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ORIGINAL RESEARCH

Perinatal death in the Nordic countries in relation to gestational age: The impact of registration practice

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Abstract

Introduction: Although perinatal death rates in the Nordic countries are among the lowest in the world, the risk of perinatal death is unevenly distributed across the Nordic countries, despite similarity in health care systems and pregnancy care. Birth registration practices across countries may explain some of the differences. We investigated differences in national registration of perinatal mortality within the Nordic countries and its impact on perinatal mortality according to gestational age.

Material and Methods: Each country provided information by answering a questionnaire about registration of perinatal deaths. Furthermore, we collected aggregated count data based on Medical Birth Registries (MBR) from all Nordic countries in 2000 to 2021. Perinatal mortality was defined as stillbirth or neonatal death occurring within first 7 days of life. Data were grouped into six groups by gestational age (GA): extremely preterm (>28 + 0 weeks, subdivided into 22 + 0–23 + 6 and 24 + 0–27 + 6), very preterm (GA 28 + 0–31 + 6), moderate preterm (GA 32 + 0–33 + 6), late preterm (GA 34 + 0–36 + 6), term (GA 37 + 0–40 + 6) and late term or post-term birth (GA ≥ 41 + 0). Perinatal mortality rate and risk ratio with 95% confidence intervals were calculated per country for each gestational age group. For Denmark, separate analyses included and excluded induced abortions.

Results: The study included 6 343 805 live births, 22 727 stillbirths and 8932 live-born infants who died within the first week of life after GA 22 + 0. Further 25 057 births were included with GA < 22 + 0, unknown GA and as a result of induced abortion. Overall, perinatal mortality rates decreased during year 2000–2021 in all Nordic countries. After exclusion of induced abortions, the perinatal mortality rate was similar in the five Nordic countries. The perinatal mortality rate for extremely preterm born infants was highest in Denmark, whereas the highest rate among infants born late term/post-term was in Sweden.

Abbreviations: BW, birthweight; CI, confidence interval; GA, gestational age; MBR, Medical Birth Registries; NOMBIR, Collaboration between the Nordic Medical Birth Registries; PM, perinatal mortality; PMR, perinatal mortality rate; RR, risk ratio; WHO, World Health Organization.

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Conclusions: The perinatal mortality rate in the Nordic countries is still decreasing, especially in the group of extremely preterm born infants. This study supports the need for further standardization of birth registration practices to ensure the validity of international comparisons.

KEYWORDS
gestational age, medical birth, Nordic countries, perinatal mortality, perinatal mortality rate, register, register, stillbirth

1 | INTRODUCTION

Perinatal mortality (PM) remains a significant health concern in high-income countries and is a dreaded complication of pregnancy with profound economic and psychosocial consequences, such as increased risk of posttraumatic stress disorder (PTSD) and depression.[1,2]

In 2011 and 2016, two issues of The Lancet focused on stillbirth as a disregarded public health issue and called for action to reduce the stillbirth rate in high-income countries.[3] It was claimed that despite improvements in healthcare, prenatal care, and childbirth practices in high-income countries over the past decade, and thus reduced mortality rates, there is still potential for further enhancement.

The perinatal mortality rate (PMR) serves as a key indicator for assessing the quality and effectiveness of perinatal care and international comparisons are used to encourage countries to improve perinatal health.[4] Despite smaller differences, the overall healthcare systems and clinical recommendations regarding antenatal care are comparable between the Nordic countries, but there are still differences in the reported PM.[5–11]

The perinatal mortality rate is defined as number of stillbirths and deaths that occur in the first week of life per 1000 total births by the World Health Organization (WHO). The perinatal period starts at the gestational age (GA) of 22 completed weeks [and a birthweight (BW) ≥ 500 g] and extends until seven completed days after birth.[12] Even though the definition of the start of the perinatal period is uniform (GA 22 weeks) the threshold for active interventions such as steroids for lung maturation, cesarean delivery on fetal indication and active neonatal life support have been reported to differ within the countries and can affect the neonatal survival rates.[10,11]

In the other end of the spectrum, post-term pregnancy is a known risk factor for perinatal death.[6,7,9] Different policies regarding surveillance of women pregnant beyond term and GA for offering induction of labor may affect the PMR.

A recent study by Hug et al.[13] analyzed the late stillbirth trend (occurring after 28 weeks of gestation) in 195 countries from 2000 till 2019 including the Nordic countries. This study reported a total reduction of 0.7–1.3 per 1000 births during the study period across the Nordic countries. However, the study focused on stillbirths from GA 28 weeks, consequently overlooking the substantial contributions of stillbirths happening in the gestational weeks between GA 22 and 28. When investigating the PM from GA 22 weeks, the rate is approximately one third higher.[14,15]

Key Message

Perinatal mortality differs among the Nordic countries, especially in newborns with borderline viability. Registration practice may contribute in relation to induced abortions, live-births before 22 weeks and twin pregnancies with fetal demise. Standardization and harmonization of definitions are highly recommended.

