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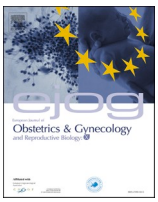

Prenatal ultrasound screening and congenital anomalies at birth by region: Pattern and distribution in Latvia

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ABSTRACT

Objective: The objective was to compare the ultrasound scan frequency and rate of congenital malformations between urban and rural areas.

Study design: We conducted a population-based retrospective study using linked data from administrative data sources and register data. All singleton live births in 2018 that could be linked (n = 18,759) were included in the data analysis. Place of residence was categorized into three groups: Riga (capital city), other big cities and rural areas (including regional cities). Adjusted ORs were calculated. The multiple regression model was adjusted for maternal age, living area and prenatal screenings.

Results: Overall, 3% (n = 536) of the live-born infants were reported to have congenital malformations at birth. The proportion of congenital anomalies was, on average, 2% higher ($p < 0.001$) in Riga (4%, n = 334) than in the rural regions (2%, n = 93) and other cities (1%, n = 109). Women whose infants had congenital anomalies at birth had higher and statistically significant odds of having abnormal findings on ultrasound (US) screening (OR=2.3; 95% CI 1.5–3.4; $p < 0.001$) and undergoing invasive diagnostic tests during pregnancy (OR=2.2; 95% CI 1.4–3.5; $p < 0.001$). The median number of ultrasound scans during pregnancy was 3 (IQR 2) in Riga and 4 (IQR 2) in the other cities and rural regions. The top 3 types of congenital anomalies at birth were deformations of the musculoskeletal system and congenital malformations of the circulatory system and genital organs.

Conclusions: The findings of this study showed a statistically significant association between the rate of foetal anomalies and the frequency of prenatal examinations. A higher average number of US examinations per pregnancy was observed in the rural regions. Regional variations exist in the rates of specific congenital anomalies. Further studies are recommended in this field for better understanding. Surveillance systems that are able to analyse the efficiency of US examinations need to be developed for the early prenatal detection of congenital anomalies.

Introduction

Congenital anomalies, which cause perinatal and infant deaths, are a worldwide problem. According to the World Health Organization (WHO), 17–42% of infant mortalities are attributed to congenital anomalies [1]. In 11 European network of population-based registries for the epidemiological surveillance of congenital anomalies (EUROCAT) countries, the average infant mortality rate due to congenital anomalies was 1.1 per 1000 births [1,2].

Prenatal ultrasound (US) screening can help to monitor normal foetal development and screen for any potential problems. Patients undergoing prenatal ultrasound should be made aware of the limitations of this tool in detecting anomalies. Prenatal detection has several practical benefits, including parental preparation, delivery planning, and the provision of optimal paediatric care [3–6]. Prenatal screening for the detection of foetal anomalies is organized by laws and guidelines [7]. Three ultrasound screening examinations during pregnancy are recommended in Latvia. The 1st US screening is performed at the 11th to 13th week of pregnancy, the 2nd is performed at the 20th to 21st week, and the 3rd is performed at 34–36 weeks for at-risk pregnant women [3]. However, antenatal screening examinations and early detection of congenital anomalies have proven to be challenging. Statistical data

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show that there are regional differences in the use of antenatal care in Latvia; the proportion of women with a timely first antenatal visit (before the 12th gestational week) ranged from 98% in Riga to 85% in Latgale, that of women who underwent ultrasound screening in the 1st trimester ranged from 89% to 93% in Riga, that of women who underwent an ultrasound screening in the 2nd trimester ranged from 95% in the Vidzemes region to 98% in Riga, and that of women who underwent genetic screening in the 1st trimester ranged from 88% in the Latgales region to 91% in Riga in 2022 [8]. Previous studies also showed that there are higher odds of late first antenatal visits (after the 12th gestational week) and incomplete antenatal care (including women without care) in regions (other cities and rural areas) other than Riga [9].

In recent years, maternal and child health as well as perinatal health have been prioritized in our country, including improving antenatal care and providing quality delivery assistance. This study sought to assess the ultrasound scan frequency and the rate of congenital malformations in urban and rural areas.

