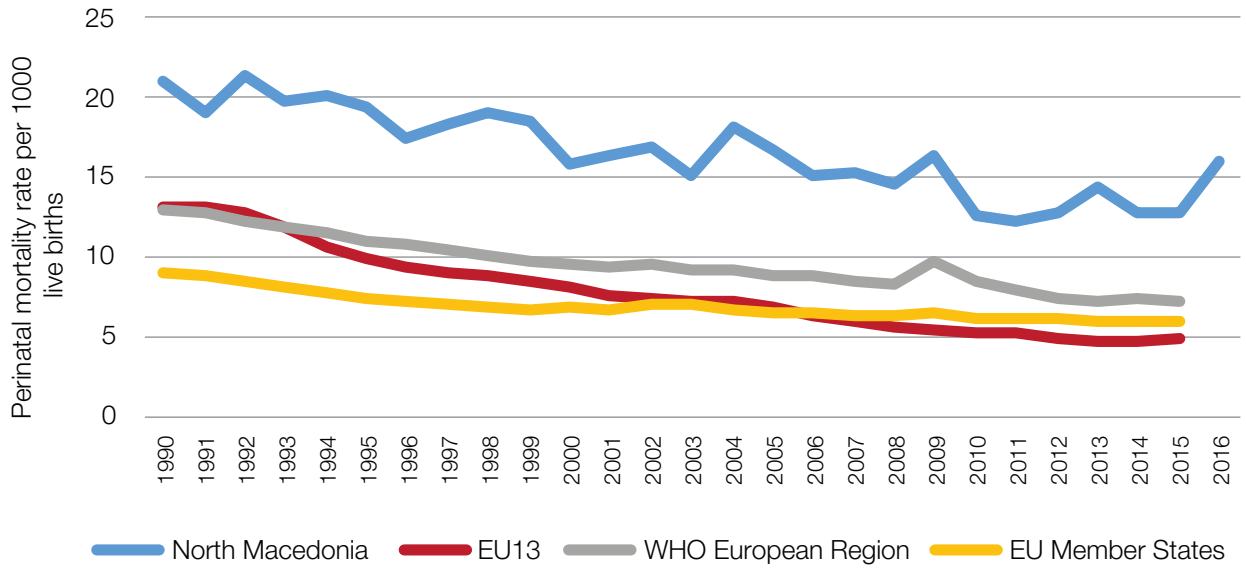


Fig. 2.2.2. Trends in estimates of perinatal mortality in North Macedonia and European country groupings, 1990–2018



2.3. North Macedonia health information system

In North Macedonia 99.5% of all deliveries take place in hospitals, which presents an opportunity for data collection on relevant health information related to perinatal mortality. Several systems of data collection are in place, and several attempts have been made to create a comprehensive data collection approach on indicators important for perinatal health and deaths, but none have been very effective. The limitations of the data collection system are described and analysed in more detail in section 2.5.

A framework is in place for institutionalizing efforts towards reducing stillbirth and neonatal mortality through audit and review of stillbirths and neonatal deaths. Chapter 5 of the country's national strategy on sexual and reproductive health for 2010–2020 *(11)* has specific goals addressing safe motherhood, and sets out a specific target to reduce the perinatal mortality rate, which includes several interventions and indicators (Table 2.3.1).

Table 2.3.1. Interventions and indicators to reduce perinatal mortality

Interventions	Indicators
• Enhancing the quality of perinatal care	• All women to deliver with professionals in attendance
• Strengthening the system of medical care for all high-risk neonates	• Maternal mortality rate to be less than 5 per 100 000 live births
• Strengthening the system of control over standards applied in delivery rooms and developing a system of accreditation of "mother- and baby-friendly hospitals"	• Perinatal mortality rate to be reduced by 30%
• Strengthening the system for reporting and analysing perinatal mortality rates at national and local levels	• 100% of hospitals to be accredited as "mother- and baby-friendly hospitals"

Source: Ministry of Health of North Macedonia *(11).*

In previous years, adequate measures have not been undertaken to strengthen the system for reporting perinatal mortality at national and local levels. To achieve the target to reduce perinatal mortality, it is imperative that data are collected at the national level and analysed in a timely manner to guide the formulation of effective policies and programmes. Timely collection and analysis would facilitate improvements in data collection, quality of care and accountability. To that end, establishing perinatal and neonatal death surveillance systems serves as an effective strategy: these could be used to monitor follow-up of every pregnant woman and assess how well the health targets are being achieved. The current national data reporting system does not establish whether all stillbirths and neonatal deaths occurring in an institution have been fully and promptly reported.

Existing information systems and reports on perinatal mortality in North Macedonia remain fragmented, with little opportunity to identify modifiable factors, health risks and essential information. Ascertaining a cause of death for stillbirths and neonatal deaths is challenging: misclassification and incorrect coding according to the ICD-10, are important contributors. A correct diagnosis often requires a skilled clinical health care provider and laboratory facilities. Even in more developed countries where such services and technology are available, difficulties in diagnosis persist, particularly for stillbirths and early neonatal deaths. To ascertain the correct cause of death for stillbirths and neonatal deaths, investigations that are unavailable in a particular clinic or in the country are often required.

The current health information system in North Macedonia cannot capture stillbirths and neonatal deaths to the fullest extent – in particular the distribution of mortality by time, birth weight and gestational age. Such stratification is essential in order to monitor perinatal health and develop a strategy for future activity at the national level.

2.4. Data sources and indicators

The Perinatal Mortality Review Committee was set up and received dedicated capacity-building training on the most important steps of the mortality audit cycle and coding of perinatal deaths, using materials published by the United Nations Children's Fund (UNICEF), from an international consultant *(12)*. It investigated the quality of the reported information on stillbirths and neonatal deaths and the availability of data through the national electronic database. It concluded that the information was insufficient for in-depth analysis of all the cases identified.

As a result, by ministerial order and under the supervision of the Ministry of Health, all hospitals with delivery rooms (state or privately owned) were mandated to appoint a technical officer tasked with reporting cases of stillbirth and neonatal death. This officer would send copies of the medical records to a designated person at the Ministry of Health every 15 days. This individual had to report and send the cases to the chair of the Perinatal Mortality Steering Committee. All stillbirths and neonatal deaths occurring ≥22 completed gestational weeks or with a birth weight of ≥500 g were included in the reports sent to the Perinatal Mortality Steering Committee. Antenatal care records were missing in large proportions of cases, and no permission could be obtained to request them.

In response, a database for case review of stillbirths and neonatal deaths with key variables suggested by the WHO Regional Office for Europe was developed. The database was reviewed, discussed and finalized by Committee members, with the support of the international consultants. All variables included in the database were based on other perinatal death databases. Classification of causes of perinatal deaths was made using the WHO application of ICD-10 to deaths during the perinatal period (ICD-PM) (see Annex 2 for the ICD-PM categories) *(13)*.

Establishing a system of adequate data collection is a challenging process, especially if more than just quantitative data is needed – such as qualitative information about the quality of care and health system bottlenecks. The data collection system should also facilitate collection of data for in-depth analysis of the potential causes of stillbirths and neonatal deaths.

This report is the starting-point for the national Perinatal Mortality Review Committee to set up a system to collect data regularly on perinatal deaths. The aim is to reduce mortality by improving care during pregnancy, the time around childbirth and the neonatal period. The objectives of this report are to:

- describe the methodology used to set up the national Perinatal Mortality Review Committee and a national programme for perinatal death reporting and review;
- describe the most common causes and contributing factors to perinatal deaths;
- make evidence-based recommendations for action to reduce perinatal mortality in North Macedonia.

A report will be generated on a yearly basis describing the trends, causes of death and contributing factors and will follow up on previous report for accountability.

The goal is to make recommendations that will be useful for programme planners/managers to develop strategies to strengthen the existing surveillance process and capitalize on the preventable nature of stillbirths and neonatal deaths, in order to reduce further the rates of stillbirths and neonatal mortality.

2.5. Limitations of the registration system

North Macedonia has several systems of data collection, and several attempts have been made to create a comprehensive data collection approach to perinatal health indicators and deaths, but none has yet been very effective or long-lived. Four institutions currently collect and/or analyse data related to perinatal mortality:

- the State Statistical Office (SSO)
- the Institute for Mother and Child Health
- the Electronic Health Directorate of the Ministry of Health (My Termin[1])
- the State Centre for Reproductive Health.

The principles of data collection and analysis also differ. The SSO gets the information from health institutions, which are obliged to report on a daily basis, using birth and death certificate forms. The SSO collects only basic data, and does not provide enough data for further in-depth analysis. Challenges include sometimes inadequate ICD-10 coding of deaths. Data collected by SSO are published every three months on the Office's webpage but this presents only numbers of stillbirths and infant deaths, without additional details.

Another challenge is gestational age information: these data are only collected from birth certificates and are not included in the death certificate. Data on gestational age are not systematically analysed; they are only reported to the Institute of Mother and Child Health.

The Institute of Mother and Child Health is part of the Health Centre, Skopje, but within its broader mandate and activities receives data from the SSO and Institute of Public Health. Data are analysed and an annual report is published

[1] "My Termin" translates as "my appointment" in English and is an electronic platform used by the primary health care system to book medical appointments for higher level of care; it can also be used as an electronic patient file by the primary health care system.

once a year. Due to the complicated data collection processes, the report is usually published in the second half of the following year, making it difficult to produce timely available data and information for actions.

My Termin collects data on pregnancy and the perinatal and neonatal periods, and has developed a set of instruments for data collection that should be completed electronically by the health institutions working in this field. The health information system of the Ministry of Health has developed a form for antenatal care to be completed by primary health care level gynaecologists. This is called the "electronic mother book", where all relevant data about the pregnancy and specific related examinations including screening tests, analyses and ultrasound exams should be entered; it can be used by health care workers at the secondary and tertiary care levels when delivery starts. The electronic mother book could be used to analyse perinatal deaths. Ideally, every woman should have a gynaecologist at the primary care level who is their first line of care, including during pregnancy.

In addition, the health information system collects data on stillbirths and neonatal deaths, which incorporates information about gestational age, treatment and therapies given, ICD-10 coding of conditions and date of neonatal death. Unfortunately, the electronic forms within the platform are not completed regularly with the necessary data. Very few of the primary care gynaecologists enter the information in either the electronic forms or the paper-based book.

The State Centre for Reproductive Health collects perinatal data from a set of appointed people (nurses) at the delivery rooms in hospitals, using an outdated MS-DOS system (originating from the 1990s), and does not perform any in-depth analyses on the collected data. The number of perinatal deaths ascertained through this method of collection differs from that collected through the SSO.

3. Methods

3.1. Setting up the national Perinatal Mortality Review Committee

Perinatal mortality rates in North Macedonia are higher than those of other European countries (see section 2.2). In order to understand the risk factors and contributory causes, and to create relevant health programmes and strategies, the Ministry of Health and relevant international partners (WHO, the United Nations Population Fund and UNICEF) decided to act.

Reducing perinatal mortality and discovering the potential numbers of preventable deaths in the perinatal period is not possible without assessing and collecting correct numbers about perinatal deaths. This information needs to be stratified according to time of death (antenatal, early or late neonatal death, birth weight and gestational age) and an in-depth analysis of the possible modifiable factors influencing the rates of perinatal and neonatal mortality needs to be conducted.

The Perinatal Mortality Steering Committee was formed by a ministerial order on 20 February 2019, with the task of analysing all stillbirths and neonatal deaths (over 22 gestational weeks and up to 29 days of life). Its aim was to identify possible systematic issues and modifiable factors in the country's health care provision, with the purpose of providing recommendations to improve this provision to influence perinatal mortality rate reductions at the national level.

The Perinatal Mortality Steering Committee is composed of an interdisciplinary team, including members with different expertise such as gynaecologists, neonatologists, paediatricians, midwifes, nurses, social workers, pathologists, epidemiologists, anaesthesiologists, public health specialists, representatives of the Ministry of Health and representatives UNICEF, the United Nations Population Fund and WHO.

To provide relevant professional and structural analysis, the Perinatal Mortality Review Committee consists of a team of highly motivated professionals (gynaecologists/obstetricians and neonatologists/paediatricians) from the Perinatal Mortality Steering Committee, as well as academics and clinicians. The Perinatal Mortality Review Committee is tasked

with collecting the data on perinatal deaths, collating it according to predefined variables and analysing it. The Perinatal Mortality Steering Committee has a supervisory and advisory role in the data collection and review processes.

The anonymized cases were analysed in depth periodically, under the supervision of a WHO-appointed international consultant. The final cause of death and modifiable factors were decided through consensus.

The findings of the Perinatal Mortality Review Committee were presented to the Perinatal Steering Committee on several occasions and discussed.

3.2. Data collection

The Perinatal Review Committee maintained a publicly available dataset from the SSO, which contains nationally representative empirical data relevant to perinatal mortality. Since the database was identified as having several deficiencies, case notes (medical records) represented a main source of information for the perinatal audits. Copies of case notes of stillbirths and neonatal deaths were sent to a designated person at the Ministry of Health every 15 days.

According to the standard in WHO's *Making every baby count: audit and review of stillbirths and neonatal deaths (7)*, all information on antenatal, obstetric and neonatal medical records, as well as transportation sheets (in the case of outpatient admission) must be reviewed and analysed. Such an approach helps to create a richer understanding of delays and modifiable factors.

All stillbirths and neonatal deaths identified during 2019 were entered in a predesigned database. The database and the variables were included in a consultative manner to ensure that maternal characteristics and information on risk factors during pregnancy, care during pregnancy, social factors and quality of neonatal care were included. Cases with severe malformation that led to induced abortion in the early stages of pregnancy were excluded, as these do not identify challenges in care for the mother or the newborn, and possible underlying causes are outside the scope of this review.

In addition to the qualitative data collection, an in-depth review was conducted of 34 cases, which provided a rich understanding of the issues in maternal and neonatal care, as well as the referral system. Such an approach helps to create a richer understanding of important delays and modifiable factors. The findings of this analysis are presented in a separate report.[2]

3.3. The perinatal mortality review meetings

A series of meetings of the Perinatal Mortality Steering Committee took place during 2019. The first two were part of a capacity-building programme organized by UNICEF on the methodology of audit and review of stillbirths and neonatal deaths. The subsequent meetings were set up to discuss the basic procedures of the Committee, the terms of reference of its members, the regulations for meetings and important decisions considering anonymization of data. These led to a consent form via which members agreed to keep data and cases discussed classified. During visits of the international consultant and WHO representatives, a joint meeting was organized with the members of the Perinatal Mortality Steering Committee to discuss the progress of the activity and share experiences.

Medical records were distributed to the members of the group: in cases of neonatal death the members with expertise in obstetrics and gynaecology analysed the antenatal records, and neonatologists/paediatricians analysed the medical history of the neonates in the postnatal period. In cases of stillbirth, medical records were given to the members with expertise in obstetrics and gynaecology.

All the health care interventions given to the mother or the neonate were analysed. Application of international or national (if available) standards of health care were assessed, as well as the existence of possible delays in providing adequate medical care.

All the data collected were entered in the predesigned database provided by WHO, for quantitative analyses. A summary of every analysed case was provided by the person undertaking the review; it was then analysed by the group, under the supervision of the international expert. This approach added additional capacity-building to all members of the group,

[2] WHO Regional Office for Europe, unpublished perinatal audit case review for North Macedonia, 2019.

giving them more knowledge about the structure of the process of in-depth analyses, especially with implementation of the ICD-PM classification to the perinatal death cases. The classifications and forms were taken from WHO's *Making every baby count: audit and review of stillbirths and neonatal deaths* and UNICEF's capacity-building package, which were then adapted by the national experts *(7, 14, 15).*

At the end of each review, a discussion took place with the coordinator and selected participants on their understanding of the objectives of having a review and their perception of its usefulness. Other details identified were any system changes that should be made as a result, follow-up mechanisms, the strengths and limitations identified in the surveillance system of stillbirths and neonatal deaths and modifiable factors and delays.

4. Results

During 2019, a total of 202 cases of perinatal death were identified from all the referral centres in North Macedonia. Detailed information about pregnancy, childbirth and the postpartum period was collected and is presented below. A subset of cases (n = 34) was reviewed in greater depth, generating detailed information about barriers and systematic issues that it was not possible to capture quantitatively. A report on the in-depth review of specific cases will be published separately.

4.1. Facilities and level of care

In North Macedonia, three institutions have a third level of care (tertiary care), with fully functioning neonatal intensive care units (NICUs): two state-owned (the University Clinic of Obstetrics and Gynaecology (54.5%; n = 109) and the University Clinic of Paediatrics (12.4%; n = 25)) and one private (Sistina; 7.4%; n = 15). The NICU unit at University Clinic of Obstetrics and Gynaecology accepts only internal referral of neonates from their delivery room, and many are in-utero transport referrals from secondary care hospitals. All other cases delivered in secondary care facilities are usually transferred to NICU at the University Clinic of Paediatrics.

In 2019 three tertiary care facilities and 11 secondary care facilities reported stillbirths and neonatal deaths (Table 4.1.1). The majority of the stillbirths and neonatal deaths took place in tertiary care facilities (73.8%; n = 149) which are referral centres and are thus expected to take more complicated cases and the majority of the deaths in tertiary facilities were neonatal deaths (93.6%; n = 102) (Table 4.1.2). It is worth noting that 26.2% (n = 53) of the deaths took place in secondary care facilities, where no neonatal intensive care is available, highlighting a possible issue of timely recognition of complications, pre-transport stabilization and transfer. The majority of the stillbirths and neonatal death cases (54.0%; n = 109) took place in the tertiary facility University Clinic of Obstetrics and Gynaecology.

Table 4.1.1. Facilities reporting stillbirths and neonatal deaths, and level of care, 2019

Facility name	Care level	Total N (%)
University Clinic for Gynecology and Obstetrics Skopje	Tertiary	109 (54.0)
University Clinic for Pediatrics Skopje	Tertiary	25 (12.4)
Clinical hospital of town of Tetovo	Secondary	16 (7.9)
Gynecology hospital "Mother Theresa"	Secondary	15 (7.4)
Private hospital "Sistina"	Tertiary	15 (7.4)
General hospital of town of Kumanovo	Secondary	4 (2.0)
General hospital of town of Gostivar	Secondary	4 (2.0)
General hospital of town of Shtip	Secondary	4 (2.0)
General hospital of town of Veles	Secondary	3 (1.5)
General hospital of town of Prilep	Secondary	3 (1.5)
General hospital of town of Kavadarci	Secondary	1 (0.5)
General hospital of town of Kichevo	Secondary	1 (0.5)
General hospital of town of Ohrid	Secondary	1 (0.5)
General hospital of town of Strumica	Secondary	1 (0.5)
Total	**–**	**202 (100.00)**

Table 4.1.2. Level of care among cases of stillbirth and neonatal death

Level of care	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Secondary	53 (26.2)	46 (49.5)	7 (6.4)
Tertiary	149 (73.8)	47 (50.5)	102 (93.6)
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**
Missing information		0	
P value[3]		<0.001	

Among the neonatal death cases, the majority of preterm birth cases (<37 gestational weeks) were cared for in a tertiary care facility (96.6%; n = 84) (Table 4.1.3).