Comparing the PMR across countries in early GA, poses a challenge because of variation in the definition of legislation and thus also in perinatal mortality, particularly regarding terminations and multiple pregnancies where one twin dies before birth. The impact of terminations of pregnancy on the stillbirth rates have greatest impact around 22 weeks of gestation and decreasing to 28 weeks of gestation.[16]

Formally, infants born before GA 22 weeks who show signs of life defined by breathing, beating of the heart, pulsation of the umbilical cord or movements of voluntary muscles whether or not the umbilical cord has been cut should be included in PMR.[12] However, the classification of live birth may be differently interpretated in different countries, despite the general use of the WHO guidelines.[17] Furthermore, induced abortion may be initiated before 22 weeks of gestation, but if the birth occurs after this period, it will be included in the Medical Birth Registry (MBR). In rare cases of severe fetal malformations, a permission for induced abortion after 22 weeks can be obtained.

The hypothesis of this study is that the differences in national reporting and definitions of perinatal mortality in very comparable countries such as the Nordic countries, will significantly impact differences in PMR. Therefore, the objective of this study is to investigate the PMR according to GA in the Nordic countries and how national reporting practices may contribute to the differences in the PMR across countries.

2 | MATERIAL AND METHODS

The Nordic countries, including Denmark, Finland, Iceland, Norway, and Sweden, have a total number of approximately 275 000–300 000

newborn infants per year. Each of the Nordic countries established a Medical Birth Registry (MBR) over the period 1967 (Norway) to 1987 (Finland) and provide validated data for quality improvement and research.[18,19] The registers contain data on the birth of liveborn and stillborn infants in each country.

This study was conducted within the collaboration between the Nordic Medical Birth Registers (NOMBIR). Each country delivered anonymized, aggregated count data on the PM from 2000 to 2020 (Iceland) and 2000–2021 (Denmark, Finland, Norway and Sweden) by GA. The data were provided in Microsoft Excel tables by the NOMBIR representative from each country's MBR.

In Sweden, stillbirths before GA 28+0 weeks were not registered in MBR before year 2008. Furthermore, a representant working on the MBR in each country filled in a questionnaire with the following questions:

1. What is the definition of perinatal death in your country?
2. How are stillbirths reported to the register? Has the procedure changed from year 2000 until now?
3. Are stillbirths after GA 22 weeks defined as perinatal death if they are a result of an induced abortion?
4. Are infants born after induced abortion showing signs of life reported and included as perinatal deaths? And if positive, are there any limits on gestational age, BW, time from birth to death or other issues?
5. How are multiple pregnancies handled in the register, where one or more fetuses die intrauterine either by fetal reduction or spontaneous intrauterine death? If they are included, are they reported separately, and how is it defined?

To evaluate the impact of different registration practices in different countries, we measured PMR with and without inclusion of (1) infants with unknown GA, (2) liveborn infants born before GA 22+0 weeks, and (3) infants born after GA 22+0 weeks registered with a code for induced abortion.

2.1 | Statistical analyses

The aggregated count data from each country were handled in R version 4.2.2 (2022-10-31) and Excel. We calculated PMR with 95% confidence intervals (CI). PMRs are expressed as the sum of fetal deaths (stillbirths) and deaths during the first week after birth per 1000 infants (all births in the specific gestational age).[20] The R package "Epitools" was applied to calculate the risk ratio (RR) and 95% CI for PM in each country for following GA groups: extremely preterm (GA < 28 weeks, subdivided into 22+0–23+6 and 24+0–27+6), very preterm (GA 28+0–31+6), moderate preterm (GA 32+0–33+6), late preterm (GA 34+0–36+6), term (GA 37+0–40+6) and late term/post-term (GA ≥ 41+0). Sweden was chosen as reference due to the largest population.

3 | RESULTS

3.1 | National reporting practices

The definitions of perinatal death varied among the Nordic countries and are reported in Table 1. In Denmark and Finland, pregnancies are dated in first trimester, whereas in Norway and Sweden mostly in second trimester. In Denmark and Finland, livebirths born before GA 22+0 weeks are included in the MBR regardless of BW. In Norway, these cases are classified as miscarriages and not included in the MBR if GA < 22+0 weeks and BW < 500 g. In Sweden, live births before GA 22+0 are registered in the category "unknown GA".

3.1.1 | Induced abortions

In Denmark, infants showing sign of life born after induced abortion before GA 22+0 weeks are included in the MBR and all births after GA 22+0 weeks following induced abortion are reported as perinatal deaths. Until September 2022, induced abortions were included in the PMR estimates in the Danish MBR, but since then, it has been possible to distinguish these cases.