Materials and methods

In this nationwide, register-based, cross-sectional study, we included all singleton births in 2018 (n = 18,759). We used a linked data source—the Health Care Monitoring Datalink (HCMD). Information on ultrasound scans during pregnancy was retrieved from administrative data sources (ambulatory care data about ultrasound scans during pregnancy provided by public and private health care providers) and data about congenital anomalies were retrieved from the register (Medical Birth Register). All births in Latvia are required to be reported to the registry, and notification is made by standardized medical record forms that are used by all maternity units across the country. Ultrasound scans were identified by manipulation codes (50694 and 50695) used to pay for health care services according to the National Health Service information: 50694—routine ultrasound screening in the 1st trimester of pregnancy; and 50695—ultrasound scan in obstetrics [10].

The regulatory frameworks “Procedures for the Provision of Maternity Assistance”, “Procedures for providing childbirth assistance” and “Requirements for ultrasonographic examination of pregnancy” were developed in Latvia: ultrasonographic examinations for physiologically occurring pregnancies during the 1st and 2nd trimesters of pregnancy and ultrasonographic investigations in high-risk pregnancies (including medium and high genetic risks) are required. Ultrasound scans in pregnancy are performed in accordance with these regulations. The first ultrasound screening is performed between the 11th and 13th weeks, the second is performed at the 20th to 21st weeks and the third is performed at the 34th to 36th weeks of pregnancy. The examination is performed by a certified gynaecologist (obstetrician) who meets the following conditions: has received the therapeutic and diagnostic "Ultrasonography in obstetrics and gynaecology” certificate; has acquired at least five years of work experience in performing ultrasound scans; and uses the standard technical equipment. The requirements depend on which trimester in which the examination should be performed [3]. There are also national clinical algorithms and pathways for prenatal screening [11]. Genetic screening in the 1st trimester is performed according to the clinical pathway “Screening of foetal chromosomal pathology in the first trimester”. A serum test is performed during early pregnancy in gestational weeks 9 + 0–11 + 6, and the measurement of nuchal translucency combined with general ultrasound screening is performed during early pregnancy in gestational weeks 11 + 0–13 + 6 [11]. In cases of high-risk pregnancy, an ultrasound scan is performed by an ultrasonography specialist with Foetal Medicine Foundation (FMF) certification. Invasive diagnostics (chorion biopsy; amniocentesis), if necessary, can be performed at the Medical Genetics and Prenatal Diagnostics Clinic of the Children’s Clinical University Hospital or the prenatal diagnostic department of the Perinatal Care Center [3,11].

Place of residence was categorized into three groups: Riga (capital city), other big cities (Daugavpils, Jekabpils, Jelgava, Jurmala, Liepaja, Rezekne, Valmiera, and Ventspils) and rural areas (including regional cities). Birth defect types were classified by diagnosis codes (Q00-Q99) using ICD-10 classification groups.

Descriptive statistics for all the continuous variables are reported as the mean ± standard deviation (SD), while categorical variables are reported as frequencies and percentages. The categorical variables were compared by using the chi-square test. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were estimated. The multiple regression model was adjusted for maternal age, living area and antenatal care factors. A P value < 0.05 was considered statistically significant.

The study was conducted with the approval of the Medical and Biomedical Research Ethics Committee of the Riga East Clinical University Hospital Support Foundation.

Results

A total of 41% of the pregnant women were from Riga, 39% were from the other big cities and 20% were from the rural regions. There was a statistically significant difference in the mean maternal age: it was higher in Riga (31.4 years (SD 5.3)) than in the other big cities (30.1 years (SD 5.5)) and rural areas (29.7 years (SD 5.5)) ($p < 0.01$). A total of 84% (n = 15,824) of pregnant women were routinely screened in the 1st trimester. A total of 75% of pregnant women underwent 3 US examinations during pregnancy, and the proportion was higher in the other big cities than in Riga and the rural regions ($p < 0.001$). The median number of scans during pregnancy was 3 (IQR 2) in Riga and the other big cities and 4 (IQR 2) in the rural regions.

The characterization of congenital anomalies at birth and antenatal examinations by region is shown in Table 1. First-trimester genetic screening was performed in 89% of cases. A higher proportion of genetic screening was observed in Riga ($p < 0.001$); the proportion was 7% higher than that in the rural regions and 3% higher ($p < 0.001$) than that in the other big cities.