Table 4.1.3. Level of care among cases of neonatal death, by prematurity

Level of care	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Secondary	7 (6.5)	3 (3.5)	4 (20.0)
Tertiary	100 (93.5)	84 (96.6)	16 (80.0)
Total	**107 (100.0)**	**87 (100.0)**	**20 (100.0)**
Missing information		2	
P value		0.022	

[3] The level of statistical significance is often expressed as a *P* value between 0 and 1. The smaller the *P* value, the stronger the evidence that there is a difference between the groups compared. Here Fisher's exact test is used.

4.2. Referrals

4.2.1. Referrals to higher levels of care

In total, 15.1% (n = 30) of the cases were referred to a higher level of care. Among the referred cases, 86.7% were neonatal deaths (n = 26/30). Cases that were not referred were admitted to secondary or tertiary care facilities directly (Table 4.2.1). Among the neonatal deaths in tertiary care facilities (with availability of NICU), the majority of the referred cases were preterm neonatal deaths (preterm 54.2% (n = 13/24) versus term 45.8% (n = 11/24)) (Table 4.2.2).

Table 4.2.1. Referrals among cases of stillbirth and neonatal death

Referral	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Admitted to secondary or tertiary care facility	169 (84.9)	89 (95.7)	80 (75.5)
Referred to secondary or tertiary care facility	30 (15.1)	4 (4.3)	26 (24.5)
Total	**199 (100.0)**	**93 (100.0)**	**106 (100.0)**
Missing information		3	
P value		<0.001	

Table 4.2.2. Cases of neonatal death in tertiary care facilities, by prematurity

Referral	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Admitted to tertiary care facility	80 (76.9)	68 (84.5)	9 (45.0)
Referred to tertiary care facility	24 (23.1)	13 (15.5)	11 (55.0)
Total	**104 (100.0)**	**84 (100.0)**	**20 (100.0)**
Missing information		5	
P value		<0.001	

4.2.2. Status at referral (in utero or born)

Most babies were transferred after they had been born (79.3%; n = 23). Very few were transferred in utero (Table 4.2.3). This is an important finding, because transport may pose a risk in itself.

Table 4.2.3. Status at referral among stillbirths and neonatal deaths

Status at referral	Total N (%)	Antepartum stillbirth N (%)	Intrapartum stillbirth N (%)	Early neo-natal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
In utero	6 (20.7)	2 (33.3)	1 (16.7)	2 (33.3)	1 (16.7)
Born	23 (79.3)	0 (0.0)	0 (0.0)	16 (69.6)	7 (30.4)
Total	**29 (100.0)**	**2 (6.9)**	**1 (3.5)**	**18 (62.1)**	**8 (27.6)**
No information of status			173		
P value			0.011		

4.2.3. NICU transfer

Transfer to NICU was carried out in 50% of the neonatal death cases (n = 99), in particular among preterm cases (83.8% versus 16.2%) (Table 4.2.4).

Table 4.2.4. Transfer to NICU among cases of neonatal death, by prematurity

NICU transfer	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
No	8 (7.5)	4 (50.0)	4 (50.0)
Yes	99 (92.5)	83 (83.8)	16 (16.2)
Total	**107 (100.0)**	**87 (81.3)**	**20 (18.7)**
Missing information		2	
P value		0.039	

4.2.4. Time to NICU transfer

Among the cases of neonatal deaths, four cases (4.0%) were not referred, although referral was warranted. It was more common to transfer preterm than term babies to the NICU within 24 hours (86.5% versus 13.5%) (Table 4.2.5).

Table 4.2.5. Time to NICU transfer among cases of neonatal death, by prematurity

Time to NICU transfer	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
≤24 hours	89 (89.0)	77 (86.5)	12 (13.5)
>24 hours	7 (7.0)	4 (57.1)	3 (42.9)
Not referred	4 (4.0)	2 (50.0)	2 (50.0)
Total	**100 (100.0)**	**87 (82.1)**	**19 (17.9)**
Missing information		9	
P value		0.037	

4.3. Maternal characteristics

Information on maternal characteristics such as age, parity (number of previous births), socioeconomic information (ethnicity, education, civil status, employment) and body mass index (BMI) can help to identify whether any specific groups are at higher risk of stillbirth or maternal death. For instance, maternal age, ethnicity and BMI (high and low) are risk factors for various adverse maternal and perinatal outcomes *(16–19)*.

4.3.1. Maternal age

Among the reviewed cases of perinatal death in North Macedonia in 2019, the median maternal age was 29 years and the mean 29.1 years; the range was 17–42 years. The majority of the women who had a stillbirth or neonatal death were between 25 and 34 years of age (59.4%; n = 120). There was no statistically significant difference in age distribution between women who had a stillbirth or neonatal death. Neither was there a difference in terms of having a preterm (<37 weeks) or term birth (≥37 weeks) (Table 4.3.1 and Table 4.3.2).

Table 4.3.1. Maternal age distribution among women who had a stillbirth or neonatal death

Maternal age	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
15–19 years	12 (5.9)	3 (3.2)	9 (8.3)
20–24 years	34 (16.8)	21 (22.6)	13 (11.9)
25–29 years	57 (28.2)	27 (29.0)	30 (27.5)
30–34 years	63 (31.2)	26 (28.0)	37 (33.9)
≥35 years	36 (17.8)	16 (17.2)	20 (18.4)
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**
Median maternal age		29 years	
Mean (min–max) maternal age		29.1 (17–42) years	
P value		0.194	

Table 4.3.2. Maternal age distribution among women who had a stillbirth or neonatal death, by prematurity

Maternal age	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
15–19 years	12 (6.0)	9 (6.0)	3 (6.0)
20–24 years	34 (17.0)	21 (14.0)	13 (26.0)
25–29 years	55 (27.5)	41 (27.3)	14 (28.0)
30–34 years	63 (31.5)	47 (31.3)	16 (32.0)
≥35 years	36 (18.0)	32 (21.3)	4 (8.0)
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**
P value	0.128		

4.3.2. Parity

The number of women who were nulliparous (no previous births) (51.0%; n = 102) and multiparous (one or more previous births) (49.0%; n = 98) was almost equal. The maximum number of previous births was 6 (n = 1). There was no statistically significant difference in terms of parity between the women who had had a stillbirth and those who had had a neonatal death (Table 4.3.3).

Table 4.3.3. Parity among women who had a stillbirth or neonatal death

Maternal parity	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Nulliparous	102 (51.0)	50 (54.8)	51 (47.7)
Multiparous	98 (49.0)	42 (45.2)	56 (52.3)
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**
Missing	2		
Median (min–max)		0 (0–6) births	
P value		0.325	

4.3.3. Ethnicity

The majority of the women were either Albanian (42.1%; n = 85) or Macedonian (39.6%; n = 80). A small Muslim minority of 0.5% was also part of the cohort. There was no statistically significant difference between the groups in terms of ethnicity and by type of death or prematurity or a preterm birth (Table 4.3.4 and Table 4.3.5).

Table 4.3.4. Ethnicity of women who had a stillbirth or neonatal death

Ethnicity	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Albanian	85 (42.1)	40 (43.0)	45 (41.3)
Macedonian	80 (39.6)	32 (34.4)	48 (44.0)
Romanian	24 (11.9)	13 (14.0)	11 (10.1)
Turkish	11 (5.6)	6 (6.5)	5 (4.6)
Muslim	1 (0.5)	1 (1.1)	0 (0.0)
Other	1 (0.5)	1 (1.1)	0 (0.0)
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**
P value		0.460	

Table 4.3.5. Ethnicity of women who had a stillbirth or neonatal death, by gestational age

Ethnicity	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Albanian	84 (42.0)	64 (42.7)	20 (40.0)
Macedonian	79 (39.5)	59 (39.3)	20 (40.0)
Romanian	24 (12.0)	17 (11.3)	7 (14.0)
Turkish	11 (5.5)	8 (5.3)	3 (6.0)
Muslim	1 (0.5)	1 (0.7)	0 (0.0)
Other	1 (0.5)	1 (0.7)	0 (0.0)
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**
P value		0.958	

4.3.4. Maternal education

The majority of the women who had a stillbirth or neonatal death had at least 10 years of formal education (68.0%; n = 72). Women who had a stillbirth had a lower number of formal years of education compared to women who had had a neonatal death (>12 years of education; 15.8% versus 40.8%) (Table 4.3.6).

Table 4.3.6. Maternal education in women who had a stillbirth or neonatal death

Years of formal education	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
No education	6 (5.7)	5 (8.8)	1 (2.0)
1–9 years	28 (26.4)	17 (29.8)	11 (22.5)
10–12 years	43 (40.6)	26 (45.6)	17 (34.7)
≥12 years	29 (27.4)	9 (15.8)	20 (40.8)
Total	**106 (100.0)**	**57 (100.0)**	**49 (100.0)**
Missing information		96	
P value		0.024	

When comparing education levels between women at term or preterm, there was a higher risk of prematurity (<37 weeks) in women with higher education (>12 years) (93.1% (n = 27/29) versus 6.9% (n = 2/29)) (Table 4.3.7).

Table 4.3.7. Maternal education in women who had a stillbirth or neonatal death, by gestational age

Years of formal education	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
No education	6 (5.7)	5 (6.3)	1 (3.9)
1–9 years	28 (26.4)	19 (23.8)	9 (34.6)
10–12 years	43 (40.6)	29 (36.3)	14 (53.9)
≥ 12 years	29 (27.4)	27 (33.8)	2 (7.7)
Total	**106 (100.0)**	**80 (100.0)**	**26 (100.0)**
Missing		96	
P value		0.038	

4.3.5. Maternal civil status

Most of the women were cohabiting with the baby's father (90.7%; n = 175). There was no statistical difference in civil status between the women who had a stillbirth or neonatal death (Table 4.3.8).

Table 4.3.8. Civil status of women who had a stillbirth or neonatal death

Civil status	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Cohabiting with the baby's father	175 (90.7)	78 (89.7)	97 (91.5)
Single	18 (9.3)	9 (10.3)	9 (8.5)
Total	**193 (100.0)**	**87 (100.0)**	**106 (100.0)**
Missing		9	
P value		0.804	

4.3.6. Maternal employment status

There was no statistical difference between women who had had a stillbirth or neonatal death in terms of maternal employment status: 39.4% (n = 54) of the women were employed at the time of the stillbirth or neonatal death. Unemployment was registered in 20.4% (n = 28) of the women (Table 4.3.9).

Table 4.3.9. Maternal employment status among women who had a stillbirth or neonatal death

Employment status	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Employed	54 (39.4)	20 (31.3)	34 (46.6)
Unemployed	28 (20.4)	15 (23.4)	13 (17.8)
Stay-at-home parent[a]	55 (40.2)	29 (45.3)	26 (35.6)
Total	**137 (100.0)**	**64 (100.0)**	**73 (100.0)**
Missing		65	
P value		0.188	

[a] The difference between an unemployed person and a stay-at-home parent is that an unemployed person is seeking a job, while a stay-at-home parent is not.

4.3.7. Risk factors for adverse pregnancy outcomes

It is important to screen for a number of risk factors during pregnancy to be able to introduce interventions to mitigate the risk of adverse outcomes for the mother and her infant. These include obesity (assessed via BMI), tobacco use, prenatal alcohol consumption and use of illicit drugs *(20–22)*.

For BMI, height and weight were registered for one woman only.

The majority of the women were non-smokers (87.6%: n = 148). There was no statistical difference between the groups of women who had a stillbirth or neonatal death in terms of smoking habits (Table 4.3.10).

Table 4.3.10. Smoking during pregnancy among women who had a stillbirth or neonatal death

Smoking during pregnancy	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Non-smoker	148 (87.6)	80 (87.9)	68 (87.2)
1–9 cigarettes/day	12 (7.1)	6 (6.6)	6 (7.7)
≥10 cigarettes/day	9 (5.3)	5 (5.5)	4 (5.1)
Total	**169 (100.0)**	**91 (100.0)**	**78 (100.0)**
Missing		33	
P value		1.000	

Information on alcohol use during pregnancy was available for 79.2% (n = 160) of the women and on drug use for 61.9% (n = 125): none of the women stated that they had used either alcohol or drugs during pregnancy.

4.4. Antenatal care

Antenatal care (ANC) can be defined as the care provided by skilled health professionals to pregnant women and adolescent girls in order to ensure the best health conditions for both mother and baby during pregnancy. The components of ANC include risk identification, prevention and management of pregnancy-related or concurrent diseases, health education and health promotion. WHO recently published a new ANC model, outlining an increased number of visits compared with the previous focused ANC model, with an emphasis on the content of care and on considering pregnancy a positive experience for the woman *(23).*

ANC reduces maternal and perinatal morbidity and mortality both directly, through detection and treatment of pregnancy-related complications, and indirectly, through identification of women and girls at increased risk of developing complications during labour and delivery, thus ensuring referral to an appropriate level of care. In addition, ANC provides an important opportunity to prevent and manage concurrent diseases through integrated service delivery *(24, 25)*.

4.4.1. Number of ANC visits

The majority of women (65.6%; n = 103) who had had a stillbirth or neonatal death in the reviewed cases had 5–8 ANC visits; 25.5% of the women (n = 40) had more than eight visits. There was no statistically significant difference between the women who had a stillbirth or a neonatal death in terms of number of visits (Table 4.4.1). Access to ANC services was therefore considered good. However, information transfer between ANC and the maternity clinic was scarce and hence important to be able to take preventive measure for HIV at birth, in case of an HIV-positive woman giving birth. There was no information collected on the content of care beyond screening for HIV and syphilis.

Table 4.4.1. Distribution of ANC visits among women who had a stillbirth or neonatal death

Number of ANC visits	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
0	2 (1.3)	2 (2.5)	0 (0.0)
1–4	12 (7.6)	4 (4.9)	8 (10.5)
5–8	103 (65.6)	58 (71.6)	45 (59.2)
>8	40 (25.5)	17 (21.0)	23 (30.3)
Total	**157 (100.0)**	**81 (100.0)**	**76 (100.0)**
Missing		45	
P value		0.122	

4.4.2. Number of ultrasound scans

WHO recommends at least one ultrasound during pregnancy for dating and a scan for congenital anomalies *(23).* In practice, many countries offer at least two scans, or more, depending on any pathology that may arise.

The majority of the women (90.4%; n = 141) had more than four ultrasound scans during their pregnancy. There was evidence of access issues to ultrasound scans, but overutilization may be possible (Table 4.4.2).

Table 4.4.2. Number of ultrasound scans during pregnancy among women who had a stillbirth or neonatal death

Number of ultrasound scans	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
0	2 (1.3)	2 (2.5)	0 (0.0)
2	1 (0.6)	1 (1.2)	0 (0.0)
3	4 (2.6)	2 (2.5)	2 (2.7)
4	8 (5.1)	4 (4.9)	4 (5.3)
>4	141 (90.4)	72 (88.9)	69 (92.0)
Total	**156 (100.0)**	**81 (100.0)**	**75 (100.0)**
Missing		46	
P value		0.731	

4.4.3. Routine screening for syphilis and HIV

Syphilis is a bacterial sexually transmitted infection caused by *Treponema pallidum*, which is transmitted through sexual contact, via blood transfusion or transplacentally from a pregnant woman to her fetus. Mother-to-child transmission of syphilis can, if undetected and untreated, give rise to congenital syphilis, which is associated with a high burden of mortality such as stillbirths, early and late neonatal deaths. In addition, congenital syphilis can also give rise to preterm birth, intrauterine growth restriction and long-term morbidity for the infant. The fetus can be easily cured with treatment, and the risk of adverse outcomes to the fetus is minimal if the mother receives adequate treatment during early pregnancy. The WHO sexually transmitted infection guideline recommends screening all pregnant women for syphilis during the first ANC visit; in pregnant women with early syphilis, it recommends benzathine penicillin intramuscularly *(26)*.

Mother-to-child transmission of HIV occurs when HIV is transmitted from a woman living with HIV to her baby during pregnancy, labour or delivery, or after delivery through breastfeeding. HIV infection of infants results in early mortality for many, or creates a lifelong chronic condition that greatly shortens life expectancy. Without treatment, approximately 15–30% of infants born to HIV-positive women will become infected with HIV during gestation and delivery, with a further 5–15% becoming infected through breastfeeding. To prevent mother-to-child transmission of HIV and reduce HIV-related infant mortality, WHO recommends effective access to HIV testing and counselling, initiation of lifelong antiretroviral therapy for mothers living with HIV, safe delivery practices, optimal infant feeding practices and access to postnatal antiretroviral prophylaxis for infants *(27)*.

Information on routine screening for infections such as HIV and syphilis was scarce. Screening is important to prevent mother-to-child transmission of both infections. In the database of stillbirths and neonatal deaths, details of syphilis screening status and syphilis treatment in the case of positive testing was unknown. Information on the HIV status of the pregnant woman was available for only 2.5% (n = 5) of the cases (Table 4.4.3).

The in-depth review of specific cases revealed a lack of information transfer between ANC clinics regarding HIV and syphilis status and treatment, which is a huge challenge for prevention of mother-to-child transmission.[4]

Table 4.4.3. Screening and treatment of syphilis and HIV during pregnancy among women who had a stillbirth or neonatal death

Screening and treatment of syphilis and HIV during pregnancy	N (%)
Syphilis screening	
Negative	0 (0.0)
Positive	0 (0.0)
Unknown	202 (100.0)
Syphilis treatment	
Yes	0 (0.0)
No	0 (0.0)
Unknown	202 (100.0)
HIV screening	
Negative	5 (2.5)
Positive	0 (0.0)
Unknown	197 (97.5)
HIV treatment	
Yes	0 (0.0)
No	3 (1.5)
Unknown	199 (98.5)

[4] WHO Regional Office for Europe, unpublished perinatal audit case review for North Macedonia, 2019.

4.4.4. Signs of intrauterine growth restriction detected during pregnancy

Intrauterine growth restriction (IUGR) is a sign of reduced placenta function and may be detected during ANC and symphysis-fundus measurements and/or prenatal ultrasound scans. Babies who are small for gestational age have a higher risk of stillbirth, antepartum hypoxia and development delays. Timely detection of IUGR and surveillance to plan for the optimal time for delivery reduces the risk of stillbirths *(28)*.

It was more common to detect IUGR during pregnancy among the cases of neonatal death than among the cases of stillbirth (78.8% (n = 26/33) versus 21.2% (n = 7/33)) (Table 4.4.4).