In Finland and Norway, deliveries following induced abortions are not included in the MBR, regardless of GA and signs of life. In Sweden and Iceland, theoretically, an induced abortion delivered after GA 22+0 weeks would be included in MBR, but the number of such cases is expected to be very low, <5 cases per year in Sweden and <5 cases in total for Iceland during the study period.

3.1.2 | Intrauterine death and fetal reduction in multiple pregnancies

Also, the handling of multiple pregnancies with intrauterine death or fetal reduction differs among the Nordic countries. In Denmark, Finland, and Norway (until May 2023), they will be reported as stillbirths if one twin dies in uterus before GA 22+0 weeks and the delivery takes place at or after GA 22+0 weeks.

In Sweden and Iceland, the estimated GA at death in cases with intrauterine death of one twin determines if it is considered a stillbirth (GA ≥ 22+0 weeks) or a miscarriage (GA < 22+0 weeks). Miscarriages are not reported to the MBR. Thus, if one of the fetuses die in GA 33+0 in a multiple pregnancy and the delivery takes place in GA 40+0, then the pregnancy will be registered as one stillbirth in GA 33+0 and one livebirth in GA 40+0. If one of the fetuses die in GA 16+0 and the delivery takes place in GA 40+0, the pregnancy will be registered with only a livebirth in GA 40+0 weeks.

Considering fetal reduction in multiple pregnancies, the reduced fetus is in Finland, Norway and Sweden not included in the PMR. In Denmark, the reduced fetus shall be included if the birth of the other fetus takes place after GA 22+0 weeks, irrespective of GA at reduction, and will be reported as a perinatal death.

TABLE 1 Overview over the registration practices in the Nordic Countries.

	Country				
	Denmark	**Finland**	**Iceland**	**Norway**	**Sweden**
Dating of pregnancy	First trimester ultrasound	First trimester ultrasound	First trimester ultrasound (about 75–80%), otherwise Second trimester ultrasound. In case of IVF: GA calculated from embryo transfer date	Second trimester ultrasound	Ultrasound (mostly in second trimester) is preferred or LMP
What is the definition of perinatal death in your country?	Liveborn infants who die within 1 week after birth (0–6 days) *regardless* of GA *or* stillbirth from GA ≥ 22 + 0 weeks	Liveborn infants who die within 1 week after birth (0–6 days) *regardless of* GA *or* stillbirth from GA ≥ 22 + 0 *or* with a birthweight ≥of 500 g	Liveborn infants who die within 1 week after birth (0–6 days) or stillbirth *from* GA 22 + 0 weeks	Liveborn infants who die within 1 week after birth (0–6 days) or stillbirth *from* GA 22 + 0 weeks *or* with birthweight ≥500 g Live births before GA 22 + 0 with birthweight <500 g are classified as "spontaneous abortions"	Liveborn infants who die within 1 week after birth (0–6 days) *regardless* GA *or* stillbirth from GA ≥ 22 + 0 Live births before GA 22 + 0 will be registered as "unknown GA"
How are stillbirths reported to the register? Has the procedure changed during from year 2000 until now?	From 2000 to primo 2019, all stillbirths are reported by the midwife in paper forms. From 2019, they are reported directly to the National Patient register. In 2004 the definition for stillbirth changed from GA ≥28 + 0 to GA ≥22 + 0	All birth hospitals (currently 23) report all births. If the birth occurs outside hospital planned, the midwife reports the birth. MBR is linked to Cause-of-Death Register to complete any missing stillbirth or infant death	Live births and stillbirths from 22 + 0 are reported by midwifes on a specific electronic form and did not change between 2000 and 2020. A week later, information related to the infants is added. The forms are validated and then transferred to MBR	Stillbirths are reported in the same form as livebirths with relevant information The procedure has overall not changed since 2000	They are reported by midwifes and obstetricians at maternity wards Before 2008 stillborn with GA ≤28 + 0 was not collected
Are stillbirths after GA 22 weeks defined as perinatal death if they are a result of an induced abortion?	Yes, but since autumn 2022 reported separately, also backwards in time	No	No, not in theory, but a few cases has been recorded as stillbirths in the register 2000–2020 (and included in these data)	No	Yes However, if the procedure is not conducted at maternity ward, it will not be registered in the MBR
Are infants born after induced abortion showing signs of life reported and included as perinatal deaths?	Yes, but since autumn 2022 reported separately, also backwards in time	No	Births after GA ≥ 22 + 0 should be registered. However, induced abortions after GA 22 weeks are very rare in Iceland especially unlikely to have been registered as live births	No	In theory yes, if occurring ≥ GA 22 + 0

TABLE 1 (Continued)