Of the 18,759 infants born during the study period, 536 had birth defects, giving a total prevalence rate of 28.6 per 1000 births. The proportion of congenital anomalies was 2% higher ($p < 0.001$) on average in Riga (4%) than in the rural regions (2%) and other big cities (1%).

The top five congenital anomaly groups at birth were deformations of the musculoskeletal system (24%), congenital malformations of the circulatory system (19%), congenital malformations of genital organs (14%), congenital malformations of the urinary system (11%) and congenital malformations of the digestive system (10%).

Major anomalies regarding EUROCAT coding groups more frequent were registered from musculoskeletal system - club foot – talipes equinovarus (n = 4; Q66.0), hip dislocation and / or dyspasia (n = 6; Q65.0-Q65.2; Q65.8), polydactyly (n = 19; Q69), syndactyly (n = 27; Q70), abdominal wall defects (n = 7; Q79.2; Q79.3; Q79.5), from heart defects - severe congenital heart defects (n = 18; Q20.0-Q.20.4; Q20.3; Q20.4; Q21.2; Q21.3; Q22.0; Q22.4; Q22.5; Q22.6; Q23.0; Q23.2-Q23.4; Q25.1; Q25.2; Q26.2), from genital organs - hypospadias (n = 22; Q54), from urinary system – congenital hydronephrosis (n = 17; Q62.0), from digestive system - atresia or stenosis of other parts of small intestine (n = 6; Q41.1-Q41.8), ano-rectal atresia and stenosis (n = 4; Q42.0-Q42.3), from chromosomal anomalies all cases were Down syndrome (n = 11; Q90).

There were statistically significant differences among regions by birth defect type.

During the study time period, the highest proportion ($p < 0.001$) was observed for digestive system anomalies (36%), followed by congenital malformations and deformations of the musculoskeletal system (31%) ($p < 0.05$), in the rural regions than Riga and other big cities. The rate of congenital malformations of the circulatory system was 15% higher ($p < 0.01$) in the other big cities than in the rural regions. Birth defects of genital organs and the urinary system were more common in Riga (12% higher; ($p < 0.001$)), than in the rural regions.

Table 1
Examinations of antenatal care and structure of congenital anomalies at birth by region, % (n).

	Riga (capital city), % (n)	Other cities, % (n)	Rural area, % (n)	p value	Total, % (n)
Examinations of antenatal care[a]	**(n = 7634)**	**(n = 7279)**	**(n = 3846)**		**(n = 18,759)**
3 ultrasonography scans during pregnancy[b]	74 (5678)	79 (5729)	73 (2804)	p < 0.001	76 (14,211)
1st trimester genetic screening[c]	91 (6933)	88 (6379)	84 (3219)	p < 0.001	89 (16,531)
Invasive diagnostic methods in pregnancy[b]	1 (106)	2 (171)	2 (61)	NS	2 (338)
Abnormal findings in ultrasound screening (ICD-10; O28)[c]	1 (48)	4 (39)	2 (79)	p < 0.001	2 (424)
Congenital anomalies group; ICD-10 codes[a]	**(n = 334)**	**(n = 109)**	**(n = 93)**		**(n = 536)**
Congenital malformations of the nervous system; Q00-Q07	4 (14)	1 (1)	(0)	NS	3 (15)
Congenital malformations of eye, ear, face and neck; Q10-Q18	3 (11)	4 (4)	2 (2)	NS	3 (17)
Congenital malformations of the circulatory system; Q20-Q28†	19 (64)	25 (27)	10 (9)	p < 0.001	19 (100)
Congenital malformations of the respiratory system; Q30-Q34	3 (9)	1 (1)	1 (1)	NS	2 (11)
Cleft lip and cleft palate; Q35-Q37	3 (11)	6 (7)	3 (3)	NS	4 (21)
Other congenital malformations of the digestive system; Q38-Q45††	4 (14)	4 (4)	36 (33)	p < 0.001	10 (51)
Congenital malformations of genital organs; Q50-Q56†††	17 (58)	13 (14)	3 (3)	p < 0.001	14 (75)
Congenital malformations of the urinary system; Q60-Q64†††	13 (44)	11 (12)	2 (2)	p < 0.001	11 (58)
Congenital malformations and deformations of the musculoskeletal system; Q65-Q79†	23 (75)	23 (25)	31 (29)	p < 0.05	24 (129)
Other congenital malformations; Q80-Q89	8 (26)	13 (14)	9 (8)	NS	9 (48)
Chromosomal abnormalities; Q90-Q99	2 (8)	(0)	3 (3)	NS	2 (11)