Table 4.4.4. Signs of IUGR among cases of stillbirth and neonatal death

Signs of IUGR	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Yes	33 (19.3)	7 (9.0)	26 (28.0)
No	138 (80.7)	71 (91.0)	67 (72.0)
Total	**171 (100.0)**	**78 (100.0)**	**93 (100.0)**
Missing information		31	
P value		0.002	

4.4.5. Decreased fetal movements during pregnancy

Decreased fetal movement during pregnancy may be a sign of a compromised fetus, due to poor placental function to deliver oxygen and nutrients. Women are therefore made aware during ANC that they should be vigilant for decreased fetal movements.

It was more common among women who had a stillbirth to report an episode of decreased fetal movements during pregnancy (71.4% versus 28.6%) (Table 4.4.5).

Table 4.4.5. Decreased fetal movements reported during pregnancy among cases of stillbirth and neonatal death

Decreased fetal movements during pregnancy	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Yes	14 (11.3)	10 (17.2)	4 (6.1)
No	110 (88.7)	48 (82.8)	62 (93.9)
Total	**124 (100.0)**	**58 (100.0)**	**66 (100.0)**
Missing information		78	
P value		0.085	

4.4.6. Pregnancy complications

The three most common complications during pregnancy were premature rupture of membranes (10.6%), hypertensive disorders (10.1%) and infections (9.8%). Among cases of neonatal death, premature rupture of membranes (13.7%) and hypertensive disorders (12.7%) were more common complications; among cases of stillbirth, infections were more common (13.7%) (Table 4.4.6).

Table 4.4.6. Pregnancy complications among women who had a stillbirth or neonatal death

Pregnancy complication	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
No complication	162 (45.4)	80 (49.7)	82 (41.6)
Premature rupture of membranes	38 (10.6)	11 (6.8)	27 (13.7)
Hypertensive disorders during pregnancy[a]	36 (10.1)	11 (6.8)	25 (12.7)
Infections[b]	35 (9.8)	22 (13.7)	13 (6.6)

Table 4.4.6. (contd)

Pregnancy complication	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Oligohydramnios	21 (5.9)	8 (5.0)	13 (6.6)
Other complications[c]	20 (5.6)	6 (3.7)	14 (7.1)
Placental abruption	15 (4.2)	7 (4.3)	8 (4.1)
Polyhydramnios	7 (2.0)	2 (1.2)	5 (2.5)
Multiple pregnancy[d]	6 (1.7)	4 (2.5)	2 (1.0)
Diabetes mellitus in pregnancy	6 (1.7)	5 (3.1)	1 (0.5)
Poor fetal growth	5 (1.4)	3 (1.9)	2 (1.0)
Anaemia during pregnancy	3 (0.8)	1 (0.6)	2 (1.0)
Placenta previa	3 (0.8)	1 (0.6)	3 (1.5)
Total	**357 (100.0)**	**161 (100.0)**	**197 (100.0)**
Missing information (unknown)	37		

Notes: Complications in this table were counted separately – i.e. one case can have more than one complication – hence the larger number than number of total cases.
[a] Hypertensive disorders include pre-pregnancy hypertension, pregnancy-induced hypertension and pre-eclampsia.
[b] The category "infections" is grouped to include other infections, amniotic sac infection and genitourinary tract infection.
[c] "Other complications" include prolonged pregnancy, hydrops fetalis (due to low case numbers) and rhesus isoimmunization.
[d] Multiple pregnancy includes twins and triplets.

5. Quality of intrapartum care

The time around birth is most dangerous for both the mother and her infant. It is therefore critical to the survival of women and their babies, as the risk of morbidity and mortality could increase considerably if complications arise. By providing timely high-quality care to women during childbirth, mortality and morbidity in women and their infants can be prevented *(1, 29)*.

5.1. Characteristics of labour

5.1.1. Onset of labour

Labour induction was more common among women who had a stillbirth than women who had a neonatal death (81.4% versus 18.6%) in the reviewed cases. Caesarean section (C-section) before the onset of labour was carried out more frequently among the neonatal deaths than the stillbirths (66.1% versus 33.9%). This can be explained by obstetrics practice of not performing a C-section unless the mother's or the infant's life is compromised.

In the case of an antepartum stillbirth, if the mother's health situation is stable, induction of labour is the best option to avoid uterine scarring and ensure safe future pregnancy and childbirth. In the cases of neonatal death, the C-section may have been carried out due to signs of intrapartum asphyxia (Table 5.1.1 and Table 5.1.2).

Table 5.1.1. Onset of labour among women who had a stillbirth or neonatal death

Onset of labour	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Spontaneous	89 (47.3)	38 (41.3)	51 (53.1)
Induced	43 (22.9)	35 (38.0)	8 (8.3)
C-section before onset	56 (29.8)	19 (20.7)	37 (38.5)

Table 5.1.1. (contd)

Onset of labour	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Total	**188 (100.0)**	**92 (100.0)**	**96 (100.0)**
Missing information		14	
P value		<0.001	

Table 5.1.2. Onset of labour among women who had a stillbirth or neonatal death, by gestational age

Onset of labour	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Spontaneous	88 (47.1)	66 (45.5)	22 (52.4)
Induced	43 (23.0)	33 (22.8)	10 (23.8)
C-section before onset of labour	56 (30.0)	46 (31.7)	56 (30.0)
Total	**187 (100.0)**	**145 (100.0)**	**42 (100.0)**
Missing information		15	
P value		0.636	

5.1.2. Mode of delivery

The majority of the cases were delivered vaginally (58.0%; n = 116). Stillbirths were mostly delivered vaginally (72.0%; n = 67) and neonatal deaths were delivered to a larger extent by C-section (53.3%; n = 57). Nevertheless, a significant proportion of the stillbirths were delivered by C-section (25.8%; n = 24) which could have health implications for the next pregnancy, and should therefore be avoided if possible. It makes sense to deliver a stillbirth vaginally to avoid unnecessary scarring of the uterus to decrease the risk of complications in future pregnancies (Table 5.1.3).

In addition, preterm babies were delivered by C-section more often than term babies (43.0%; n = 64), which may be explained by preterm infants being more vulnerable to labour and asphyxia (Table 5.1.4).

Table 5.1.3. Mode of delivery among women who had a stillbirth or neonatal death

Mode of delivery	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Vaginal	116 (58.0)	67 (72.0)	49 (45.8)
C-section	81 (40.5)	24 (25.8)	57 (53.3)
Vacuum extraction	3 (1.5)	2 (2.2)	1 (0.9)
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**
Missing information		2	
P value		<0.001	

Table 5.1.4. Mode of delivery among women who had a stillbirth or neonatal death, by gestational age

Mode of delivery	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Vaginal	115 (57.8)	85 (57.1)	30 (60.0)
C-section	81 (40.7)	64 (43.0)	17 (34.0)
Vacuum extraction	3 (1.5)	0 (0.0)	3 (6.0)
Total	**199 (100.0)**	**149 (100.0)**	**50 (100.0)**
Missing information		3	
P value		0.018	

5.1.3. Elective versus emergency C-section

Among women who had a stillbirth or neonatal death, childbirth by emergency C-section (13.5% versus 5.4%) or elective C-section (38.5% versus 20.7%) was more common among women who had a neonatal death. The majority of stillbirths were delivered vaginally, irrespective of spontaneous onset of delivery or labour induction (71.7%; n = 66). It is notable that 20.7% of the stillbirths (n = 19) were delivered by elective C-section, which may have consequences for subsequent pregnancies (Table 5.1.5).

Emergency (10.3% versus 7.1%) and elective (31.7% versus 23.8%) C-section was more common among women with a preterm infant (Table 5.1.6).

Table 5.1.5. Type of delivery among women who had a stillbirth or neonatal death

Delivery type	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Vaginal	111 (59.0)	66 (71.7)	45 (46.9)
Instrumental	3 (1.6)	2 (2.2)	1 (1.0)
Emergency C-section[a]	18 (9.6)	5 (5.4)	13 (13.5)
Elective C-section[b]	56 (29.8)	19 (20.7)	37 (38.5)
Total	**188 (100.0)**	**92 (100.0)**	**96 (100.0)**
Missing information		14	
P value		0.002	

[a] Emergency C-section is defined as spontaneous onset of labour or onset of labour through induction, but ends with a C-section.
[b] Elective C-section is defined as C-section before onset of labour.

Table 5.1.6. Type of delivery among women who had a stillbirth or neonatal death, by gestational age

Delivery type	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Vaginal	110 (58.8)	84 (57.9)	26 (61.9)
Instrumental	3 (1.6)	0 (0.0)	3 (7.1)
Emergency C-section[a]	18 (9.6)	15 (10.3)	3 (7.1)
Elective C-section[b]	56 (30.0)	46 (31.7)	10 (23.8)
Total	**187 (100.0)**	**145 (100.0)**	**42 (100.0)**
Missing information		15	
P value		0.026	

[a] Emergency C-section is defined as spontaneous onset of labour or onset of labour through induction, but ends with a C-section.
[b] Elective C-section is defined as C-section before onset of labour

5.2. Fetal heart sounds on admission

It is vital to examine a pregnant woman on admission to establish the presence of fetal heart sounds to know whether the baby is alive or whether health is compromised and a quick delivery through an emergency C-section is required. This is an important indicator of the quality of intrapartum care; it is recommended by WHO guidelines and in the WHO standards for improving quality of maternal and neonatal care in health facilities *(29, 30)*.

All but 14 of the women were examined on admission for fetal heart sounds (information unknown in four cases) (Table 5.2.1).

Table 5.2.1. Fetal heart sounds on admission among stillbirths and neonatal deaths

Fetal heart sounds on admission	Total N (%)	Antepartum stillbirth N (%)	Intrapartum stillbirth N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not indicated	92 (46.0)	85 (92.47)	2 (33.3)	3 (4.0)	2 (6.3)
Yes	94 (47.0)	2 (2.3)	4 (66.7)	61 (81.3)	27 (84.4)
Not examined	14 (7.0)	0 (0.0)	0 (0.0)	11 (14.7)	3 (9.4)
Total	**200 (100.0)**	**87 (100.0)**	**5 (100.0)**	**75 (100.0)**	**32 (100.0)**
Missing information			2		
P value			<0.001		

6. Infant characteristics

6.1. Sex

A slight majority of the stillbirths and neonatal deaths were male (53.7%; n = 108). There was no statistical difference between the groups that had a stillbirth or neonatal death in regard to sex distribution, or between male and female infants in terms of gestational age categories (Table 6.1.1 and Table 6.1.2).

Table 6.1.1. Distribution of infant sex, by type of death

Sex	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
Male	108 (53.7)	52 (56.5)	56 (51.4)
Female	93 (46.3)	40 (43.5)	53 (48.6)
Total	**201 (100.0)**	**92 (100.0)**	**109 (100.0)**
Missing information		1	
P value		0.481	

Table 6.1.2. Distribution of gestational age categories, by infant sex

Gestational age category	Total N (%)	Male N (%)	Female N (%)
Extremely preterm (<28 weeks)	60 (30.2)	29 (27.4)	31 (33.3)
Very preterm (28–31+6 weeks)	34 (17.1)	16 (15.1)	18 (19.4)
Moderately preterm (32–36+6 weeks)	55 (27.6)	36 (34.0)	19 (20.4)
Term (37–41+6 weeks)	48 (24.1)	25 (23.6)	23 (24.7)
Post-term (≥42 weeks)	2 (1.0)	0 (0.0)	2 (2.2)
Total	**199 (100.0)**	**106 (100.0)**	**93 (100.0)**
Missing information		3	
P value		0.152	

6.2. Growth measured at birth

Among the cases of stillbirth and neonatal death, the majority were classified as appropriate for gestational age (AGA) in terms of growth (67.7%; n = 130); 24.0% (n = 46) were classified as small for gestational age (SGA) and 8.3% (n = 16) as large for gestational age (LGA). Among preterm births, there was a non-significant higher proportion of SGA infants (25.9%; n = 37) compared to term births (18.4%; n = 9) (Table 6.2.1 and Table 6.2.2).

Table 6.2.1. Growth categories measured at birth among cases of stillbirth and neonatal death

Growth at birth	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)
LGA	16 (8.3)	8 (9.4)	8 (7.5)
AGA	130 (67.7)	56 (65.9)	74 (69.2)
SGA	46 (24.0)	21 (24.7)	25 (23.4)
Total	**192 (100.0)**	**85 (100.0)**	**107 (100.0)**
Missing information		10	
P value		0.821	

Table 6.2.2. Growth categories measured at birth among cases of stillbirth and neonatal death, by prematurity

Growth at birth	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
LGA	16 (8.3)	13 (9.1)	3 (6.1)
AGA	130 (67.7)	93 (65.0)	37 (75.5)
SGA	46 (24.0)	37 (25.9)	9 (18.4)
Total	**192 (100.0)**	**143 (100.0)**	**49 (100.0)**
Missing information		10	
P value		0.430	

7. Details of the stillbirths and neonatal deaths

7.1. Stillbirths and neonatal deaths by gestational age

The majority of the deaths were neonatal 54.0% (n = 109) and stillbirths made up 46.0% (n = 93) of the cases. Antepartum stillbirths were the largest group among the perinatal deaths (43.1%; n = 87) followed by early neonatal deaths (0–6 days) (37.5%; n = 76) (Table 7.1.1).

Table 7.1.1. Distribution of perinatal deaths according to time of death

Type of death	Proportion (%)	Number
Antepartum stillbirth	43.1	87
Intrapartum stillbirth	3.0	6
Early neonatal death (0–6 days)	37.6	76

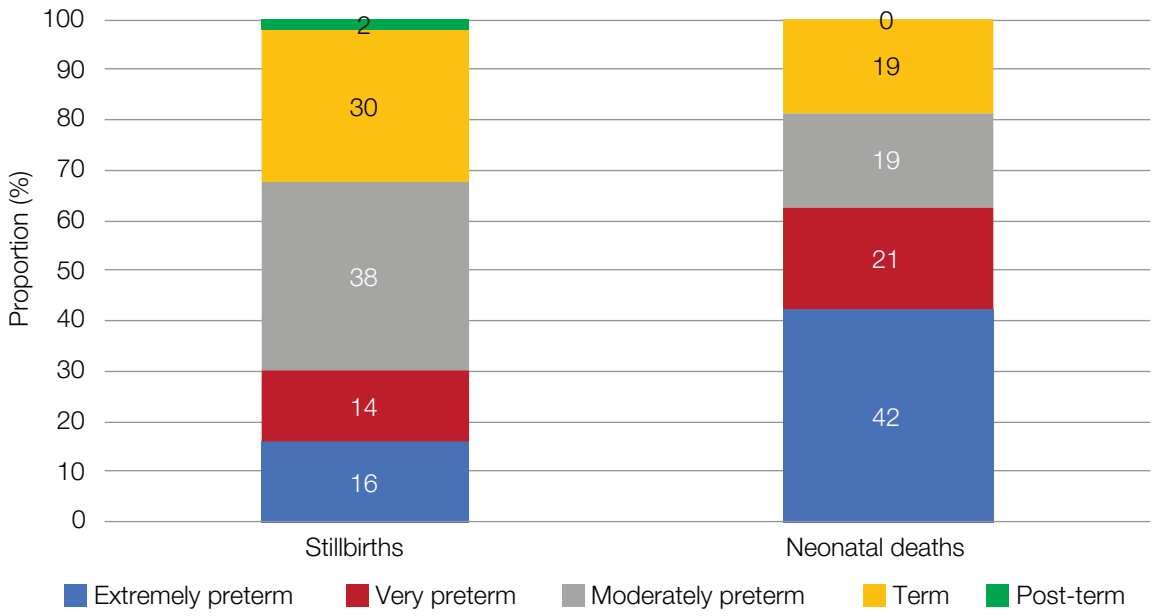
Table 7.1.1. (contd)

Type of death	Proportion (%)	Number
Late neonatal death (7–27 days)	16.3	33
Total	**100.0**	**202**
Missing information	0.0	0

The majority (75%; n = 150) of the stillbirths and neonatal deaths were preterm (<37 gestational weeks). Term births (≥37 weeks) and moderately preterm births (32–36+6 weeks) made up a significant proportion of all deaths 51.5% (n = 103). Among the term and moderately preterm groups, neonatal deaths accounted for 37.4% (n = 40) and stillbirths for 67.7% (n = 63) of the deaths.

Very preterm births (28–31+6 weeks) made up 20.6% (n = 22) of the cases of neonatal death; these require specific prevention strategies (including antenatal usage of corticosteroids and magnesium sulfate) and interventions (including administration of surfactant, thermal control and ventilation support) for survival. Extremely preterm births (<28 weeks) made up 42.1% (n = 45) of the cases of neonatal death; these require more complex interventions and higher levels of care (neonatal intensive care). Overall, neonatal mortality was higher among the very preterm and extremely preterm groups, while stillbirths occurred more often among the term and moderately preterm groups. The differences between the groups were statistically significant (Fig. 7.1.1).

Fig. 7.1.1. Distribution of gestational age categories by type of death

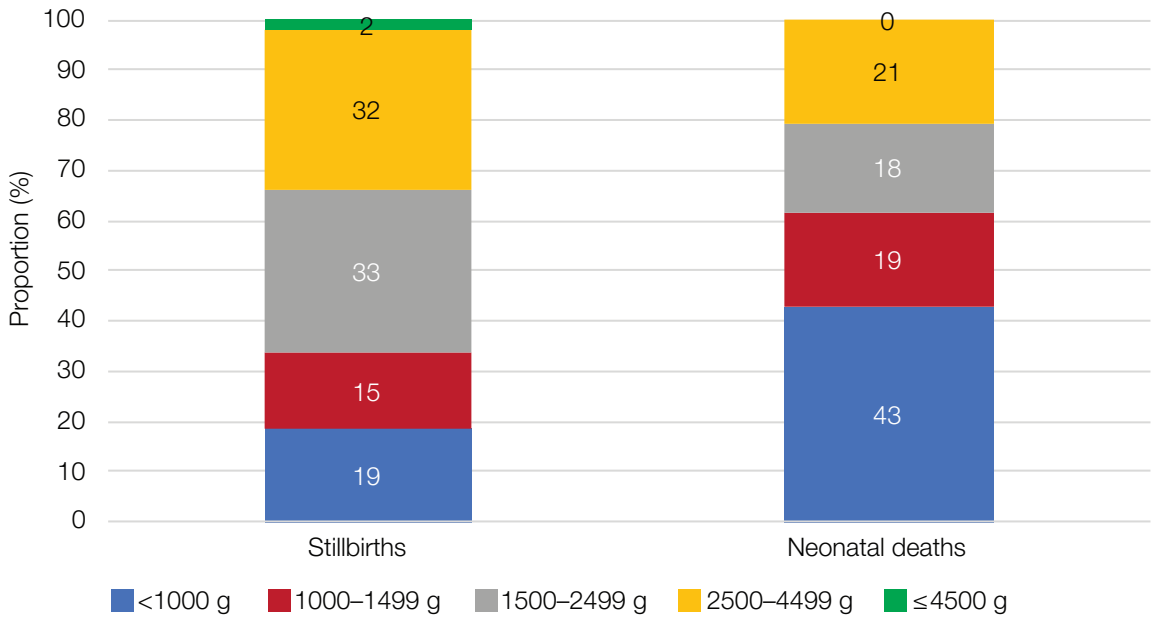


7.2. Stillbirths and neonatal deaths by birth weight category

Among the neonatal deaths, extremely low birth weight (<1000 g) and very low birth weight (1000–1499 g) made up 61.7% (n = 66) of all cases. These cases require a high level of neonatal intensive care and complex interventions to survive. Among the neonatal deaths, however, 20.6% (n = 22) were of normal birth weight (2500–4499 g), giving them a better of chance of survival with less complex interventions. Among stillbirths, the proportion with a birth weight >1500 g was 66.3% (n = 61).