	Country				
	Denmark	Finland	Iceland	Norway	Sweden
How are multiple pregnancies where one or more fetuses are stillborn handled in the register?	In case of intrauterine death of one twin before GA 22+0, it will be reported as stillbirth *if the delivery takes place after* GA 22+0	Multiple births are classified according to the number of fetuses at birth. In case of intrauterine death of one twin before GA 22+0, it will be reported as stillbirth *if the delivery takes place after* GA 22+0	The birth of each infant was registered on separate forms 2000–2020. It is likely that intrauterine deaths were registered as stillbirths if the GA *at the time of death* occurred after GA 22+0 and as miscarriage if it occurred before GA 22+0	Outcomes for each infant are reported separately. In case of intrauterine death of one twin before GA 22+0, it will be reported as stillbirth *if the delivery takes place after* GA 22+0. This practice was changed in 2023	Intrauterine deaths were registered as stillbirths if the GA *at the time of death* occurred after GA 22+0 and as miscarriage if it occurred before GA 22+0
Fetal reduction in multiple pregnancies	According to Danish law, a newborn *must be* reported as stillborn if the birth takes place after GA 22+0, and in cases with signs of life as live birth regardless of GA and fetal reduction during pregnancy	Fetal reductions are *not* included: For example, a termination of one fetus at 21 weeks and live birth at 22 weeks is calculated as a singleton birth	This was never clearly defined, but likely included after GA 22+0	If one fetus in a multiple pregnancy dies due to fetal reduction from week 16+0 onwards and the reason is a fetal anomaly, the fetus will *not* be included in the perinatal mortality	Fetal reduction is treated as abortions and therefore *not* included

Abbreviations: GA, gestationel age; LMP, last menstrual period; MBR, Medical Birth Register.

3.2 | Development in PMR

This study included a total of 6 391 589 infants, including deliveries with GA < 22 + 0 weeks, unknown GA and induced abortions, across the Nordic countries from 2000 to 2021. Iceland was only able to provide data from 2000 to 2020. Including only GA ≥ 22 + 0 (excluding unknown GA, induced abortions and GA < 22 + 0), there was a total of 6 366 532 infants, of which 6 343 805 were live births, 22 727 were stillbirths (3.6/1000 births) and 8932 were liveborn infants who died within the first week of life (1.4/1000 live births) (Table 2). During the study period the PMR decreased in all the Nordic countries (Figure 1). Denmark had the highest PMR (5.3/1000 infants) in 2021, whereas the lowest rate was observed in Finland (3.2/1000) (Figure 1). When excluding induced abortions, the PMR in Denmark decreased from 5.3/1000 infants to 4.4/1000 infants and declined to the same level as the other countries (Figure 1 and Table S1).

Dividing data into 5-year periods, we investigated the development of PMR in the deliveries of extreme preterm, very preterm, moderate preterm, late preterm, term and late term/post-term and found a decreasing or steady trend over time in all gestational age groups (Table 3).

3.3 | Risk of perinatal death across the Nordic countries

Examining the last time period (2016–2021), and excluding induced abortions from the Danish data, the risk of perinatal deaths in relation to the earliest GA for extremely preterm infants (GA 22 + 0–23 + 6) was higher in Norway [RR: 1.26 (95% CI: 1.15–1.39)], Finland [RR: 1.23 (95% CI: 1.11–1.38)] and Denmark [RR: 1.61 (95% CI:1.50–1.74)] compared with Sweden (Figure 2). Among infants born at GA 24 + 0–27 + 6, the risk of perinatal death was higher in Denmark [RR: 1.15 (95% CI:1.01–1.30)], whereas the other Nordic countries did not have any notable differences compared with Sweden. In very preterm deliveries (GA 28 + 0–31 + 6), the risk of perinatal death was lower in Norway [RR 0.79 (95% CI: 0.66–0.95)] compared with Sweden. In Iceland, the risk of perinatal death was lower [RR 0.47 (95% CI: 0.21–1.04)] than Sweden, even though it was not statistically significant (Figure 2).

Moreover, for the same 5-year period, in moderate preterm deliveries (GA 32 + 0–33 + 6) and late preterm deliveries (GA: 34 + 0–36 + 6), the risk of perinatal death was lower in Norway and Denmark compared with Sweden. At term, the risk of perinatal death was significantly lower in Finland and Denmark compared with Sweden. In late term/post-term deliveries, the RR was lower in Norway, Finland and Denmark compared with Sweden (Figure 2).

When examining the overall risk ratio for perinatal death across all GA, we found that the risk is slightly lower in Iceland [RR 0.79 (95% CI: 0.63–0.99)] and Finland [RR 0.84 (95% CI: 0.79–0.90)] compared with Sweden. In contrast, the risk Norway [RR 0.94 (95% CI: 0.88–1.00)] and Denmark [excluded induced abortion, RR 0.97 (95% CI:0.92–1.03)] is comparable with that in Sweden. However, when

TABLE 2 Overview over study population.