† statistically significant difference between other cities and rural regions
†† statistically significant difference between rural regions and other groups (Riga and other cities)
††† statistically significant difference between Riga and rural regions
[a] Represents % (n) and Chi square test is used; NS: Not Significant
[b] statistically significant difference between other cities and other groups (Riga and rural regions)
[c] statistically significant difference between all groups

For a small number of cases (2% (n = 424)), it was noted from medical reports that abnormal findings were detected in antenatal screening during ambulatory care visits (Table 1.). Of all these cases, 7% (n = 29) were registered in the Medical Birth Register as diagnosed congenital anomalies at birth. More than half (59%; n = 17) of the cases were related to congenital malformations of the circulatory system (Q20-Q28), such as common arterial trunk (Q20.0), discordant ventriculoarterial connection (Q20.3), tetralogy of Fallot (Q21.3), congenital malformations of the aortic and mitral valves (Q21), and coarctation of aorta (Q25.1). An average of 4 cases of congenital malformations and deformations of the musculoskeletal system and malformations of the urinary system were observed.

Fig. 1 presents the adjusted odds ratio of congenital anomalies related to prenatal screenings. Women whose foetuses had congenital anomalies at birth had higher and statistically significant odds of undergoing invasive diagnostic procedures during pregnancy (OR=2.2; 95% CI 1.4–3.5; $p < 0.001$) and having abnormal findings on US screening (OR=2.3; 95% CI 1.5–3.4; $p < 0.001$). Slightly higher odds of congenital anomalies at birth were related to first-trimester genetic screening (OR=1.5; 95% CI 1.2–2.1; $p < 0.01$) and preterm deliveries (OR=1.5; 95% CI 1.2–2.1; $p < 0.05$).

Discussion

This register-based study provides an epidemiological description of the rate of congenital anomalies and antenatal screening frequency, which may be helpful for understanding the overall situation and aid in more comprehensive studies of congenital anomalies and prenatal detection rates in health care systems, monitoring, prevention and policy-making.

Birth defects are a major contributor to perinatal and infant mortality, morbidity and lifelong disability worldwide. Birth defects affect at least 3% of babies in most populations [1,12,13]. In the current study, we detected that 3% of newborns had congenital anomalies. Birth defects in the circulatory, musculoskeletal, urogenital and digestive systems were more common, which is in accordance with the data of other countries. EUROCAT (European Surveillance of Congenital Anomalies) network data showed similar trends: congenital heart defects were the most common nonchromosomal subgroup, at 6.5 per 1000 births, followed by limb defects (3.8/1000), anomalies of the urinary system (3.1/1000) and nervous system defects (2.3/1000) [13].

Previous studies showed that there are differences in total infant mortality and causes of death by region in Latvia. From 2000–2010, the infant mortality rate was higher in the rural areas. The most common subgroup of congenital malformations was circulatory system malformations, in which unspecified malformations of the heart and discordant ventriculoarterial connections were the most common causes of death in the rural areas [14]. This study identified some regional differences by type of birth defect, as also mentioned in the scientific literature [15–18]. This study results showed that in the urban areas, congenital malformations of the circulatory system and defects of genital organs and the urinary system were diagnosed more often, but in the rural regions, digestive system birth defects and malformations and deformations of the musculoskeletal system were diagnosed more often.