In conclusion, a larger proportion of cases with low birth weight (below 1500 g) was seen among the neonatal deaths, while among stillbirths the birth weight was higher. This difference between the groups was statistically significant (Fig. 7.2.1).

Fig. 7.2.1. Distribution of birth weight categories by type of death



7.3. Timing of neonatal deaths after birth

A recent systematic review showed that one third of all neonatal deaths occur within the first 24 hours after birth, and 75% within the first week of life. Of those deaths occurring within 24 hours, 75% are due to birth asphyxia *(31)*.

A large proportion of neonatal deaths among the reviewed cases took place in the first 24 hours following birth (32.0%; n = 31). The majority of deaths took place within the first week of life (75.3%; n = 73), which is indicative of the first days being the most vulnerable ones for the neonate. It is worth noting that among the neonatal deaths at term, the majority of the deaths took place within 24 hours after birth (64.7%, n = 11). This could be an indication of poor intrapartum management (Table 7.3.1). See Annex 3 for a detailed summary of the 11 term neonatal death cases.

Table 7.3.1. Time after birth of neonatal deaths, by prematurity

Time	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
<24 hours	31 (32.0)	20 (25.0)	11 (64.7)
1–3 days	24 (24.7)	21 (26.3)	3 (17.7)
4–7 days	18 (18.6)	17 (21.3)	1 (5.9)
8–10 days	9 (9.3)	9 (11.3)	0 (0.0)
11–14 days	6 (6.2)	5 (6.3)	1 (5.9)
15–27 days	9 (9.3)	8 (10.0)	1 (5.9)
Total	**97 (100.0)**	**80 (100.0)**	**17 (100.0)**
P value		0.062	

7.4. Neonatal deaths by birth weight distribution

There was no statistical difference in terms of birth weight between early and late neonatal deaths (Table 7.4.1).

Table 7.4.1. Early and late neonatal deaths, by birth weight category

Birth weight category	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Extremely low birth weight (<1000 g)	46 (43.0)	34 (45.3)	12 (37.5)
Very low birth weight (1000–1499 g)	20 (18.7)	12 (16.0)	8 (25.0)
Low birth weight (1500–2499 g)	19 (17.8)	15 (20.0)	4 (12.5)
Normal birth weight (2500–4499 g)	22 (20.6)	14 (18.7)	8 (25.0)
Macrosomia (≥4500 g)	0 (0.0)	0 (0.0)	0 (0.0)
Total	**107 (100.0)**	**75 (100.0)**	**32 (100.00)**
Missing information		2	
P value		0.495	

7.5. Causes of neonatal death according to ICD-10

Among the neonatal deaths, the three most common causes according to ICD-10 classification were extreme immaturity (<28 weeks) (20.2%; n = 22); extremely low birth weight (<1000 g) (17.4%; n = 19); and hyaline membrane disease (15.6%; n = 17).

Among the early neonatal deaths, the most common causes of death were extremely low birth weight (<1000 g) (19.7%; n = 15); birth asphyxia (19.7%; n = 15); and hyaline membrane disease (15.8%; n = 12).

Among the term cases the most common cause of death was birth asphyxia (60.0%; n = 12); among preterm cases it was extreme immaturity (<28 weeks) (25.3%; n = 22) (Table 7.5.1 and Table 7.5.2).

Table 7.5.1. Causes of death according to ICD-10 classification, by early or late neonatal death

Main neonatal condition ICD-10 diagnosis	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Other	1 (0.9)	1 (1.3)	0 (0.0)
SGA	1 (0.9)	1 (1.3)	0 (0.0)
Extremely low birth weight <1000 g	19 (17.4)	15 (19.7)	4 (12.1)
Low birth weight 1000–2499 g	2 (1.8)	1 (1.3)	1 (3.0)
Extreme immaturity <28 weeks	22 (20.2)	13 (17.1)	9 (27.3)
Birth asphyxia	16 (14.7)	15 (19.7)	1 (3.0)
Hyaline membrane disease (respiratory distress syndrome)	17 (15.6)	12 (15.8)	5 (15.2)
Respiratory distress of newborn	16 (14.7)	12 (15.8)	4 (12.1)
Early-onset sepsis (within 3 days)	4 (3.7)	1 (1.3)	3 (9.1)
Late-onset sepsis (after 3 days)	5 (4.6)	1 (1.3)	4 (12.1)
Major malformation	6 (5.5)	4 (5.3)	2 (6.1)
Total	**109 (100.0)**	**87 (100.0)**	**20 (100.0)**
Missing information		0	

Table 7.5.2. Causes of death according to ICD-10 classification, by prematurity

Main neonatal condition ICD-10 diagnosis	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Other	1 (0.9)	0 (0.0)	1 (5.0)
SGA	1 (0.9)	1 (1.2)	0 (0.0)
Extremely low birth weight <1000 g	19 (17.8)	19 (21.8)	0 (0.0)
Low birth weight 1000–2499 g	2 (1.9)	2 (2.3)	0 (0.0)
Extreme immaturity <28 weeks	22 (20.6)	22 (25.3)	0 (0.0)
Birth asphyxia	15 (14.0)	3 (3.5)	12 (60.0)
Hyaline membrane disease (respiratory distress syndrome)	17 (15.9)	17 (19.5)	0 (0.0)
Respiratory distress of newborn	16 (15.0)	14 (16.1)	2 (10.0)
Early-onset sepsis (within 3 days)	3 (2.8)	2 (2.3)	1 (5.0)
Late-onset sepsis (after 3 days)	5 (4.7)	5 (5.8)	0 (0.0)
Major malformation	6 (5.6)	2 (2.3)	4 (20.0)
Total	**107 (100.0)**	**87 (100.0)**	**20 (100.0)**
Missing information	2		

7.6. Causes of stillbirths and neonatal deaths using ICD-PM classification

ICD-PM was one of the approaches used to classify stillbirths and neonatal deaths: this classifies deaths according to time of death (antepartum, intrapartum and early neonatal period; see Annex 2 for the details of the main categories). Although the database includes information on both early and late neonatal deaths (0–27 days), the ICD-PM classification presented in this section does not include the late neonatal deaths (n = 34).

Among the early neonatal deaths (n = 74), the most common cause was "N9 Low birth weight and prematurity" (40.1%; n = 30), followed by "N7 Respiratory and cardiovascular disorders" (29.7%; n = 22) and "N4 Complications of intrapartum events" (18.9%; n = 14) (Fig. 7.6.1).

Among the antepartum and intrapartum stillbirths (n = 93), the most common cause was "A6 Antepartum deaths of unspecified cause" (34.4%; n = 32), followed by "A3 Antepartum hypoxia" (23.7%; n = 22) and "A5 Disorders related to fetal growth" (17.2%; n = 16) (Fig. 7.6.2).

When stratifying by prematurity among all cases, the categories "A6 Antepartum death of unspecified cause" (18.9%; n = 23), "N7 Respiratory and cardiovascular disorders" (17.2%; n = 21) and "N9 Low birth weight and prematurity" (24.6%; n = 30) appeared to be the most common causes of death at <37 weeks of gestation.

The categories "A3 Antepartum hypoxia" (21.7%; n = 10), "N4 Complications of intrapartum events" (26.1%; n = 12) and "A6 Antepartum death of unspecified cause" (19.6%; n = 9) appeared to be the most common causes of death in the group born at term, according to ICD-PM classification (Table 7.6.1).

Fig. 7.6.1. Causes of death among early neonatal deaths (0–6 days), by ICD-PM classification

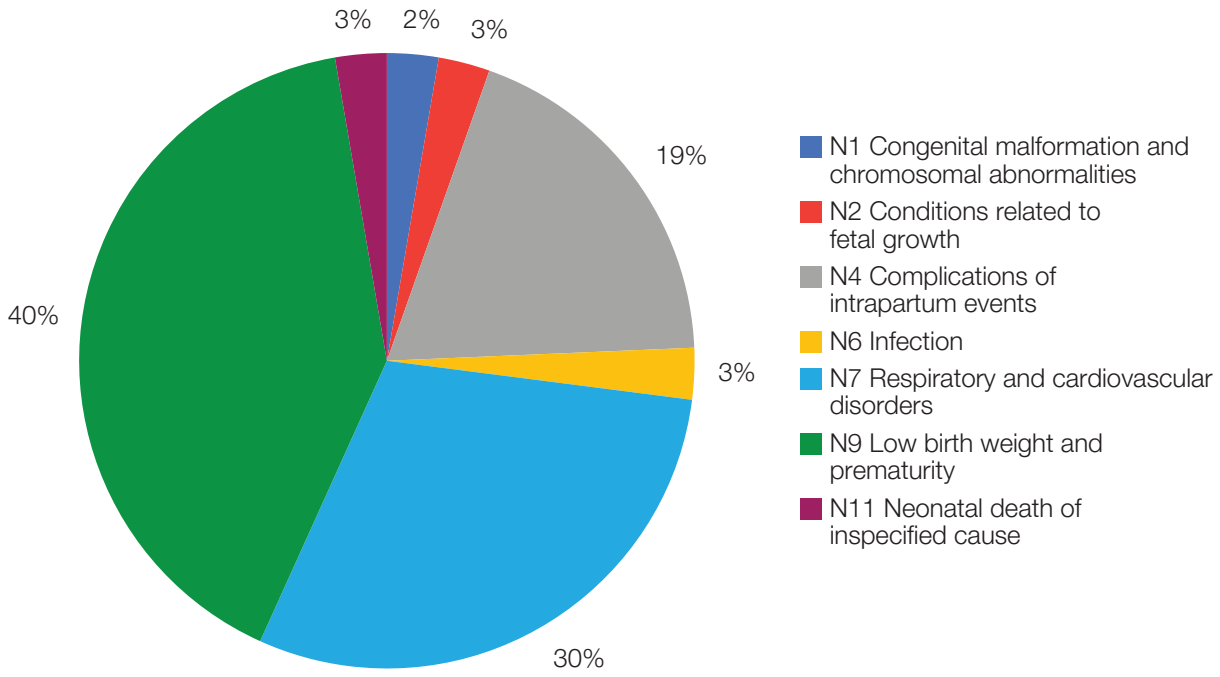


Fig. 7.6.2. Causes of death among antepartum and intrapartum stillbirths, by ICD-PM classification

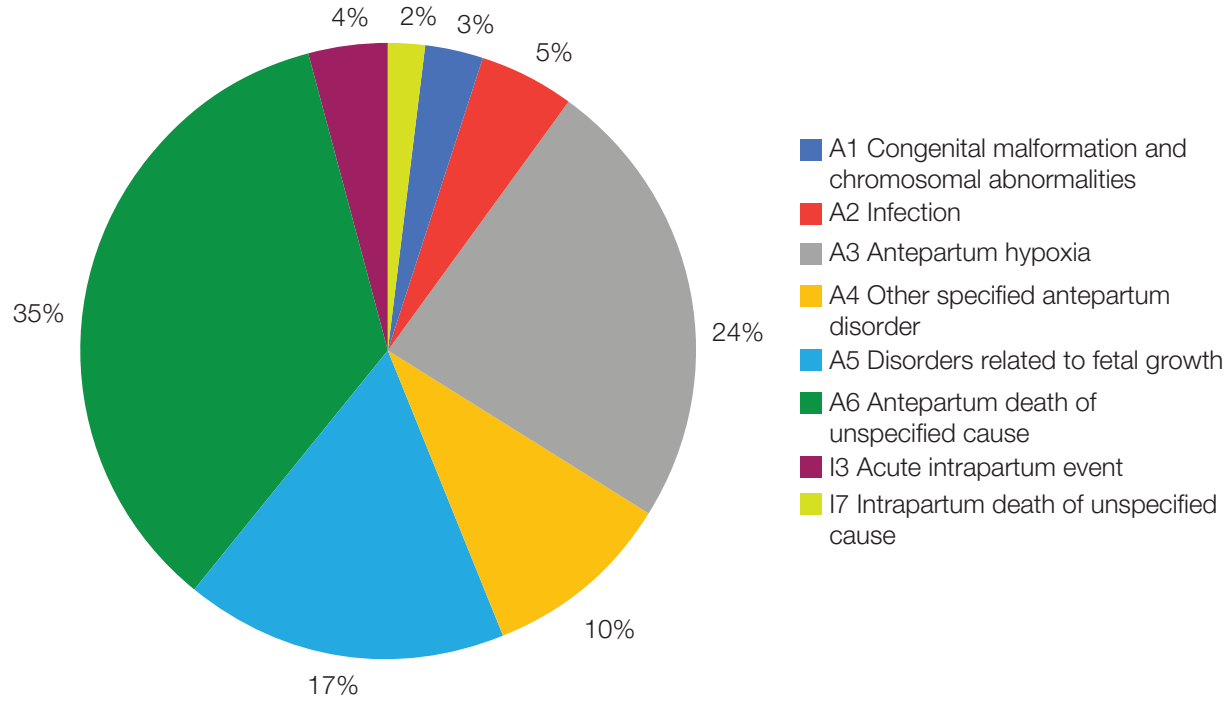


Table 7.6.1. Causes of death according to ICD-PM classification, by gestational age categories

ICD-PM category	Total N (%)	Very preterm (<32 weeks) N (%)	Moderately preterm (32–36 weeks) N (%)	Term (≥37 weeks) N (%)
A1 Congenital malformation and chromosomal abnormalities	4 (2.4)	2 (2.7)	1 (2.1)	1 (2.2)
A2 Infection	5 (3.0)	2 (2.7)	2 (4.3)	1 (2.2)
A3 Antepartum hypoxia	22 (13.1)	6 (8.0)	6 (12.8)	10 (21.7)
A4 Other specified antepartum disorder	9 (5.4)	2 (2.7)	6 (12.8)	10 (21.7)

Table 7.6.1. (contd)

ICD-PM category	Total N (%)	Very preterm (<32 weeks) N (%)	Moderately preterm (32–36 weeks) N (%)	Term (≥37 weeks) N (%)
A5 Disorders related to fetal growth	17 (10.1)	9 (12.0)	5 (10.6)	3 (6.5)
A6 Antepartum death of unspecified cause	32 (19.1)	7 (9.3)	16 (34.0)	9 (19.6)
I3 Acute intrapartum event	4 (2.4)	0 (0.0)	1 (2.1)	3 (6.5)
I7 Intrapartum death of unspecified cause	2 (1.2)	1 (1.3)	0 (0.0)	1 (2.2)
N1 Congenital malformation and chromosomal abnormalities	2 (1.2)	0 (0.0)	1 (2.1)	1 (2.2)
N2 Conditions related to fetal growth	2 (1.2)	1 (1.3)	1 (2.1)	0 (0.0)
N4 Complications of intrapartum events	14 (8.3)	1 (1.3)	1 (2.1)	12 (26.1)
N6 Infection	2 (1.2)	0 (0.0)	2 (4.3)	0 (0.0)
N7 Respiratory and cardiovascular disorders	22 (13.1)	14 (18.7)	7 (14.9)	1 (2.2)
N9 Low birth weight and prematurity	30 (17.9)	30 (40.0)	0 (0.0)	0 (0.0)
N11 Neonatal death of unspecified cause	1 (0.6)	0 (0.0)	0 (0.0)	1 (2.2)
Total	**168 (100.0)**	**75 (100.0)**	**47 (100.0)**	**46 (100.0)**
Missing information	34 (includes late neonatal deaths)			

When examining the causes of death according to birth weight category, among the stillbirths and neonatal deaths with a birth weight of <2500 g the most common causes were "N9 Low birth weight and prematurity" (24.4%; n = 30), "A6 Antepartum death of unspecified cause" (17.9%; n = 22) and "N7 Respiratory and cardiovascular disorders" (17.1%; n = 21) (Table 7.6.2).

Table 7.6.2. Causes of death according to ICD-PM classification, by birth weight category

ICD-PM category	Total N (%)	Birth weight <2500 g N (%)	Normal birth weight 2500–4499 g N (%)	Macrosomia ≥4500 g N (%)
A1 Congenital malformation and chromosomal abnormalities	4 (2.4)	3 (2.4)	1 (2.4)	0 (0.0)
A2 Infection	5 (3.0)	5 (4.1)	0 (0.0)	0 (0.0)
A3 Antepartum hypoxia	22 (13.2)	9 (7.3)	12 (28.6)	1 (50.0)
A4 Other specified antepartum disorder	9 (5.4)	5 (4.1)	4 (9.5)	0 (0.0)
A5 Disorders related to fetal growth	17 (10.2)	16 (13.0)	1 (2.4)	0 (0.0)
A6 Antepartum death of unspecified cause	31 (18.6)	22 (17.9)	8 (19.1)	1 (50.0)
I3 Acute intrapartum event	4 (2.4)	1 (0.8)	3 (7.1)	0 (0.0)
I7 Intrapartum death of unspecified cause	2 (1.2)	2 (1.6)	0 (0.0)	0 (0.0)
N1 Congenital malformation and chromosomal abnormalities	2 (1.2)	2 (1.6)	0 (0.0)	0 (0.0)
N2 Conditions related to fetal growth	2 (1.2)	2 (1.6)	0 (0.0)	0 (0.0)
N4 Complications of intrapartum events	14 (8.4)	3 (2.4)	11 (26.2)	0 (0.0)
N6 Infection	2 (1.2)	2 (1.6)	0 (0.0)	0 (0.0)
N7 Respiratory and cardiovascular disorders	22 (13.2)	21 (17.1)	1 (2.4)	0 (0.0)

Table 7.6.2. (contd)

ICD-PM category	Total N (%)	Birth weight <2500 g N (%)	Normal birth weight 2500–4499 g N (%)	Macrosomia ≥4500 g N (%)
N9 Low birth weight and prematurity	30 (18.0)	30 (24.4)	0 (0.0)	0 (0.0)
N11 Neonatal death of unspecified cause	1 (0.6)	0 (0.0)	1 (2.4)	0 (0.0)
Total	**167 (100.0)**	**123 (100.0)**	**42 (100.0)**	**2 (100.0)**
Missing information	35 (includes late neonatal deaths)			

7.7. Contributing maternal causes according to ICD-PM

Overall, maternal categories "M4 Maternal medical and surgical conditions" (27.0%; n = 54) and "M2 Complications of placenta, fetal chord and membranes" (24.5%; n = 49) were the most common. In the preterm group these were also the most common categories, while in the term group the categories "M5 No maternal condition" (34.0%; n = 17) and "M4 Maternal medical and surgical conditions" (22.0%; n = 11) were the most common (Table 7.7.1).