	Study population for main analysis				Other			
	All*	Live births* (%)[a]	Stillbirths* (%)[a]	Died 0–6 days* (%)[b]	GA ≤ 21 + 6 (%)[c]	Unknown GA (%)[d]	Unknown GA and PM (%)[e]	Induced abortions registered in MBR (%)[f]
Denmark	1373666	1368529 (99.63)	5137 (0.37)	2549 (0.19)	347 (0.03)	11639 (0.84)	374 (3.21)	680 (0.05)
Finland	1224197	1220421 (99.69)	3776 (0.31)	1662 (0.14)	21 (<0.01)	3071 (0.25)	53 (1.73)	1043** (0.08)
Iceland	92015	91718 (99.78)	297 (0.32)	94 (0.10)	8 (0.01)	100 (0.11)	<5 (<5.00)	–
Norway	1286472	1281401 (99.61)	5071 (0.39)	1725 (0.13)	156 (0.01)	6397 (0.49)	101 (1.58)	–
Sweden	2390182	2381736 (99.65)	8446 (0.35)	2900 (0.12)	–	1039 (0.04)	44 (4.23)	–
All	6366532	6343805 (99.6)	22727 (0.36)	8932 (0.14)	515 (0.01)	22246 (0.35)	573 (2.58)	1723 (0.03)

Abbreviations: GA, gestational age; MBR, medical birth register; PM, perinatal mortality.

[a]% of all births.

[b]% of all live births.

[c]% of all births + GA ≤ 21 + 6.

[d]% of all births + unknown GA.

[e]% of unknown GA.

[f]% of all births + induced abortions registered in MBR.

*Including GA ≥ 22 + 0 in the period 2000–2021. Excluding unknown GA, induced abortions and GA < 22 + 0. **Not included in PM.

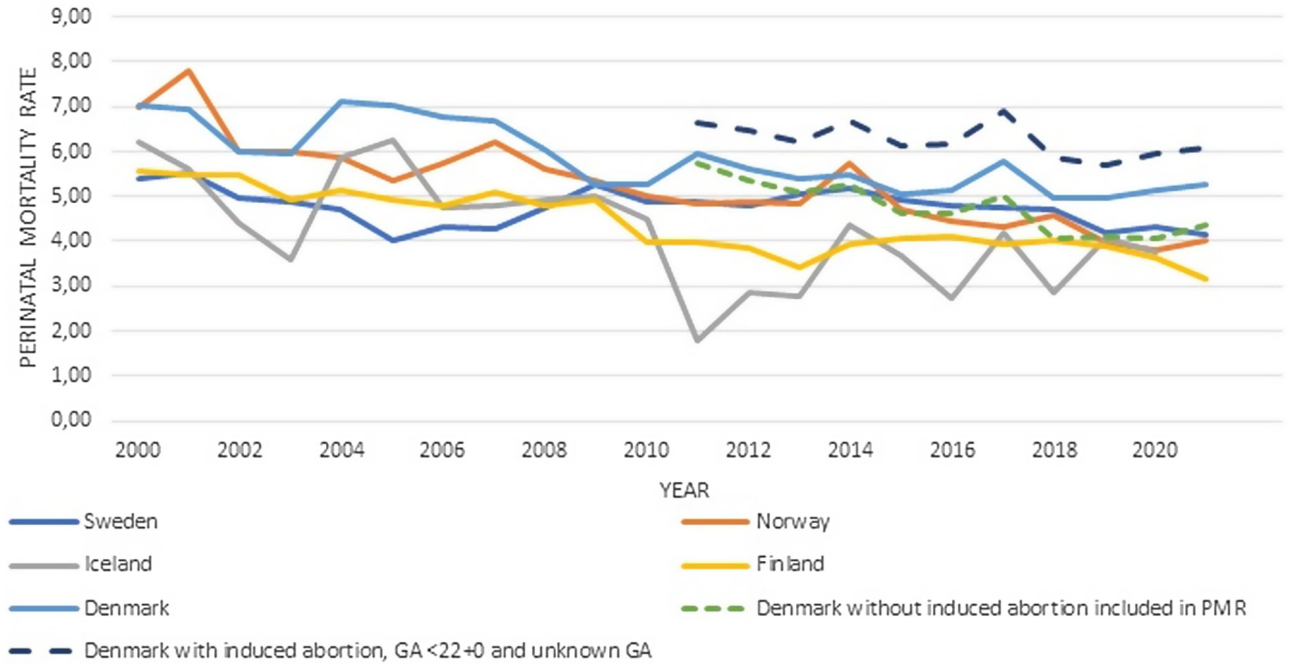

FIGURE 1 The trends in the perinatal mortality rate (PMR) from 2000 to 2021.

including the induced abortions in the Denmark in the analysis, we found a significantly higher risk [RR 1.39 (95% CI 1.31–1.47)] for perinatal death compared with Sweden (Figure 2).

A total of 680 births resulting from induced abortion were registered in Denmark during the study period, accounting for approximately 8.2% of all perinatal deaths in Denmark when included (Table 2). Finland reported 1043 late induced abortions at 22 + 0 to 24 + 0 weeks. However, these cases were not included in the perinatal mortality rates reported from Finland.