Studies in England and Wales reported significant regional variations in all major congenital anomaly subgroups except that of abdominal

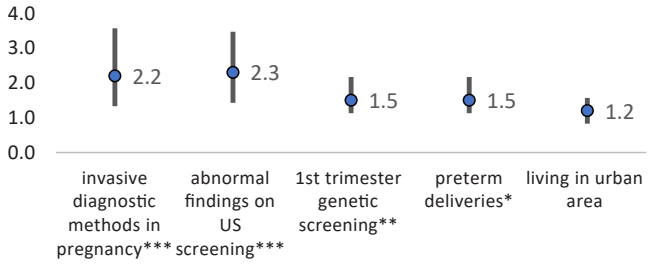

Fig. 1. aOR for congenital anomalies at birth related to prenatal care examinations. (*p < 0.05; **p < 0.01; ***p < 0.001; aOR for mother age, living area and prenatal examinations and obtained from a logistic regression model).

wall defects. Wales had the highest reported prevalence in all subgroups except that of chromosomal anomalies. This variation requires investigation to determine any additional influences other than ascertainment and the underlying true prevalence, which may vary regionally [15].

The information on congenital anomalies from MBR does not include information about cases that are discovered later, after the newborns are discharged from the maternity unit. In some cases, there may be over-reporting because the diagnosis made in the maternity units could be as provisional not always confirmed by a laboratory.

Many congenital anomalies can be diagnosed prenatally. Ultrasound-based screening has been an integral part of routine prenatal care for decades. The prenatal detection of foetal anomalies allows for optimal perinatal management [1]. Many studies have analysed the effectiveness of prenatal ultrasonography in detecting foetal anomalies [19–28]. The limitation of this study is that we were not able to evaluate the effectiveness of ultrasound scans performed prenatally due to a lack of data and linkage possibilities. However, statistical data showed that, on average, 88% of pregnant women in Latvia undergo an ultrasound examination, but the number of prenatally diagnosed cases of anomalies is relatively low. For example, regarding gastroschisis, 76.5% of the pregnant women underwent prenatal ultrasound, but only 29.4% of cases were prenatally detected; for omphalocele, 89.3% underwent prenatal ultrasound, but only 3.6% of cases were prenatally detected [29]. Data from the JRC-EUROCAT Central registry showed that the total prevalence of Down syndrome in 10,000 births increased from 16 in 1990–23 in 2015. Prenatal detection increased from 49% in 2005 to approximately 70% in 2015, but territorial differences among countries and regions exist [30]. In this study, chromosomal anomalies (Down syndrome) were observed to occur in approximately 2% of births. The data of another Latvian study indirectly showed that the number of cases of prenatally diagnosed chromosomal anomalies has increased; the prevalence of Down Syndrome in live-born infants showed a reduction tendency opposite to that of TOPFA (Termination of Pregnancy for Foetal Anomaly), where an increase was observed [31].

Prenatal detection of congenital anomalies is a factor that can reduce the perinatal mortality rate due to the impact of early interventions [5].

The role of ultrasound imaging in detecting markers for chromosomal anomalies and structural defects in foetuses is very important to enable early intervention or close monitoring. Ultrasound imaging is performed to evaluate foetal and maternal structures for abnormalities that could lead to maternal and/or perinatal mortality [25]. Systematic review analysis showed that detection rates of first-trimester foetal anomalies ranged from 32% in low-risk groups to more than 60% in high-risk groups, demonstrating that first-trimester ultrasound has the potential to identify a large proportion of foetuses affected by structural anomalies. The use of a standardized anatomical protocol improves the sensitivity of first-trimester ultrasound screening for all anomalies and major anomalies in populations at varying risk [26]. Similar results were also mentioned in another systematic review study, where the importance of first-trimester screening is highlighted; first-trimester ultrasound examination of the foetal heart allows over half of foetuses affected by a major cardiac pathology to be identified [27].

There are also national clinical algorithms and pathways for prenatal screening in Latvia which helps health care provider to choose the most appropriate approach to pregnancy monitoring.

Diagnostic ultrasound examination may be employed in a variety of specific circumstances during pregnancy, such as after the occurrence of clinical complications or when concerns about foetal growth exist. Because adverse outcomes may also occur in pregnant women without clear risk factors, assumptions have been made that routine ultrasound in all pregnancies will prove to be beneficial by enabling earlier detection and improved management of pregnancy complications [3]. Patient-centred care is very important during pregnancy and delivery. Published literature indicates that women should receive information regarding abnormal ultrasound findings in a clear, sympathetic, and timely fashion and in a supportive environment that ensures privacy. Referral to appropriate paediatric or surgical subspecialist(s) should be considered to provide the most accurate information possible concerning the anomaly or anomalies and the associated prognosis [28].