Among the low birth weight group, the categories "M4 Maternal medical and surgical conditions" (27.0%; n = 54) and "M2 Complications of placenta, fetal chord and membranes" (28.4%; n = 42) were the most common maternal conditions.

Table 7.7.1. Maternal conditions according to ICD-PM classification, by prematurity

ICD-PM category	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
M1 Maternal complications of pregnancy	41 (20.5)	32 (21.3)	9 (18.0)
M2 Complications of placenta, fetal chord and membranes	49 (24.5)	42 (28.0)	7 (14.0)
M3 Other complications of pregnancy and childbirth	13 (6.5)	7 (4.7)	6 (12.0)
M4 Maternal medical and surgical conditions	54 (27.0)	43 (28.7)	11 (22.0)
M5 No maternal condition	43 (21.5)	26 (17.3)	17 (34.0)
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**
P value	0.021		

The WHO application of ICD-10 to deaths during the perinatal period: ICD-PM *(13)* is a programmatically driven system designed to be used for all antepartum, intrapartum and early neonatal deaths. It contains meaningful groupings of ICD categories to enable both consistent application of ICD coding and rules, and analysis of that application to drive programmes aimed at reducing mortality. The features of ICD-PM enable it to link contributing maternal conditions with perinatal deaths and to identify the time of death – antepartum (before onset of labour), intrapartum (during labour but before birth) and early neonatal (up to day 7 of postnatal life).

The major causes of antepartum and neonatal deaths according to ICD-PM classification can be seen in Table 7.7.2. The major causes of antenatal death occurred among groups A6 (Antepartum death of unspecified cause) and M5 (No maternal condition) (n = 17). Among the early neonatal deaths, the major groups were N7 (Respiratory and cardiovascular disorders) and M2 (complications of placenta, fetal chord and membranes) (n = 9).

Table 7.7.2. ICD-PM tabulation for perinatal cause of death and maternal condition, by timing of death

ICD-PM category	M1	M2	M3	M4	M5	Total
Antepartum death						
A1 Congenital malformation and chromosomal abnormalities	0	0	0	2	2	4
A2 Infection	0	3	0	2	0	5
A3 Antepartum hypoxia	3	5	1	8	5	22
A4 Other specified antepartum disorder	5	3	0	1	0	9
A5 Disorders related to fetal growth	2	5	1	5	4	17
A6 Antepartum death of unspecified cause	4	4	0	7	17	32
Intrapartum death						
I3 Acute intrapartum event	2	0	1	1	0	4
I7 Intrapartum death of unspecified cause	0	0	1	1	0	2
Early neonatal death						
N1 Congenital malformation and chromosomal abnormalities	0	1	0	0	1	2
N2 Conditions related to fetal growth	1	1	0	0	0	2
N4 Complications of intrapartum events	6	3	3	0	3	15
N6 Infection	1	0	0	1	0	2
N7 Respiratory and cardiovascular disorders	4	9	0	7	2	22
N9 Low birth weight and prematurity	8	6	5	7	4	30
N11 Neonatal death of unspecified cause	0	0	0	0	1	1
Total	**36**	**40**	**12**	**42**	**39**	**169**
Missing information		35				

[a] ICD-PM only includes early neonatal deaths at 0–6 days of life; hence, the analysis is restricted to include only early neonatal deaths.
M1 = Maternal complications of pregnancy
M2 = Complications of placenta, fetal chord and membranes
M3 = Other complications of pregnancy and childbirth
M4 = Maternal medical and surgical conditions
M5 = No maternal condition

8. Quality of neonatal care

Complications of prematurity are the single largest cause of neonatal death globally *(32)*. Infant death and morbidity following preterm birth can be reduced through interventions provided to the mother before or during pregnancy, and to the preterm infant after birth. When preterm birth is inevitable, WHO recommends providing a set of interventions to the mother shortly before or during childbirth. These interventions are given to overcome lung immaturity (antenatal corticosteroids), infection susceptibility (intrapartum antibiotic prophylaxis in high-risk deliveries) and neurological complications (antenatal use of magnesium sulfate) *(33)*. In addition, other interventions such as early endotracheal installation of exogenous surfactant in neonates with respiratory distress syndrome may be beneficial *(34, 35)*.

8.1. Antenatal corticosteroids

Preterm infants' lungs are yet not mature and do not produce enough surfactant, which helps the lungs to expand and the infant to breathe. Corticosteroids are important for inducing lung maturation and improving lung function in preterm babies (24–34 gestational weeks) *(33)*. They are given to pregnant women at risk of imminent preterm labour, and have been proven to reduce the risk of death at birth and to prevent common prematurity-related complications, improving outcomes for preterm babies *(36, 37)*.

Most premature babies in the categories extremely preterm (<28 weeks) and very preterm (28–31+6 weeks) in the reviewed cases did not receive corticosteroid treatment to improve outcomes (88.0% and 90.0%) (Table 8.1.1).

Table 8.1.1. Corticosteroids given to women who had a stillbirth or neonatal death, by gestational age

Antepartum corticosteroids	Total N (%)	Extremely preterm (<28 weeks) N (%)	Very preterm (28–31+6 weeks) N (%)	Moderately preterm (32–36+6 weeks) N (%)	Term (37–41+6 weeks) N (%)	Post-term (≥42 weeks)
Not given	106 (66.3)	44 (88.0)	18 (90.0)	25 (54.4)	17 (40.5)	2 (100.0)
Given	17 (10.6)	6 (12.0)	2 (10.0)	8 (17.4)	1 (2.4)	0 (0.0)
Not indicated	37 (23.1)	0 (0.0)	0 (0.0)	13 (28.3)	24 (57.1)	0 (0.0)
Total	**160 (100.0)**	**50 (100.0)**	**20 (100.0)**	**46 (100.0)**	**42 (100.0)**	**2 (100.0)**
Missing information			42			
P value			<0.001			

8.2. Antenatal usage of magnesium sulfate

Preterm birth is one of the main risk factors for cerebral palsy – a leading cause of lifelong disability in children. Magnesium sulfate given prior to imminent preterm birth has been proven to be neuroprotective and reduce the risk of cerebral palsy *(38, 39).* The WHO recommendations on interventions to improve preterm birth outcomes recommend the use of magnesium sulfate for women at risk of imminent preterm birth before 32 weeks of gestation to prevent cerebral palsy in the infant *(33)*.

Only one patient received magnesium sulfate treatment for neuroprotection of the preterm infant in the reviewed cases.

8.3. Surfactant

Surfactant is produced in the alveoli of the lungs and prevents atelectasis (lung collapse) at the end of expiration by lowering surface tension. Respiratory distress syndrome is caused by a deficiency or dysfunction of pulmonary surfactant, which can be added during ventilation to reduce respiratory distress. Early administration is more efficient to reduce the risk of poor outcomes. The WHO recommendations to improve preterm birth outcomes recommend surfactant replacement therapy for intubated and ventilated neonates with respiratory distress syndrome *(33, 35)*.

A significant number of preterm neonates (<32 weeks) who were eligible to receive surfactant did not receive it (39.0%; n = 37). The data stratified by gestational age categories show that 34.9% (n = 13) of the neonates below 32 gestational weeks did not receive surfactant (Table 8.3.1). The in-depth review of specific cases demonstrated that the timing, dose and indication were not always in line with guidelines and protocols.

Among the early neonatal deaths, this difference was even greater: 47.7% (n = 31) did not receive surfactant to improve breathing (Table 8.3.2).

Table 8.3.1. Surfactant given directly after birth to neonates, by gestational age

Surfactant	Total N (%)	Extremely preterm (<28 weeks) N (%)	Very preterm (28–31+6 weeks) N (%)	Moderately preterm (32–36+6 weeks) N (%)	Term (37–41+6 weeks) N (%)
Not given	37 (39.0)	12 (28.6)	1 (6.3)	10 (55.6)	14 (73.7)
Given	55 (57.9)	30 (71.4)	15 (93.8)	6 (33.3)	4 (21.1)
Not indicated	3 (3.2)	0 (0.0)	0 (0.0)	2 (11.1)	1 (5.3)
Total	**95 (100.0)**	**42 (100.0)**	**16 (100.0)**	**18 (100.0)**	**19 (100.0)**
Missing information			14		
P value			<0.001		

Table 8.3.2. Surfactant given directly after birth to neonates, by timing of death

Surfactant	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not given	38 (39.2)	31 (47.7)	7 (21.9)
Given	56 (57.7)	33 (50.8)	23 (71.9)
Not indicated	3 (3.1)	1 (1.5)	2 (6.3)
Total	**97 (100.0)**	**65 (100.0)**	**31 (100.0)**
Missing information		12	
P value		0.019	

8.4. Antibiotics

Antibiotics were given in most of the cases in which they were indicated (91.0%; n = 91). The in-depth review of specific cases, however, revealed overuse of broad-spectrum antibiotics, frequent changes in treatment and no clear indication for antibiotic treatment. These issues can give rise to antibiotic resistance, hospital-acquired infections and sepsis. There was no statistical difference in antibiotic use between term and preterm babies (Table 8.4.1).

Table 8.4.1. Antibiotics given among early and late neonatal deaths

Antibiotics	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not given	9 (9.0)	9 (13.2)	0 (0.0)
Given	91 (91.0)	59 (86.8)	32 (100.0)
Total	**100 (100.0)**	**68 (100.0)**	**32 (100.0)**
Missing information		9	
P value		0.054	

8.5. Hypothermia screening within first hour

Neonatal hypothermia is defined as an abnormal thermal state in which the neonate's body temperature drops below 36.5 °C. Progressive reduction in body temperature leads to adverse clinical effects ranging from mild metabolic stress to death *(40)*. WHO recognizes thermal care as a critical and essential component of essential newborn care *(41)*. Neonatal hypothermia is a major contributory cause of significant morbidity and even mortality *(42)*, yet it remains underdocumented, underrecognized and undermanaged.

Neonates in general and preterm infants in particular are prone to excessive heat loss because they have a relatively large surface area in relation to body mass. It is therefore essential that all babies receive thermal care and screening to take timely corrective actions to maintain normal body temperature. Thermal care and screening are one of the main indicators for quality of care in the NICU.

Among the neonatal deaths in North Macedonia in 2019, thermal screening was not performed in more than half of the cases (53.1%; n = 26); this underlines the gap in quality of care for neonates. There was no statistical difference between early and late neonatal deaths, or between term and preterm infants (Table 8.5.1).

Table 8.5.1. Neonatal hypothermia screening among early and late neonatal deaths

Hypothermia screening	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not done	26 (53.1)	16 (51.6)	10 (55.6)
Done	21 (42.9)	14 (45.2)	7 (38.9)
Not indicated	2 (4.1)	1 (3.2)	1 (5.6)
Total	**49 (100.0)**	**31 (100.0)**	**18 (100.0)**
Missing information		61	
P value		0.890	

8.6. Inotropic support

Inotropic support is important when managing critically ill neonates, and preterm babies in particular. Proper approach of cardiovascular support based on disease pathophysiology is crucial for successful treatment *(43)*.

A significant proportion of the babies among the reviewed cases did not receive inotropic support (28.8%; n = 23), with a higher proportion among the early neonatal deaths compared to the late neonatal deaths (39.3% versus 4.2%) (Table 8.6.1). There was no difference across the gestational age categories in terms of not receiving inotropic support.

Among preterm babies, the extremely preterm (<28 weeks) (32.3%; n = 10), very preterm (29.4%; n = 5), moderately preterm (21.4%; n = 3) and term babies (29.4%; n = 5) did not receive inotropic support. The in-depth review of specific cases highlighted a lack of timely and adequate administration of inotropic support.

Table 8.6.1. Inotropic support given to early and late neonatal deaths

Inotropic support	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
1 drug given	39 (48.8)	28 (50.0)	11 (45.8)
2 drugs given	18 (22.5)	6 (10.7)	12 (50.0)
Not given	23 (28.8)	22 (39.3)	1 (4.2)
Total	**80 (100.0)**	**56 (100.0)**	**24 (100.0)**
Missing information		29	
P value		<0.001	

8.7. Neonatal resuscitation

Asphyxia is one of the three leading causes of neonatal mortality globally *(2)*. Neonates who survive birth asphyxia may have lifelong consequences such as cerebral palsy, epilepsy and learning disabilities *(44)*. Neonatal resuscitation has the potential to prevent perinatal mortality caused by intrapartum-related asphyxia in the critical first minutes after birth *(45)*. The Neonatal Resuscitation Program has been the standard of care for resuscitating neonates since 1987; it includes immediate, thorough and vigorous drying of every neonate, and provision of routine care (provision of warmth, delayed cord cutting and early initiation of breastfeeding) for babies who breathe spontaneously. For babies who do not breathe well after drying, providing more vigorous stimulation and, if needed, suction of mouth and nose are recommended. The final stage is to initiate and establish early and effective ventilation within the "golden first minute" *(46, 47)*.

Among the neonatal deaths in the reviewed cases, 11.1% (n = 10) did not receive resuscitation, despite needing it. There was no significant difference between early and late neonatal deaths (Table 8.7.1).

The various steps of the Neonatal Resuscitation Program include routine care (stage A), which was received by 10% (n = 9). Most babies received more advanced resuscitation, including ventilation with bag and mask (44.4%; n = 40). To be able to ventilate more effectively and for a longer period of time, intubation was carried out for neonates with severe asphyxia (31.1%; n = 28) (Table 8.7.2).

Table 8.7.1. Neonatal resuscitation among cases of neonatal death

Resuscitation	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not done	10 (11.1)	8 (12.7)	2 (7.4)
Carried out	77 (85.6)	53 (84.1)	24 (88.9)
Not indicated	3 (3.3)	2 (3.2)	1 (3.3)
Total	**90 (100.0)**	**63 (100.0)**	**27 (100.0)**
Missing information		19	
P value		0.873	

Table 8.7.2. Resuscitation approach among cases of neonatal death

Resuscitation	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not indicated	3 (3.3)	2 (3.2)	1 (3.7)
Not done	10 (11.1)	8 (12.7)	2 (7.4)
Only stage A	9 (10.0)	8 (12.7)	1 (3.7)
With bag and mask	40 (44.4)	26 (41.3)	14 (51.9)
With intubation	28 (31.1)	19 (30.2)	9 (33.3)
Total	**90 (100.0)**	**63 (100.0)**	**27 (100.0)**
Missing information		19	
P value		0.668	

8.8. Resuscitation staff

The majority of neonates were resuscitated by a neonatologist/paediatrician (94.4%; n = 84) and only a few cases were resuscitated by a midwife (1.1%; n = 1) (Table 8.8.1 and Table 8.8.2). Given that most births are attended by a midwife, this highlights unexploited potential to start early resuscitation by the midwife through task shifting.

Table 8.8.1. Staff category performing resuscitation among neonatal deaths

Resuscitation by staff category	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not applicable	2 (2.3)	2 (3.2)	0 (0.0)
Neonatologist/paediatrician	84 (94.4)	57 (91.9)	27 (100.0)
Anaesthesiologist	2 (2.3)	2 (3.2)	0 (0.0)
Midwife	1 (1.1)	1 (1.6)	0 (0.0)
Total	**89 (100.0)**	**62 (100.0)**	**27 (100.0)**
Missing information		20	
P value		1.00	

Table 8.8.2. Staff category performing resuscitation among neonatal deaths, by prematurity

Resuscitation by staff category	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Not applicable	2 (2.3)	2 (2.7)	0 (0.0)
Neonatologist/paediatrician	83 (94.3)	71 (96.0)	12 (85.7)
Anaesthesiologist	2 (2.3)	0 (0.0)	2 (14.3)
Midwife	1 (1.1)	1 (1.4)	0 (0.0)
Total	**88 (100.0)**	**74 (100.0)**	**14 (100.0)**
Missing information		21	
P value		0.057	

8.9. Invasive and non-invasive respiratory support

Some kind of respiratory support was given to most infants (94.9%; n = 93). In 5.1% of the cases (n = 5), respiratory support should have been given but was not (Table 8.9.1). Timely and proper initiation of respiratory support is essential for the survival of sick neonates with breathing difficulties *(48)*.

Table 8.9.1. Respiratory support among early and late neonatal deaths

Respiratory support	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not given	5 (5.1)	4 (6.1)	1 (3.1)
Invasive ventilation	56 (57.1)	36 (54.6)	56 (57.1)
Non-invasive ventilation	18 (18.4)	18 (27.3)	18 (18.4)
Invasive and non-invasive ventilation	19 (19.4)	8 (12.1)	19 (19.4)
Total	**98 (100.0)**	**66 (100.0)**	**32 (100.0)**
P value	< 0.001		

8.10. Apgar score at 5 minutes of age

The most routinely used measure of health status in neonates is the Apgar score; this is typically quantified at 1 minute and 5 minutes after birth, and sometimes at 10 minutes when the 5-minute Apgar score is low *(49)*. Low Apgar scores (especially scores of 0–3) at 5 minutes or 10 minutes are associated with substantially increased risks of mortality and asphyxia-related neonatal morbidity, and with long-term neurological outcomes *(50, 51)*.

In general, most babies in the reviewed cases had their Apgar scores measured. A low Apgar score of 3 or lower at 5 minutes of age was more common among early compared with late newborn deaths (36.6% versus 10.3%) (Table 8.10.1). This is logical, as early neonatal deaths are expected to be born with lower Apgar score. The database also includes information on Apgar scores at 1 minute and 10 minutes of birth; these are detailed in Annex 4 and Annex 3.

Table 8.10.1. Apgar score at 5 minutes of age among neonatal deaths

Apgar score at 5 minutes	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
0	1 (1.0)	1 (1.4)	0 (0.0)
1–3	29 (29.0)	26 (36.6)	3 (10.3)
4–7	53 (53.0)	32 (45.1)	21 (72.4)
8–10	15 (15.0)	10 (14.1)	5 (17.2)
Not measured	2 (2.0)	2 (2.8)	0 (0.0)
Total	**100 (100.0)**	**71 (100.0)**	**29 (100.0)**
Missing information		9	
P value		0.030	

8.11. Feeding practices

Breast milk and early and timely initiation of enteral feeding have beneficial effects for neonatal morbidity and survival *(52–54)*. This is especially true for preterm and low-birth-weight babies. Breast milk contains non-nutrient factors including immunoglobulins, lactoferrin and human milk oligosaccharides that promote intestinal adaptation and maturation; improve enteral feed tolerance; and protect against infective and inflammatory disorders. When no maternal milk is available to be given to the infant, formula feeding is an option, but formula-fed infants have a higher risk of developing necrotizing enterocolitis *(55)*.