3.4 | Inclusion of infants with unknown GA or GA < 22 + 0

Investigating the number of registered deliveries with GA < 22 + 0 weeks during the study period, most cases were reported in Denmark ($n = 344$, 67.1% of all deliveries with GA < 22 + 0 weeks in all countries during the study period) with an increasing trend (Table 2 and Figure 3). Sweden does not register these cases, and Iceland and Finland have very few cases. Norway

TABLE 3 The perinatal mortality rate (PMR) calculated for each GA for each country in the periods 2000–2005, 2006–2010, 2011–2015 and 2016–2021.

GA	22+0–23+6	24+0–27+6	28+0–31+6	32+0–33+6	34+0–36+6	37+0–40+6	>=41+0
	PMR (95%CI)	PMR (95%CI)	PMR (95%CI)	PMR (95%CI)	PMR (95%CI)	PMR(95%CI)	PMR (95%CI)
2000–2005							
Sweden[b]	–	–	114.6 (104.6–124.5)	54.4 (48.2–61.2)	18.6 (17.0–20.4)	2.4 (2.3–2.6)	2.5 (2.2–2.7)
Norway	821.9 (781.9–857.2)	296.4 (271.8–321.8)	88.7 (78.3–100.0)	41.6 (35.2–48.9)	16.5 (14.6–18.5)	2.6 (2.4–2.8)	2.1 (1.8–2.4)
Iceland	941.2 (803.2–992.8)	371.4 (258.9–495.2)	86.7 (47.0–143.6)	60.8 (30.7–106.1)	14.7 (8.2–24.1)	2.1 (1.4–2.9)	0.4 (0.1–1.3)
Finland	904.3 (866.9–934.1)	364.4 (334.0–395.6)	105.5 (92.5–119.6)	52.4 (44.2–61.7)	17.9 (15.8–20.2)	1.8 (1.6–1.9)	1.3 (0.1–1.6)
Denmark	901.9 (859.6–934.9)	309.5 (284.3–335.6)	122.8 (111.8–134.5)	44.9 (38.8–51.7)	18.3 (16.5–20.3)	2.9 (2.7–3.1)	2.6 (2.3–3.0)
2006–2010							
Sweden[b]			98.5 (89.0–108.8)	47.9 (41.7–54.6)	15.5 (14.0–17.2)	2.1 (2.0–2.3)	2.1 (1.9–2.4)
Norway	900.9 (863.0–931.2)	306.8 (278.2–336.5)	90.3 (78.8–102.9)	38.2 (32.2–46.7)	14.0 (12.2–16.1)	2.2 (2.0–2.5)	1.5 (1.2–1.8)
Iceland	931.0 (772.3–991.5)	373.3 (264.3–492.7)	66.2 (32.2–118.4)	15.5 (3.2–44.5)	13.2 (7.1–22.5)	1.7 (1.1–2.5)	0.8 (0.3–1.9)
Finland	864.2 (816.9–903.0)	321.2 (289.4–354.3)	112.6 (98.1–128.5)	41.8 (33.9–51.1)	14.0 (12.2–16.1)	1.6 (1.5–1.8)	1.1 (0.8–1.3)
Denmark	968.8 (948.2–982.9)	352.6 (323.8–382.3)	80.8 (70.6–92.1)	29.1 (23.4–35.7)	15.2 (13.3–17.3)	2.2 (2.0–2.4)	1.6 (1.3–1.9)
2011–2015							
Sweden	637.2 (595.6–677.3)	250.8 (230.9–271.6)	105.8 (95.8–116.4)	42.6 (36.8–49.0)	16.9 (15.3–18.7)	2.1 (1.9–2.2)	1.8 (1.6–2.0)
Norway	790.7 (740.3–835.3)	295.3 (267.0–324.7)	92.6 (88.2–106.1)	41.6 (34.2–50.2)	14.9 (12.9–17.1)	1.9 (1.7–2.1)	1.2 (0.9–1.4)
Iceland	772.7 (546.3–921.8)	166.7 (74.8–302.2)	38.1 (10.5–94.7)	27.0 (8.8–61.9)	8.5 (3.7–16.6)	1.2 (0.7–1.9)	1.2 (0.4–2.6)
Finland	767.4 (705.2–822.2)	240.9 (210.6–273.3)	89.6 (75.9–104.9)	38.9 (31.1–48.1)	14.4 (12.4–16.7)	1.5 (1.3–1.7)	1.1 (0.8–1.4)
Denmark	958.0 (931.7–976.3)	305.5 (276.6–335.6)	88.8 (76.9–101.9)	34.2 (27.6–41.8)	12.3 (10.5–14.4)	1.9 (1.7–2.1)	0.9 (0.7–1.1)
2016–2021							
Sweden	568.5 (529.0–607.4)	230.1 (212.2–248.8)	95.1 (86.2–104.5)	49.2 (43.3–55.5)	15.3 (13.9–16.9)	2.0 (1.8–2.1)	1.7 (1.5–1.9)
Norway	718.1 (669.7–763.0)	230.6 (204.4–258.5)	75.0 (64.1–87.1)	33.8 (27.3–41.3)	11.5 (9.8–13.3)	1.7 (1.6–1.9)	1.2 (1.0–1.5)
Iceland[a]	681.8 (451.3–861.4)	187.5 (89.5–326.2)	44.8 (16.6–94.9)	28.8 (7.9–72.0)	11.7 (6.1–20.4)	1.7 (1.1–2.5)	0.7 (0.1–2.0)
Finland	701.8 (637.8–760.4)	240.6 (209.3–274.2)	96.3 (81.4–112.5)	41.3 (33.2–50.8)	15.4 (13.3–17.7)	1.4 (1.3–1.6)	1.2 (0.9–1.5)
Denmark	918.2 (885.9–943.7)	263.8 (237.6–291.3)	80.7 (70.2–92.3)	39.6 (33.0–47.2)	12.1 (10.4–13.9)	1.5 (1.4–1.7)	1.0 (0.8–1.2)
DK incl. TOP	952.4 (933.1–967.4)	270.6 (244.3–298.2)	–	–	–	–	–