Three ultrasound screening examinations during pregnancy are recommended in Latvia [3]. Our study results showed an average of 3 US scans during pregnancy in urban regions and 4 in rural regions. Population-based data in France analysed trends for the three subgroups defined by the number of scans performed per pregnancy: ≥ 4, 3 or ≤ 2. The percentage of women with ≥ 4 US examinations increased between 2010 and 2014 (+4.6%), while those monitored according to the guidelines, that is, three US examinations, decreased by 6%. Moreover, the proportion of women with fewer than three examinations than recommended by the guidelines remained stable [19]. Our study confirmed that there are differences in antenatal screenings frequency by region in Latvia. The reason might be related to better access to specialists in cities. Women from rural regions may visit specialists more often to make sure of the antenatal examination or to compare the results not just from place of residence but also to use health care services in larger cities as well as the declared place of residence is not always the actual one. Different political document reports identified main problems related to human resources in health care – lack of doctors of certain specialties, insufficient number of nurses, disproportion of doctors and nurses, uneven geographical distribution of specialists, insufficient level of remuneration, ageing of staff and ineffective generational change. Although the number of specialty doctors is currently sufficient in the country as a whole, the concentration of these specialists can be observed mostly in large cities, so their lack is a very urgent problem in many places outside of Riga (capital city). Gynaecologists, anaesthesiologists and resuscitators are missing in all institutions outside Riga analysed in the audit report [32].

Antenatal care is an important predictor of favourable childbirth outcomes. The increasing tendency of US screening during pregnancy is reflected in routine statistical data in Latvia among births in the last decade—an increase in US screening from 60% to 90% in the 1st trimester—as well as the same tendency in the 2nd and 3rd trimesters of pregnancy [33]. The same tendency was found in France, where the number of US examinations per pregnancy increased over time, and the prenatal detection rate of foetal anomalies has not increased in recent years. These data suggest that there is a need to implement policies to improve the efficacy of US examinations for the prenatal diagnosis of congenital anomalies, including the provision of more high-quality training programmes [23]. Another study also mentioned that the training levels of ultrasound providers may affect detection rates [21].

This study provides a better understanding of the data problems and gaps in information systems. A limitation of our study is the lack of detailed information about ultrasound screening results in available health information systems that we could use to analyse the effectiveness of prenatally detecting congenital anomalies. The data information systems that we used contain only information about ultrasound screening without detailed s of the results. The small number of cases (2.3% (n = 424)) of abnormal findings on antenatal screening indicates this problem, probably because not all cases may have been recorded. We can assume that not all data about prenatal detection are being reported and that the prenatal detection rate is likely to be higher. In addition, these data included only state paid services, not examinations paid for by women. This is indirectly indicated by the data on the higher likelihood of having a newborn with congenital anomalies was around 2 times higher for women who had invasive diagnostic methods during pregnancy (OR=2.2), abnormal US screening findings (OR=2.3) and first-trimester genetic screening (OR=1.5). Special effort should be made to improve data reporting in electronic health data systems.

Despite these limitations, the main strength of the study is that the data were population-based, which means that the study utilized a large sample of newborns. Register-based data are essential for planning health care and determining temporal trends. Strengthening health information systems, providing regular perinatal examinations and

improving the skills of diagnosis and monitoring are crucial to lower the incidence of birth defects.

Conclusions

A higher average number of ultrasound scans per pregnancy was observed in the rural regions. Regional variation existed in the frequency of specific congenital anomalies.

Pregnancy outcomes of congenital anomalies at birth were related to a higher number of prenatal maternal screening examinations. Greater awareness of regional differences in the frequency of various anomalies is needed.

Further studies are recommended in this field for better understanding. Surveillance systems that are able to analyse the efficiency of US examinations need to be developed for the early prenatal detection of congenital anomalies.

Declaration of Competing Interest

None.

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