The majority of the neonatal deaths in the reviewed cases did not receive breast milk in the NICU (95.1%; n = 58) (Table 8.11.1). Further, a large proportion of the neonates did not receive enteral feeding (74.7%; n = 68) (Table 8.11.2). Term neonates did not receive breast milk to a greater extent than preterm infants (85.7% versus 72.7%) (Table 8.11.3).

Table 8.11.1. Breast milk in the NICU among cases of neonatal death

Breast milk in the NICU	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Not given	58 (95.1)	43 (97.7)	15 (88.2)
Given	3 (4.9)	1 (2.3)	2 (11.8)
Total	**61 (100.0)**	**45 (100.0)**	**17 (100.0)**
Missing information		48	
P value		0.185	

Table 8.11.2. Enteral feeding among cases of neonatal death

Enteral feeding	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Never	68 (74.7)	57 (90.5)	11 (39.3)
Breast milk	3 (3.3)	1 (1.6)	2 (7.1)
Formula	18 (19.8)	5 (7.9)	13 (46.4)
Formula + breast milk	2 (2.2)	0 (0.0)	2 (7.1)

Table 8.11.2. (contd)

Enteral feeding	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)
Total	**91 (100.0)**	**63 (100.0)**	**28 (100.0)**
Missing information		18	
P value		<0.001	

Table 8.11.3. Enteral feeding among cases of neonatal death, by prematurity

Enteral feeding	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)
Never	68 (74.7)	56 (72.7)	12 (85.7)
Breast milk	3 (3.3)	2 (2.6)	1 (7.1)
Formula	18 (19.8)	18 (23.4)	0 (0.0)
Formula + breast milk	2 (2.2)	1 (1.3)	1 (7.1)
Total	**91 (100.0)**	**77 (100.0)**	**14 (100.0)**
Missing information		18	
P value		0.050	

9. Conclusions and key findings

The purpose of perinatal audits is to identify key systemic issues and barriers to adequate quality of care to prevent future similar deaths and avoid severe future morbidity in neonates. The processes and systems for perinatal death audits are similar to those used in the aviation industry: identifying systemic issues through quantification of errors and in-depth analysis.

The analyses of the perinatal deaths identified and reviewed showed that quality of care for pregnant women and during childbirth and postnatal and neonatal care in North Macedonia requires improvement to address suboptimal care that may lead to adverse outcomes.

- Information was lacking among providers of ANC on screening of several important maternal conditions that are crucial to detect during pregnancy to improve outcomes for infants, such as HIV, syphilis and BMI. Given the paucity of data on these conditions and interventions, it is not yet possible to formulate any strategies to improve outcomes. Improving access to ANC information is therefore an important recommendation.

- A large proportion of the neonatal deaths that died within 24 hours after birth were term neonates and received a diagnosis of birth asphyxia. This was most probably caused by poor intrapartum care and management. Intrapartum care needs to be improved to reduce the number of deaths among term and otherwise healthy neonates.

- A relatively large proportion of stillbirths were delivered by C-section, and even by elective C-section. Reducing this number could improve the outcomes for subsequent pregnancies in these women. In addition, most admissions to the delivery ward received an examination for fetal heart sounds, but a smaller proportion did not; this examination is crucial to establish whether the stillbirth occurred before the onset of labour or during labour.

- Antenatal prevention of complications related to prematurity (such as respiratory distress syndrome and intraventricular haemorrhage) includes provision of corticosteroids and magnesium sulfate to improve outcomes related to prematurity. The majority of the preterm cases before 32 weeks of gestation did not receive corticosteroids for lung maturation, and only one case received magnesium sulfate for protection of the brain against intraventricular haemorrhage. Providing corticosteroids and magnesium sulfate to pregnant women at high risk could substantially improve neonatal outcomes.

- The majority of the referral cases were among neonates at term, who were referred after birth. This may represent a missed opportunity, as pre-referral stabilization might not be adequate, and transportation time could deteriorate underlying conditions.

- The in-depth analysis of specific cases showed that the causes of death in the majority of cases were due to asphyxia in high-risk neonates with respiratory distress – in particular among premature babies – it is crucial to provide timely and adequate respiratory care, including early therapy with surfactant administration. Early and timely use of surfactant reduces the risk of complications, increases the probability of survival and lowers the risk of complications. A significant proportion did not receive surfactant – in particular the early neonatal death cases.

- In critically ill neonates, timely initiation and adequate inotropic support is essential to reduce poor outcomes. The analysis detected that a significant proportion of cases did not receive inotropic support.

- Essential newborn care is a package of interventions that should be given to all neonates to improve health outcomes; it includes thermal care, screening for temperature and breast feeding. Half of the neonates were not screened for hypothermia. These simple interventions, including thermal control, could be implemented easily and would improve outcomes for neonates.

- It is crucial that neonatal resuscitation is initiated in a timely manner and according to recommendations from the American Heart Association. In most cases, the neonatologist or paediatrician was responsible for resuscitation, but a proportion of neonates did not receive resuscitation. Continuous capacity-building, including a refresher training course on performing initial resuscitation, is essential.

In summary, high-quality prematurity care requires complex interventions, equipment, coordination, resources and staff capacity. Thus, the biggest gains to reduce the number of stillbirths and neonatal deaths can be made among the term and moderately preterm babies with simple interventions during pregnancy and antenatal and intrapartum care to improve the quality of care for term or moderately preterm babies.

In addition, the in-depth analysis of 34 cases of stillbirth and neonatal death showed important shortcomings in the provision of care and referral procedures, which it was not possible to capture in detail within this report.

10. Next steps

This is the first report by the Perinatal Mortality Review Committee established in North Macedonia in 2019. The report highlights important challenges and gaps in the quality of care across pregnancy, childbirth and care during the neonatal period, as well as gaps in data completeness, quality of information, record-keeping and the referral system.

The Government of North Macedonia declared that strengthening the health system and fast-tracking improvements in maternal and newborn health outcomes are strategic priorities for the coming years. This will accelerate the country's progress towards achieving the ambitious targets of the Sustainable Development Goals.

The Perinatal Care Master Plan is the conclusion of a combined effort by the Macedonian Ministry of Health and WHO in line with these strategic priorities. It provides a consolidated set of analyses of the current organization of the perinatal

care system across the full spectrum of service delivery. It also sets out prospective recommendations on improving maternal and neonatal health outcomes by establishing risk-appropriate care and by rationalizing and optimizing maternal and newborn service provision, with strong quality assurance systems and relevant health information support.

The Master Plan focuses on key strategic areas that must be tackled to achieve the set goals:

- service delivery (including service organization by level of care, infrastructure, equipment, human resources, transport and the referral system); and

- quality of care and health information systems.

Enhancing the area of quality of care and health information systems will improve the perinatal health care system by establishing a framework of perinatal care quality indicators; further strengthening and developing a system for maternal/newborn death/stillbirth review; and putting in place a standardized system for complete, high-quality perinatal data collection, analysis, reporting and data utilization to inform health policy and decision-making.

The Master Plan also encompasses an implementation plan, which outlines a roadmap to transform the recommended model into reality by converting it into gradual and realistic practical steps. These also take into account budgetary constraints, required resources, professional capacity and other factors that might affect (accelerate or hamper) the implementation process.

Implementation of the Master Plan will start as a pilot project in two districts in North Macedonia and will be scaled up when the processes are established.

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Annex 1. Glossary

Stillbirth	For international comparison, WHO recommends using the definition of baby born without any signs of life, of birth weight of 1000 g or more and/or gestational age of 28 weeks or greater and/or body length of 35 cm or more *Note:* the International Statistical Classification of Diseases and Related Health Problems definition of perinatal mortality includes fetal deaths from 22 weeks of gestation – this definition is more acceptable worldwide and according the country policy of North Macedonia uses the lower limit of 22 gestational weeks for stillbirths and perinatal deaths.
Neonatal death	A baby born alive but dying within the first 28 days of life, regardless of weight or gestational age: ● early neonatal death occurs in the first week of life (0–6 days) ● late neonatal death occurs after the first week but within the first month of life (7–27 days)
Perinatal death	A death occurring in the perinatal period – this period relates to an infant from 28 gestational weeks to the first week of life, but in countries that include stillbirth as occurring from 22 weeks of gestation, the perinatal period also includes stillbirths from 22 weeks of gestation
Neonatal mortality rate	Number of neonatal deaths per 1000 live births
Stillbirth rate	Number of stillbirths per 1000 total births
Perinatal mortality rate	Number of perinatal deaths per 1000 total births
Low birth weight	Birth weight of less than 2500 g, irrespective of gestational age
Very low birth weight	Birth weight of 1000–1499 g, irrespective of gestational age
Extremely low birth weight	Birth weight of <1000 g, irrespective of gestational age
Term birth	A baby born between 37 and 41 completed weeks of gestation
Preterm birth	A baby born at <37 weeks of gestation
Moderately preterm birth	A baby born between 32 and 36 weeks of gestation
Very preterm birth	A baby born at <32 weeks of gestation
Extremely preterm birth	A baby born at <28 weeks of gestation
Post-term birth	A baby born at ≥42 weeks of gestation
Small for gestational age	An infant below the 10th percentile of birth weight for a specific gestational age – may be preterm or full-term
Large for gestational age	An infant above the 90th percentile of birth weight for a specific gestational age

Annex 2. ICD-PM categories

The table describes the different categories of perinatal deaths according to timing of death and the maternal conditions as described in the WHO application to deaths in the perinatal period: ICD-PM and WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD-MM.

Fetal condition in the antepartum period	Fetal condition in the intrapartum period	Main neonatal condition	Maternal condition by ICD-MM code
A1 Congenital malformation, deformations and chromosomal abnormalities	I1 Congenital malformation, deformations and chromosomal abnormalities	N1 Congenital malformation, deformations and chromosomal abnormalities	M1 Maternal complications of pregnancy
A2 Infection	I2 Birth trauma	N2 conditions related to fetal growth	M2 Complications of placenta, fetal chord and membranes
A3 Antepartum hypoxia	I3 Acute intrapartum event	N3 Birth trauma	M3 Other complications of pregnancy and childbirth
A4 Other specified antepartum disorder	I4 Infection	N4 Complications of intrapartum events	M4 Maternal medical and surgical conditions
A5 Disorders related to fetal growth	I5 Other specified intrapartum disorder	N5 Convulsions and disorders of cerebral status	M5 No maternal condition
A6 Antepartum death of unspecified cause	I6 Disorders related to fetal growth	N6 Infection	
	I7 Intrapartum death of unspecified cause	N7 Respiratory and cardiovascular disorders	
		N8 Other neonatal conditions	
		N9 Low birth weight and prematurity	
		N10 Miscellaneous	
		N11 Neonatal death of unspecified cause	

Sources: The WHO application of ICD-10 to deaths during the perinatal period: ICD-PM. Geneva: World Health Organization; 2016 (https://www.who.int/reproductivehealth/publications/monitoring/icd-10-perinatal-deaths/en/, accessed 20 August 2020); The WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD-MM. Geneva: World Health Organization; 2012 (https://www.who.int/reproductivehealth/publications/monitoring/9789241548458/en/, accessed 10 November 2020).

Annex 3. Specific case summary

This table provides characteristics of the 11 term neonatal death cases that were reviewed in depth and reported in the complementary WHO report.[5]

Case ID	Gestational age (weeks)	Sex (male/ female)	Birth weight (grams)	Growth category	C-section (yes/no)	Referred (yes/no)	Apgar score 1 min	Apgar score 5 min	Apgar score 10 min	Level of care (secondary/ tertiary)	Complication during pregnancy and childbirth	Main neonatal condition (diagnosis and ICD-10 code)
2	41	Female	4150	LGA	No	Yes	5	7	2	Tertiary	Urinary tract infection Pregnancy-induced hypertension Asphyxia	Birth asphyxia (P21.9) Meconium aspiration (P24.0)
3	37	Male	3460	AGA	No	Yes	3	N/M	N/M	Tertiary	Placental abruption	Birth asphyxia (P21.9) Hypovolemic shock (R57.1)
12	39	Female	2550	AGA	No	No	8	9	3	Secondary	No complication	Other
13	37	Male	2410	SGA	No	No	4	6	2	Secondary	Rhesus isoimmunization Poor fetal growth	Respiratory distress of newborn (P22.9) Hypovolemic shock (R57.1) SGA (P05.1)
76	40	Male	3890	AGA	No	Yes	1	1	1	Tertiary	Oligohydramnios Asphyxia	Birth asphyxia (P21.9) Respiratory distress of newborn (P22.9)

[5] WHO Regional Office for Europe, unpublished perinatal audit case review for North Macedonia, 2019.

Case ID	Gestational age (weeks)	Sex (male/ female)	Birth weight (grams)	Growth category	C-section (yes/no)	Referred (yes/no)	Apgar score 1 min	Apgar score 5 min	Apgar score 10 min	Level of care (secondary/ tertiary)	Complication during pregnancy and childbirth	Main neonatal condition (diagnosis and ICD-10 code)
116	37	Male	3350	AGA	No	No	1	2	1	Tertiary	Placental abruption Asphyxia	Birth asphyxia (P21.9) Respiratory distress of newborn (P22.9)
126	37	Male	3190	AGA	No	Yes	2	4	2	Tertiary	Placental abruption	Birth asphyxia (P21.9) Other infections (P39.9)
128	37	Female	2350	SGA	No	Yes	6	7	2	Tertiary	No complication	Respiratory distress of newborn (P22.9)
129	38	Female	3340	AGA	No	Yes	2	3	1	Tertiary	Placental abruption Asphyxia	Birth asphyxia (P21.9) Respiratory distress of newborn (P22.9)
149	38	Male	2800	AGA	No	No	2	3	1	Secondary	Premature rupture of membranes Asphyxia	Birth asphyxia (P21.9) Respiratory distress of newborn (P22.9) SGA (P05.1)
160	38	Male	3070	AGA	No	No	0	0	0	Secondary	Polyhydramnios	Birth asphyxia (P21.9) Respiratory distress of newborn (P22.9)

Note: N/M = not measured.

Annex 4. Statistical tables

Tables A4.1–A4.9 present the full results from the analysis of all the perinatal deaths, stratified by type of death or prematurity.

Table A4.1. Descriptive statistics of facilities, districts, facility level and referrals among cases of stillbirth and neonatal death in North Macedonia, 2019

Facilities and districts	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Facility				
University Clinic for Gynecology and Obstetrics	109 (54.0)	36 (38.7)	73 (67.0)	
University Clinic for Pediatrics	25 (12.4)	0 (0.0)	25 (22.9)	
Clinical hospital of town of Tetovo	16 (7.9)	15 (16.1)	1 (0.9)	
Gynecology hospital "Mother Theresa"	15 (7.4)	14 (15.1)	1 (0.9)	
Private hospital "Sistina"	15 (7.4)	11 (11.8)	4 (3.7)	
General hospital of town of Kumanovo	4 (2.0)	4 (4.3)	0 (0.0)	
General hospital of town of Gostivar	4 (2.0)	2 (2.2)	2 (1.8)	
General hospital of town of Shtip	4 (2.0)	2 (2.2)	2 (1.9)	0.00
General hospital of town of Veles	3 (1.5)	3 (3.2)	0 (0.0)	
General hospital of town of Prilep	3 (1.5)	3 (3.2)	0 (0.0)	
General hospital of town of Kavadarci	1 (0.5)	1 (1.1)	0 (0.0)	
General hospital of town of Kichevo	1 (0.5)	1 (1.1)	0 (0.0)	
General hospital of town of Ohrid	1 (0.5)	1 (1.1)	0 (0.0)	
General hospital of town of Strumica	1 (0.5)	0 (0.0)	1 (0.9)	
Total	**202 (100.00)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)		0		
District				
Vardarski (along the Vardar river)	2 (1.0)	2 (2.2)	0 (0.0)	
Eastern	6 (3.0)	4 (4.3)	2 (1.8)	
South West	5 (2.5)	4 (4.3)	1 (0.9)	
Pelagonia	11 (5.5)	9 (9.7)	2 (1.8)	
Polog	18 (8.9)	14 (15.1)	4 (3.7)	0.00
North East	4 (2.0)	4 (4.3)	0 (0.0)	
Skopje	156 (77.2)	56 (60.2)	100 (91.7)	
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)		2		
Facility level				
Secondary care	53 (26.2)	46 (49.5)	7 (6.4)	
Tertiary care	149 (73.8)	47 (50.5)	102 (93.6)	0.00
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)		0		
Referral				

Facilities and districts	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Admitted to secondary or tertiary care facility	169 (84.9)	89 (95.7)	80 (75.5)	0.00
Referredto secondary or tertiary care facility	30 (15.1)	4 (4.3)	26 (24.5)	
Total	**199 (100.0)**	**93 (100.0)**	**106 (100.0)**	
Missing (n)		3		

Table A4.2a. Descriptive statistics of maternal characteristics among cases of stillbirth and neonatal death in North Macedonia, 2019

Maternal characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Parity				
Nulliparous	102 (51.0)	50 (54.8)	51 (47.7)	0.325
Multiparous	98 (49.0)	42 (45.2)	56 (52.3)	
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**	
Missing (n)		2		
Years of formal education (years)				
No education	6 (5.7)	5 (8.8)	1 (2.0)	0.024
1–9 years	28 (26.4)	17 (29.8)	11 (22.5)	
10–12 years	43 (40.6)	26 (45.6)	17 (34.7)	
>12 years	29 (27.4)	9 (15.8)	20 (40.8)	
Total	**106 (100.0)**	**57 (100.0)**	**49 (100.0)**	
Missing (n)		96		
Maternal age (years)				
<20	12 (5.9)	3 (3.2)	9 (8.3)	0.194
20–24	34 (16.8)	21 (22.6)	13 (11.9)	
25–29	57 (28.2)	27 (29.0)	30 (27.5)	
30–34	63 (31.2)	26 (28.0)	37 (33.9)	
≥35	36 (17.8)	16 (17.2)	20 (18.4)	
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)		0		
Profession				
Employed	54 (39.4)	20 (31.3)	34 (46.6)	0.188
Unemployed	28 (20.4)	15 (23.4)	13 (17.8)	
Stay-at-home parent[a]	55 (40.2)	29 (45.3)	26 (35.6)	
Total	**137 (100.0)**	**64 (100.0)**	**73 (100.0)**	
Missing (n)		65		
Civil status				
Cohabiting with the baby's father	175 (90.7)	78 (89.7)	97 (91.5)	0.804
Single	18 (9.3)	9 (10.3)	9 (8.5)	
Total	**193 (100.0)**	**87 (100.0)**	**106 (100.0)**	
Missing (n)		9		

[a] The difference between an unemployed person and a stay-at-home parent is that an unemployed person is seeking a job, while a stay-at-home parent is not.