[a]Data from 2016 to 2021.

[b]Data on stillbirth at GA < 28+0 is available after 2008.

reported 140 cases during the study period with a decreasing trend (Figure 3).

A total of 21 709 infants with unknown GA were reported, where the highest incidences were observed in Denmark ($n = 11\,639$; 52.3% of all with unknown GA) and Norway ($n = 6397$; 28.8% of all with unknown GA). Of these deliveries with unknown GA, 2.6% ($n = 573$) died in the perinatal period. Figure 4 illustrates the changes in registration in deliveries with unknown GA over time.

4 | DISCUSSION

This comprehensive Nordic study based on all deliveries in Denmark, Finland, Iceland, Norway and Sweden showed a decreasing PMR from 2000 to 2021. Despite comparable health care systems in the Nordic countries, this study demonstrated national differences in PMR, both for the entire national birth cohorts as well as within different GA categories. We found that variation in the registration of perinatal death across the Nordic countries may influence the PMR, especially in the earliest GA with borderline viability. The differences are primary related to inclusion of liveborn infants born after induced abortion, inclusion of livebirths before GA 22+0 weeks, twin pregnancies with fetal reduction, and infants with unknown GA.

After exclusion of induced abortions, the overall PMR was similar in the Nordic countries and the overall RR of perinatal death did not differ significantly, though slightly lower in Iceland and Finland. Among extremely preterm infants (22+0–23+6 weeks) the RR was lowest in Sweden and highest in Denmark. In contrast, the RR among late term/post-term infants was lowest in Denmark and highest in Sweden.

The PMR is a key indicator of public health and reflects the quality and effectiveness of maternity and perinatal care.[4] International comparison across comparable countries is important to motivate improvement of maternal and perinatal care and encourage a political debate about improvement of relevant health care. Essential for comparisons of PMR is harmonization in definitions and registration practices. The challenge in this is illustrated in the study by Gissler