Table A4.2a. (contd)

Maternal characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Ethnicity				
Albanian	85 (42.1)	40 (43.0)	45 (41.3)	0.460
Macedonian	80 (39.6)	32 (34.4)	48 (44.0)	
Romanian	24 (11.9)	13 (14.0)	11 (10.1)	
Turkish	11 (5.6)	6 (6.5)	5 (4.6)	
Muslim	1 (0.5)	1 (1.1)	0 (0.0)	
Other	1 (0.5)	1 (1.1)	0 (0.0)	
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)		0		
History of smoking during pregnancy				
No	148 (87.6)	80 (87.9)	68 (87.2)	1.000
1–9 cigarettes/day	12 (7.1)	6 (6.6)	6 (7.7)	
>10 cigarettes/day	9 (5.3)	5 (5.5)	4 (5.1)	
Total	**169 (100.0)**	**91 (100.0)**	**78 (100.0)**	
Missing (n)		33		

Table A4.2b. Descriptive statistics of maternal characteristics among cases of stillbirth and neonatal death in North Macedonia, 2019, by prematurity

Maternal characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Parity				
Nulliparous	100 (50.5)	75 (50.7)	25 (50.0)	1.000
Multiparous	98 (49.5)	73 (49.3)	25 (50.0)	
Total	**198 (100.0)**	**148 (100.0)**	**50 (100.0)**	
Missing (n)		4		
Years of formal education (years)				
No education	6 (5.7)	5 (6.3)	1 (3.9)	0.038
1–9 years	28 (26.4)	19 (23.8)	9 (34.6)	
10–12 years	43 (40.6)	29 (36.3)	14 (53.9)	
>12 years	29 (27.4)	27 (33.8)	2 (7.7)	
Total	**106 (100.0)**	**80 (100.0)**	**26 (100.0)**	
Missing (n)		96		

Table A4.2b. (contd)

Maternal characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Maternal age (years)				
<20	12 (6.0)	9 (6.0)	3 (6.0)	
20–24	34 (17.0)	21 (14.0)	13 (26.0)	
25–29	55 (27.5)	41 (27.3)	14 (28.0)	
30–34	63 (31.5)	47 (31.3)	16 (32.0)	0.128
≥35	36 (18.0)	32 (21.3)	4 (8.0)	
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**	
Missing (n)		2		
Profession				
Employed	54 (39.4)	43 (40.6)	11 (35.5)	
Unemployed	28 (20.4)	22 (20.8)	6 (19.4)	
Stay-at-home parent[a]	55 (40.2)	41 (38.7)	14 (45.2)	0.806
Total	**137 (100.0)**	**106 (100.0)**	**31 (100.0)**	
Missing (n)		65		
Civil status				
Cohabiting with the baby's father	173 (90.6)	129 (90.2)	44 (91.7)	
Single	18 (9.4)	14 (9.8)	4 (8.3)	0.765
Total	**191 (100.0)**	**143 (100.0)**	**48 (100.0)**	
Missing (n)		11		
Ethnicity				
Albanian	84 (42.0)	64 (42.7)	20 (40.0)	
Macedonian	79 (39.5)	59 (39.3)	20 (40.0)	
Romanian	24 (12.0)	17 (11.3)	7 (14.0)	
Turkish	11 (5.5)	8 (5.3)	3 (6.0)	0.958
Muslim	1 (0.5)	1 (0.7)	0 (0.0)	
Other	1 (0.5)	1 (0.7)	0 (0.0)	
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**	
Missing (n)		2		
History of smoking during pregnancy				
No	147 (87.5)	116 (89.2)	31 (81.6)	
1–9 cigarettes/day	12 (7.1)	8 (6.2)	4 (10.5)	
>10 cigarettes/day	9 (5.4)	6 (4.6)	3 (7.9)	0.455
Total	**168 (100.0)**	**130 (100.0)**	**38 (100.0)**	
Missing (n)		34		

[a] The difference between an unemployed person and a stay-at-home parent is that an unemployed person is seeking a job, while a stay-at-home parent is not.

Table A4.3a. Descriptive statistics of pregnancy characteristics among cases of stillbirth and neonatal death in North Macedonia, 2019

Pregnancy characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Type of pregnancy				
Singleton	186 (92.1)	86 (92.5)	100 (91.7)	
Twin	14 (6.9)	7 (7.5)	7 (6.4)	
Higher multiple	2 (1.0)	0 (0.0)	2 (1.8)	0.407
Total	**202 (100.0)**	**93 (100.0)**	**109 (100.0)**	
Missing (n)	0			
Method of conception				
Spontaneous	190 (95.0)	87 (94.6)	103 (95.4)	
In vitro fertilization	9 (4.5)	5 (5.4)	4 (3.7)	
Intra-cytoplasmic sperm injection	1 (0.5)	0 (0.0)	1 (0.9)	0.553
Total	**200 (100.0)**	**92 (100.0)**	**108 (100.0)**	
Missing (n)	2			
Signs of IUGR during pregnancy				
Yes	33 (19.3)	7 (9.0)	26 (28.0)	
No	138 (80.7)	71 (91.0)	67 (72.0)	0.002
Total	**171 (100.0)**	**78 (100.0)**	**93 (100.0)**	
Missing (n)	31			
Decreased fetal movement during pregnancy				
Yes	14 (11.3)	10 (17.2)	4 (6.1)	
No	110 (88.7)	48 (82.8)	62 (93.9)	0.085
Total	**124 (100.0)**	**58 (100.0)**	**66 (100.0)**	
Missing (n)	78			
ANC visits				
0	2 (1.3)	2 (2.5)	0 (0.0)	
1–4	12 (7.6)	4 (4.9)	8 (10.5)	
5–8	103 (65.6)	58 (71.6)	45 (59.2)	0.122
>8	40 (25.5)	17 (21.0)	23 (30.3)	
Total	**157 (100.0)**	**81 (100.0)**	**76 (100.0)**	
Missing (n)	45			
Ultrasound scans				
0	2 (1.3)	2 (2.5)	0 (0.0)	
2	1 (0.6)	1 (1.2)	0 (0.0)	
3	4 (2.6)	2 (2.5)	2 (2.7)	
4	8 (5.1)	4 (4.9)	4 (5.3)	0.731
>4	141 (90.4)	72 (88.9)	69 (92.0)	
Total	**156 (100.0)**	**81 (100.0)**	**75 (100.0)**	
Missing (n)		46		

Table A4.3a. (contd)

Pregnancy characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
HIV screening				
Negative	5 (100.0)	4 (100.0)	1 (100.0)	
Positive	0 (0.0)	0 (0.0)	0 (0.0)	
Not investigated	0 (0.0)	0 (0.0)	0 (0.0)	–
Total	**5 (100.0)**	**4 (100.0)**	**1 (100.0)**	
Missing (n)		197		
HIV treatment				
No	3 (100.0)	2 (100.0)	1 (100.0)	
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**3 (100.0)**	**2 (100.0)**	**1 (100.0)**	–
Missing (n)		199		
Syphilis screening				
Negative	0 (0.0)	0 (0.0)	0 (0.0)	
Positive	0 (0.0)	0 (0.0)	0 (0.0)	
Not investigated	0 (0.0)	0 (0.0)	0 (0.0)	–
Total	**0 (0.0)**	**0 (0.0)**	**0 (0.0)**	
Missing (n)		202		
Syphilis treatment				
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
No	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**0 (0.0)**	**0 (0.0)**	**0 (0.0)**	–
Missing (n)		202		

Table A4.3b. Descriptive statistics of pregnancy characteristics among cases of stillbirth and neonatal death in North Macedonia, 2019, by prematurity

Pregnancy characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Type of pregnancy				
Singleton	185 (92.5)	138 (92.0)	47 (94.0)	
Twin	13 (6.5)	10 (6.7)	3 (6.0)	
Higher multiple	2 (1.0)	2 (1.3)	0 (0.0)	0.702
Total	**200 (100.0)**	**150 (100.0)**	**50 (100.0)**	
Missing (n)		2		

Table A4.3b. (contd)

Pregnancy characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Method of conception				
Spontaneous	188 (95.0)	139 (93.9)	49 (98.0)	
In vitro fertilization	9 (4.6)	8 (5.4)	1 (2.0)	
Intra-cytoplasmic sperm injection	1 (0.5)	1 (0.7)	0 (0.0)	0.507
Total	**198 (100.0)**	**148 (100.0)**	**50 (100.0)**	
Missing (n)		4		
Signs of IUGR during pregnancy				
Yes	33 (19.5)	29 (22.3)	4 (10.3)	
No	136 (80.5)	101 (77.7)	35 (89.7)	0.096
Total	**169 (100.0)**	**130 (100.0)**	**39 (100.0)**	
Missing (n)		33		
Decreased fetal movement during pregnancy				
Yes	14 (11.4)	7 (7.0)	7 (30.4)	
No	109 (88.6)	93 (93.0)	16 (69.6)	0.001
Total	**123 (100.0)**	**100 (100.0)**	**23 (100.0)**	
Missing (n)				
ANC visits				
0	2 (1.3)	1 (0.8)	1 (2.8)	
1–4	12 (7.6)	11 (9.1)	1 (2.8)	
5–8	103 (65.6)	83 (68.6)	20 (55.6)	0.098
>8	40 (25.5)	26 (21.5)	14 (38.9)	
Total	**157 (100.0)**	**121 (100.0)**	**36 (100.0)**	
Missing (n)		45		
Ultrasound scans				
None	2 (1.3)	1 (0.8)	1 (2.8)	
2	1 (0.6)	1 (0.8)	0 (0.0)	
3	4 (2.6)	4 (3.3)	0 (0.0)	
4	8 (5.1)	7 (5.8)	1 (2.8)	0.574
>4	141 (90.4)	107 (89.2)	34 (94.4)	
Total	**156 (100.0)**	**120 (100.0)**	**36 (100.0)**	
Missing (n)		46		
HIV screening				
Negative	5 (100.0)	4 (100.0)	1 (100.0)	
Positive	0 (0.0)	0 (0.0)	0 (0.0)	
Not investigated	0 (0.0)	0 (0.0)	0 (0.0)	–
Total	**5 (100.0)**	**4 (100.0)**	**1 (100.0)**	
Missing (n)		197		

Table A4.3b. (contd)

Pregnancy characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
HIV treatment				
No	3 (100.0)	2 (100.0)	1 (100.0)	–
Yes	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**3 (100.0)**	**2 (100.0)**	**1 (100.0)**	
Missing (n)		199		
Syphilis screening				
Negative	0 (0.0)	0 (0.0)	0 (0.0)	–
Positive	0 (0.0)	0 (0.0)	0 (0.0)	
Not investigated	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**0 (0.0)**	**0 (0.0)**	**0 (0.0)**	
Missing (n)		202		
Syphilis treatment				
Yes	0 (0.0)	0 (0.0)	0 (0.0)	–
No	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**0 (0.0)**	**0 (0.0)**	**0 (0.0)**	
Missing (n)		202		

Table A4.4a. Descriptive statistics of childbirth characteristics among cases of perinatal death in North Macedonia, 2019

Childbirth characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Time of birth				
Office hours (08:00–15:59)	82 (43.9)	39 (42.9)	43 (44.8)	0.967
Afternoon (16:00–20:59)	47 (25.1)	24 (26.4)	23 (24.0)	
Late evening (21:00–23:59)	20 (10.7)	9 (9.9)	11 (11.5)	
Night (00:00–07:59)	38 (20.3)	19 (20.9)	19 (19.8)	
Total	**187 (100.0)**	**91 (100.0)**	**96 (100.0)**	
Missing (n)		15		
Time of death				
Office hours (08:00–15:59)	44 (39.3)	4 (36.4)	40 (39.6)	0.581
Afternoon (16:00–20:59)	24 (21.4)	1 (9.1)	23 (22.8)	
Late evening (21:00–23:59)	19 (17.0)	2 (18.2)	17 (16.8)	
Night (00:00–07:59)	24 (21.4)	4 (36.4)	20 (19.8)	
Total	**111 (100.0)**	**11 (100.0)**	**100 (100.0)**	
Missing (n)		91		
Onset of labour				
Spontaneous	89 (47.3)	38 (41.3)	51 (53.1)	<0.001
Induced	43 (22.9)	35 (38.0)	8 (8.3)	
C-section before onset	56 (29.8)	19 (20.7)	37 (38.5)	
Total	**188 (100.0)**	**92 (100.0)**	**96 (100.0)**	
Missing (n)		14		
Mode of delivery				
Vaginal	116 (58.0)	67 (72.0)	49 (45.8)	<0.001
C-section	81 (40.5)	24 (25.8)	57 (53.3)	
Vacuum extraction	3 (1.5)	2 (2.2)	1 (0.9)	
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**	
Missing (n)		2		
Delivery type				
Vaginal	111 (59.0)	66 (71.7)	45 (46.9)	0.002
Instrumental	3 (1.6)	2 (2.2)	1 (1.0)	
Emergency C-section	18 (9.6)	5 (5.4)	13 (13.5)	
Elective C-section	56 (29.8)	19 (20.7)	37 (38.5)	
Total	**188 (100.0)**	**92 (100.0)**	**96 (100.0)**	
Missing (n)		14		

Table A4.4a. (contd)

Childbirth characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Fetal presentation				
Cephalic	143 (78.1)	73 (82.0)	70 (74.5)	0.506
Breech	23 (12.6)	9 (10.1)	14 (14.9)	
Other	17 (9.3)	7 (7.9)	10 (10.6)	
Total	**183 (100.0)**	**89 (100.0)**	**94 (100.0)**	
Missing (n)		19		
Fetal heart sounds on admission				
No	92 (46.0)	87 (93.6)	5 (4.7)	<0.001
Yes	94 (47.0)	6 (6.5)	88 (82.2)	
Not examined	14 (7.0)	0 (0.0)	14 (13.1)	
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**	
Missing (n)		2		

Table A4.4b. Descriptive statistics of childbirth characteristics among cases of perinatal death in North Macedonia, 2019, by prematurity

Childbirth characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Time of birth				
Office hours (08:00–15:59)	82 (43.9)	64 (44.8)	18 (43.9)	0.126
Afternoon (16:00–20:59)	47 (25.1)	40 (28.0)	7 (15.9)	
Late evening (21:00–23:59)	20 (10.7)	15 (10.5)	5 (11.4)	
Night (00:00–07:59)	38 (20.3)	24 (16.8)	14 (31.8)	
Total	**187 (100.0)**	**143 (100.0)**	**44 (100.0)**	
Missing (n)		15		
Time of death				
Office hours (08:00–15:59)	44 (40.0)	34 (39.1)	10 (43.5)	0.754
Afternoon (16:00–20:59)	22 (20.0)	17 (19.5)	5 (21.7)	
Late evening (21:00–23:59)	19 (17.3)	17 (19.5)	2 (8.7)	
Night (00:00–07:59)	24 (21.8)	18 (20.7)	6 (26.1)	
Total	**109 (100.0)**	**86 (100.0)**	**23 (100.0)**	
Missing (n)		93		
Onset of labour				

Table A4.4b. (contd)

Childbirth characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Spontaneous	88 (47.1)	66 (45.5)	22 (52.4)	
Induced	43 (23.0)	33 (22.8)	10 (23.8)	
C-section before onset	56 (30.0)	46 (31.7)	56 (30.0)	0.636
Total	**187 (100.0)**	**145 (100.0)**	**42 (100.0)**	
Missing (n)		15		
Mode of delivery				
Vaginal	115 (57.8)	85 (57.1)	30 (60.0)	
C-section	81 (40.7)	64 (43.0)	17 (34.0)	
Vacuum extraction	3 (1.5)	0 (0.0)	3 (6.0)	0.018
Total	**199 (100.0)**	**149 (100.0)**	**50 (100.0)**	
Missing (n)		3		
Delivery type				
Vaginal	110 (58.8)	84 (57.9)	26 (61.9)	
Instrumental	3 (1.6)	0 (0.0)	3 (7.1)	
Emergency C-section	18 (9.6)	15 (10.3)	3 (7.1)	0.026
Elective C-section	56 (30.0)	46 (31.7)	10 (23.8)	
Total	**187 (100.0)**	**145 (100.0)**	**42 (100.0)**	
Missing (n)		15		
Fetal presentation				
Cephalic	143 (78.1)	101 (73.7)	42 (91.3)	
Breech	23 (12.6)	21 (15.3)	2 (4.4)	
Other	17 (9.3)	15 (11.0)	2 (4.4)	0.046
Total	**183 (100.0)**	**137 (100.0)**	**46 (100.0)**	
Missing (n)		19		
Fetal heart sounds on admission				
No	92 (46.5)	65 (43.9)	27 (54.0)	
Yes	92 (46.5)	71 (48.0)	21 (42.0)	
Not examined	14 (7.1)	12 (8.1)	2 (4.0)	0.411
Total	**198 (100.0)**	**148 (100.0)**	**50 (100.0)**	
Missing (n)		4		

Table A4.5a. Descriptive statistics of infant characteristics among cases of perinatal death in North Macedonia, 2019

Infant characteristics	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Sex of the infant				
Male	108 (53.7)	52 (56.5)	56 (51.4)	0.481
Female	93 (46.3)	40 (43.5)	53 (48.6)	
Total	**201 (100.0)**	**92 (100.0)**	**109 (100.0)**	
Missing (n)		1		
Gestational age (weeks)				
Extremely preterm (<28 weeks)	60 (30.0)	15 (16.1)	45 (42.1)	<0.001
Very preterm (28–31+6 weeks)	35 (17.5)	13 (14.0)	22 (20.6)	
Moderately preterm (32–36+6 weeks)	55 (27.5)	35 (37.6)	20 (18.7)	
Term (37–41+6 weeks)	48 (24.0)	28 (30.1)	20 (18.7)	
Post-term (≥42 weeks)	2 (1.0)	2 (2.2)	0 (0.0)	
Total	**200 (100.0)**	**93 (100.0)**	**107 (100.0)**	
Missing (n)		2		
Birth weight (grams)				
Extremely low birth weight <1000 g	63 (31.7)	17 (18.5)	46 (43.0)	0.001
Very low birth weight 1000–1499 g	34 (17.1)	14 (15.2)	20 (18.7)	
Low birth weight 1500–2499 g	49 (24.6)	30 (32.6)	19 (17.8)	
Normal birth weight 2500–4499 g	51 (25.6)	29 (31.5)	22 (20.6)	
Macrosomia ≥4500 g	2 (1.0)	2 (2.2)	0 (0.0)	
Total	**199 (100.0)**	**92 (100.0)**	**107 (100.0)**	
Missing (n)		3		
Growth category				
SGA	46 (24.0)	21 (24.7)	25 (23.4)	0.821
AGA	130 (67.7)	56 (65.9)	74 (69.2)	
LGA	16 (8.3)	8 (9.4)	8 (7.5)	
Total	**192 (100.0)**	**85 (100.0)**	**107 (100.0)**	
Missing (n)		10		

Table A4.5b. Descriptive statistics of infant characteristics among cases of perinatal death in North Macedonia, 2019, by prematurity

Infant characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Sex of the infant				
Male	106 (53.3)	81 (54.4)	25 (50.0)	0.626
Female	93 (46.7)	68 (45.6)	25 (50.0)	
Total	**199 (100.0)**	**149 (100.0)**	**50 (100.0)**	
Missing (n)		3		
Birth weight (grams)				
<1000 g	63 (31.7)	63 (42.3)	0 (0.0)	<0.001
1000–1499 g	34 (17.1)	32 (21.5)	2 (4.0)	
1500–2499 g	49 (24.6)	41 (27.5)	8 (16.0)	
2500–4499 g	51 (25.6)	13 (8.7)	38 (76.0)	
≥4500 g	2 (1.0)	0 (0.0)	2 (4.0)	
Total	**199 (100.0)**	**149 (100.0)**	**50 (100.0)**	
Missing (n)		3		
Growth category				
SGA	46 (24.0)	37 (25.9)	9 (18.4)	0.430
AGA	130 (67.7)	93 (65.0)	37 (75.5)	
LGA	16 (8.3)	13 (9.1)	3 (6.1)	
Total	**192 (100.0)**	**143 (100.0)**	**49 (100.0)**	
Missing (n)		10		

Table A4.6a. Descriptive statistics of prematurity preventive measures among cases of perinatal death in North Macedonia, 2019

Treatment and preventive measures	Total N (%)	Stillbirths N (%)	Neonatal deaths N (%)	*P* value
Corticosteroids				
Not indicated	37 (23.1)	18 (24.0)	19 (22.4)	
Not given	106 (66.3)	52 (69.3)	54 (63.5)	
Given	17 (10.6)	5 (6.7)	12 (14.1)	
Total	**160 (100.0)**	**75 (100.0)**	**85 (100.0)**	
Missing (n)		42		
Magnesium sulfate				
Not indicated	36 (22.5)	17 (22.7)	19 (22.4)	
Not given	123 (76.9)	58 (77.3)	65 (76.5)	
Given	1 (0.6)	0 (0.0)	1 (1.2)	-
Total	**160 (100.0)**	**75 (100.0)**	**85 (100.0)**	
Missing (n)		42		

Table A4.6b. Descriptive statistics of prematurity preventive measures among cases of perinatal death in North Macedonia, 2019, by prematurity

Treatment and preventive measures	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Corticosteroids				
Not indicated	37 (23.1)	13 (11.2)	24 (54.6)	<0.001
Not given	106 (66.3)	87 (7.0)	19 (43.2)	
Given	17 (10.6)	16 (13.8)	1 (2.3)	
Total	**160 (100.0)**	**116 (100.0)**	**44 (100.0)**	
Missing (n)		42		
Magnesium sulfate				
Not indicated	36 (22.5)	13 (11.2)	23 (52.3)	<0.001
Not given	123 (76.9)	102 (87.9)	21 (47.7)	
Given	1 (0.6)	1 (0.9)	0 (0.0)	
Total	**160 (100.0)**	**116 (100.0)**	**44 (100.0)**	
Missing (n)		42		

Table A4.7a. Descriptive statistics of Apgar score and resuscitation measures at birth among neonatal deaths in North Macedonia 2019

Neonatal characteristics	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)	*P* value
Apgar at 1 minute				
0	1 (1.0)	1 (1.4)	0 (0.0)	0.019
1–3	41 (41.4)	35 (50.0)	41 (41.3)	
4–7	52 (52.5)	31 (44.3)	52 (52.5)	
8–10	5 (5.1)	3 (4.3)	5 (5.1)	
Total	**99 (100.0)**	**70 (100.0)**	**29 (100.0)**	
Missing (n)		10		
Apgar at 5 minutes				
0	1 (1.0)	1 (1.4)	0 (0.0)	0.030
1–3	29 (29.0)	26 (36.6)	3 (10.3)	
4–7	53 (53.0)	32 (45.1)	21 (72.4)	
8–10	15 (15.0)	10 (14.1)	5 (17.2)	
Not measured	2 (2.0)	2 (2.8)	0 (0.0)	
Total	**100 (100.0)**	**71 (100.0)**	**29 (100.0)**	
Missing (n)		9		

Table A4.7a. (contd)

Neonatal characteristics	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)	*P* value
Apgar at 10 minutes				
0	2 (2.0)	2 (2.9)	0 (0.0)	
1–3	8 (8.1)	8 (11.4)	0 (0.0)	
4–7	33 (33.3)	20 (28.6)	13 (44.8)	
8–10	2 (2.0)	1 (1.4)	1 (3.5)	0.217
Not measured	36 (36.4)	25 (35.7)	11 (37.9)	
Not applicable	18 (18.2)	14 (20.0)	4 (13.8)	
Total	**99 (100.0)**	**70 (100.0)**	**29 (100.0)**	
Missing (n)		10		
Resuscitation				
Not indicated	3 (3.3)	8 (12.7)	2 (7.4)	
Not done	10 (11.1)	53 (84.1)	24 (88.9)	
Yes, done	77 (85.6)	2 (3.2)	1 (3.7)	0.873
Total	**90 (100.0)**	**63 (100.0)**	**27 (100.0)**	
Missing (n)		19		
Resuscitation category				
Not indicated	3 (3.3)	2 (3.2)	1 (3.7)	
Not done	10 (11.1)	8 (12.7)	1 (3.7)	
Only stage A	9 (10.0)	26 (41.3)	14 (51.9)	
With bag and mask	40 (44.4)	19 (30.2)	9 (33.3)	0.668
With intubation	28 (31.1)	8 (12.7)	2 (7.4)	
Total	**90 (100.0)**	**63 (100.0)**	**27 (100.0)**	
Missing (n)		19		
Staff category responsible for neonatal resuscitation				
Not applicable	2 (2.3)	2 (3.2)	0 (0.0)	
Neonatologist/paediatrician	84 (94.4)	57 (91.9)	27 (100.0)	
Anaesthesiologist	2 (2.3)	2 (3.2)	0 (0.0)	1.000
Midwife	1 (1.1)	1 (1.6)	0 (0.0)	
Total	**89 (100.0)**	**62 (100.0)**	**27 (100.0)**	
Missing (n)		30		
Surfactant given				
Not given	38 (39.2)	31 (47.7)	7 (21.9)	
Given	56 (57.7)	33 (50.8)	23 (71.9)	
Not indicated	3 (3.1)	1 (1.5)	2 (6.3)	0.019
Total	**97 (100.0)**	**65 (100.0)**	**31 (100.0)**	
Missing (n)		2		

Table A4.7a. (contd)

Neonatal characteristics	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)	*P* value
Respiratory support				
Not given	5 (5.1)	4 (6.1)	1 (3.1)	<0.001
Invasive ventilation	56 (57.1)	36 (54.6)	56 (57.1)	
Non-invasive ventilation	18 (18.4)	18 (27.3)	18 (18.4)	
Invasive/non-invasive ventilation	19 (19.4)	8 (12.1)	19 (19.4)	
Total	**98 (100.0)**	**66 (100.0)**	**32 (100.0)**	
Missing (n)		11		

Table A4.7b. Descriptive statistics of Apgar score and resuscitation measures at birth among neonatal deaths in North Macedonia 2019 (by gestational age)

Neonatal characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Apgar at 1 minute				
0	1 (1.0)	0 (0.0)	1 (5.3)	0.011
1–3	41 (41.4)	32 (40.0)	9 (47.4)	
4–7	52 (52.5)	46 (57.5)	6 (31.6)	
8–10	5 (5.1)	2 (2.5)	3 (15.8)	
Total	**99 (100.0)**	**80 (100.0)**	**19 (100.0)**	
Missing (n)		10		
Apgar at 5 minutes				
0	1 (1.0)	0 (0.0)	1 (5.6)	0.126
1–3	29 (29.6)	23 (28.8)	6 (33.3)	
4–7	53 (54.1)	46 (5758)	7 (3898)	
8–10	15 (15.3)	11 (13.8)	4 (2221)	
Total	**98 (100.0)**	**80 (100.0)**	**18 (100.0)**	
Missing (n)		11		
Apgar at 10 minutes				
0	2 (2.0)	2 (2.5)	0 (0.0)	0.019
1–3	8 (8.1)	4 (4.9)	4 (22.2)	
4–7	33 (33.3)	30 (37.0)	3 (16.7)	
8–10	2 (2.0)	1 (1.2)	1 (5.6)	
Not measured	36 (36.4)	32 (39.5)	4 (22.2)	
Not applicable	18 (18.2)	12 (14.8)	6 (33.3)	
Total	**99 (100.0)**	**81 (100.0)**	**18 (100.0)**	
Missing (n)		10		

Table A4.7b. (contd)

Neonatal characteristics	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Resuscitation				
Not indicated	3 (3.4)	1 (1.4)	2 (11.1)	
Not done	10 (11.2)	8 (11.3)	2 (11.1)	
Yes, done	76 (85.4)	62 (87.3)	14 (77.8)	0.127
Total	**89 (100.0)**	**71 (100.0)**	**18 (100.0)**	
Missing (n)		20		
Resuscitation category				
Not indicated	3 (3.4)	1 (1.4)	2 (11.1)	
Not done	10 (11.2)	8 (11.3)	2 (11.1)	
Only stage A	9 (10.1)	9 (12.7)	0 (0.0)	
With bag and mask	40 (44.9)	32 (45.1)	8 (44.4)	0.190
With intubation	27 (30.3)	21 (29.6)	6 (33.3)	
Total	**89 (100.0)**	**71 (100.0)**	**18 (100.0)**	
Missing (n)		19		
Staff category responsible for neonatal resuscitation				
Not applicable	2 (2.3)	2 (2.7)	0 (0.0)	
Neonatologist/paediatrician	83 (94.3)	71 (96.0)	12 (85.7)	
Anaesthesiologist	2 (2.3)	0 (0.0)	2 (1343)	0.057
Midwife	1 (1.1)	1 (1.4)	0 (0.0)	
Total	**88(100.0)**	**74 (100.0)**	**14 (100.0)**	
Missing (n)		20		
Surfactant given				
Not given	37 (39.0)	23 (30.3)	14 (73.7)	
Given	55 7 (.9)	51 (67.1)	4 (21.1)	
Not indicated	3 (3.2)	2 (2.6)	1 (5.3)	0.001
Total	**95 (100.0)**	**76 (100.0)**	**19 (100.0)**	
Missing (n)		14		
Respiratory support				
Not given	5 (5.2)	4 (5.3)	1 (5.0)	
Invasive ventilation	55 (57.3)	43 (56.6)	12 (60.0)	
Non-invasive ventilation	18 (18.8)	12 (15.8)	6 (30.0)	
Invasive/non-invasive ventilation	18 (18.8)	17 (22.4)	1 (5.0)	0.209
Total	**96 (100.0)**	**76 (100.0)**	**20 (100.0)**	
Missing (n)		13		

Table A4.8a. Descriptive statistics of quality of neonatal care among cases of neonatal death in North Macedonia, 2019

Neonatal quality of care	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)	*P* value
Hypothermia defined within 1st hour of birth				
No	26 (53.1)	16 (51.6)	10 (55.6)	0.890
Yes	21 (42.9)	14 (45.2)	7 (38.9)	
Not applicable	2 (4.1)	1 (3.2)	1 (5.6)	
Total	**49 (100.0)**	**31 (100.0)**	**18 (100.0)**	
Missing (n)		60		
Skin to skin practised after birth				
No	73 (96.1)	47 (95.9)	26 (96.3)	1.000
Yes	3 (4.0)	2 (4.1)	3 (4.0)	
Total	**76 (100.0)**	**49 (100.0)**	**27 (100.0)**	
Missing (n)		33		
Retinopathy of prematurity screening				
Not indicated	34 (64.2)	29 (80.6)	5 (29.4)	0.001
Not done	19 (35.9)	7 (19.4)	12 (70.6)	
Yes, done	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**53 (100.0)**	**36 (100.0)**	**17 (100.0)**	
Missing (n)		56		
Breast milk in the NICU				
Not indicated	2 (3.2)	1 (2.2)	1 (5.6)	0.167
Not given	58 (92.1)	43 (95.6)	15 (83.3)	
Given	3 (4.8)	1 (2.2)	2 (11.1)	
Total	**63 (100.0)**	**45 (100.0)**	**18 (100.0)**	
Missing (n)		66		
Enteral feeding				
Never	68 (74.7)	57 (90.5)	11 (39.3)	<0.001
Breast milk	3 (3.3)	1 (1.6)	2 (7.1)	
Formula	18 (19.8)	5 (7.9)	13 (46.4)	
Breast milk and formula	2 (2.2)	0 (0.0)	2 (7.1)	
Total	**91 (100.0)**	**63 (100.0)**	**28 (100.0)**	
Missing (n)		18		
NICU transfer				
No	8 (7.3)	8 (10.5)	0 (0.0)	0.103
Yes	101 (92.7)	68 (89.5)	33 (100.0)	
Total	**109 (100)**	**76 (100.0)**	**33 (100.0)**	
Missing (n)		0		

Table A4.8a. (contd)

Neonatal quality of care	Total N (%)	Early neonatal death (0–6 days) N (%)	Late neonatal death (7–27 days) N (%)	*P* value
Time to NICU transfer				
Not applicable	6 (5.6)	6 (7.9)	0 (0.0)	0.129
Not done	4 (3.7)	4 (5.3)	0 (0.0)	
≤24 hours	90 (83.3)	62 (81.6)	28 (87.5)	
>24 hours	8 (7.4)	4 (5.3)	4 (12.5)	
Total	**108 (100.0)**	**76 (100.0)**	**32 (100.0)**	
Missing (n)		1		
Status at referral				
In utero	3 (11.5)	2 (11.1)	1 (12.5)	1.000
Newborn	23 (88.5)	16 (88.9)	7 (87.5)	
Total	**26 (100.0)**	**18 (100.0)**	**8 (100.0)**	
Missing (n)		83		
Antibiotics				
Not given	9 (9.0)	9 (13.2)	0 (0.0)	0.054
Given	91 (91.0)	59 (86.8)	32 (100.0)	
Total	**100 (100.0)**	**68 (100.0)**	**32 (100.0)**	
Missing (n)		9		
Inotropic support				
1 drug given	39 (48.8)	28 (50.0)	11 (45.8)	<0.001
2 drugs given	18 (22.5)	6 (10.7)	12 (50.0)	
Not given	23 (28.8)	22 (39.3)	1 (4.2)	
Total	**80 (100.0)**	**56 (100.0)**	**24 (100.0)**	
Missing (n)		29		

Table A4.8b. Descriptive statistics of quality of neonatal care among cases of neonatal death in North Macedonia, 2019, by gestational age

Neonatal quality of care	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Hypothermia defined within 1st hour of birth				
No	26 (55.1)	23 (54.8)	3 (42.9)	0.769
Yes	21 (42.9)	17 (40.5)	4 (57.1)	
Not applicable	2 (4.1)	2 (4.8)	0 (0.0)	
Total	**47 (100.0)**	**40 (100.0)**	**7 (100.0)**	
Missing (n)		62		

Table A4.8b. (contd)

Neonatal quality of care	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Skin to skin practised after birth				
No	73 (96.1)	66 (97.1)	7 (87.5)	0.287
Yes	3 (4.0)	2 (2.9)	1 (12.5)	
Total	**76 (100.0)**	**68 (100.0)**	**8 (100.0)**	
Missing (n)		33		
Retinopathy of prematurity screening				
Not indicated	33 (63.5)	23 (59.0)	10 (76.9)	0.328
Not done	19 (36.5)	16 (41.0)	3 (23.1)	
Yes, done	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**52 (100.0)**	**39 (100.0)**	**13 (100.0)**	
Missing (n)		57		
Breast milk in the NICU				
Not indicated	2 (3.2)	1 (2.0)	1 (7.7)	0.077
Not given	58 (92.1)	48 (96.0)	10 (76.9)	
Given	3 (4.8)	1 (2.0)	2 (15.4)	
Total	**63 (100.0)**	**50 (100.0)**	**13 (100.0)**	
Missing (n)		46		
Enteral feeding				
Never	68 (74.7)	56 (72.7)	12 (85.7)	0.050
Breast milk	3 (3.3)	2 (2.6)	1 (7.1)	
Formula	18 (19.8)	18 (23.4)	0 (0.0)	
Breast milk and formula	2 (2.2)	1 (1.3)	1 (7.1)	
Total	**91 (100.0)**	**77 (100.0)**	**14 (100.0)**	
Missing (n)		18		
NICU transfer				
No	8 (7.5)	4 (4.6)	4 (20.0)	0.039
Yes	99 (92.5)	83 (95.4)	16 (80.0)	
Total	**107 (100.0)**	**87 (100.0)**	**20 (100.0)**	
Missing (n)		2		
Time to NICU transfer				
Not indicated	7 (6.5)	4 (4.6)	3 (15.0)	0.015
Not done	4 (3.7)	2 (2.3)	2 (10.0)	
≤24 hours	89 (83.2)	77 (88.5)	12 (60.0)	
>24 hours	7 (6.5)	4 (4.6)	3 (15.0)	
Total	**107 (100.0)**	**87 (100.0)**	**20 (100.0)**	
Missing (n)		3		

Table A4.8b. (contd)

Neonatal quality of care	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
Status at referral				
In utero	2 (8.3)	2 (15.4)	0 (0.0)	0.482
Newborn	22 (91.7)	11 (84.6)	11 (100.0)	
Total	**24 (100.0)**	**13 (100.0)**	**11 (100.0)**	
Missing (n)		83		
Antibiotics				
Not given	9 (9.2)	7 (8.9)	2 (10.5)	0.554
Given	89 (90.8)	72 (91.1)	17 (89.5)	
Total	**98 (100.0)**	**79 (100.0)**	**19 (100.0)**	
Missing (n)		11		
Inotropic support				
Not given	23 (29.1)	18 (29.0)	5 (27.8)	0.938
1 drug	39 (49.4)	30 (48.4)	9 (52.9)	
2 drugs	17 (21.5)	14 (22.6)	3 (17.7)	
Total	**79 (100.0)**	**62 (100.0)**	**17 (100.0)**	
Missing (n)		30		

Table A4.9. Number of days from birth to death among cases of neonatal deaths in North Macedonia, 2019, by prematurity

Time from birth to death	Total N (%)	Preterm (<37 weeks) N (%)	Term (≥37 weeks) N (%)	*P* value
<24 hours	31 (32.0)	20 (25.0)	11 (64.7)	0.062
1–3 days	24 (24.7)	21 (26.3)	3 (17.7)	
4–7 days	18 (18.6)	17 (21.3)	1 (5.9)	
8–10 days	9 (9.3)	9 (11.3)	0 (0.0)	
11–14 days	6 (6.2)	5 (6.3)	1 (5.9)	
15–27 days	9 (9.3)	8 (10.0)	1 (5.9)	
Total	**97 (100.0)**	**80 (100.0)**	**17 (100.0)**	
Missing (n)		13		

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