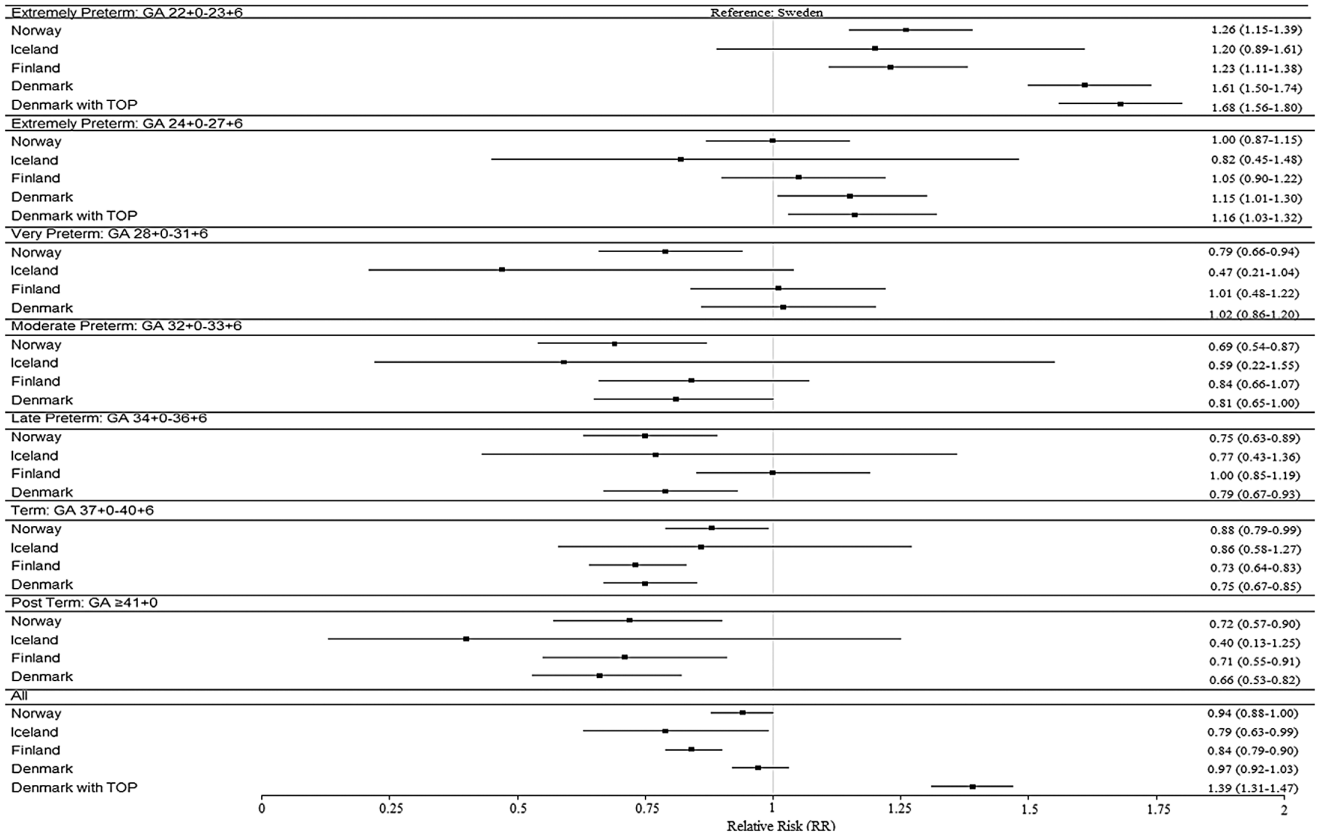

FIGURE 2 Risk ratio (95% CI) for perinatal mortality in the Nordic countries with Sweden as reference in the period 2016–2021.

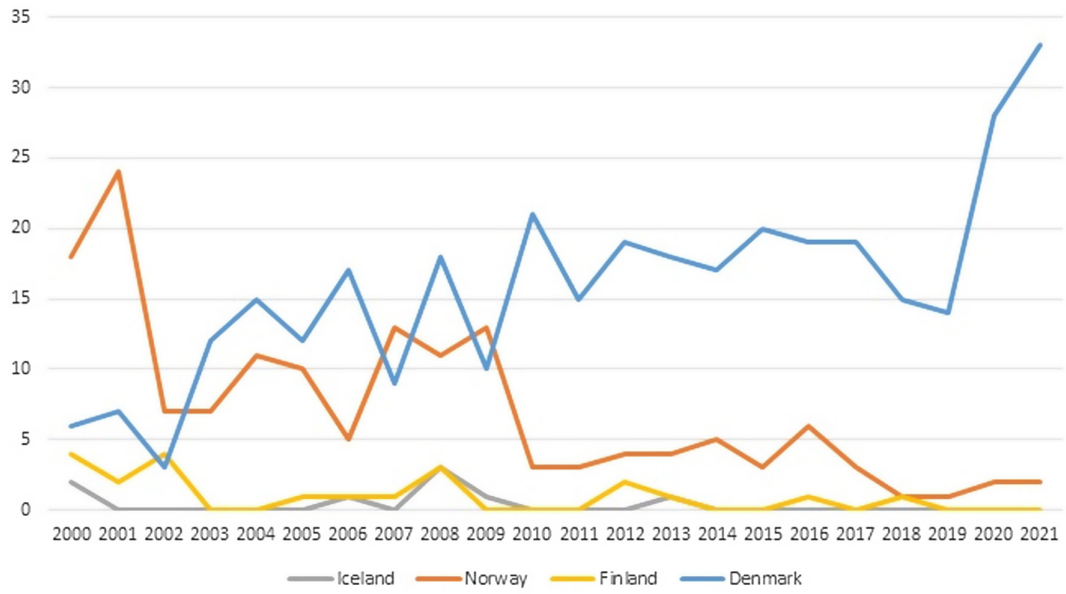

FIGURE 3 The number of registered infants with GA ≤ 21 + 6 during the study period from 2000 to 2021.

et al. comparing PMR across European countries, based on data from Eurostat and Euro-Peristat.[21] The study revealed notable disparities between the two data sources within each country, leading to discrepancies in the mortality rate reported for the same country. This disparity persisted after aligning of the inclusion criteria. This may be due to different data-sources, different updates in the data-sources and different definitions in the data-sources. Furthermore, a study by Deb-Rinker et al.[22] found a substantial international variation in the frequency and mortality of infants delivered extremely preterm with GA near viability of life comparing data across the

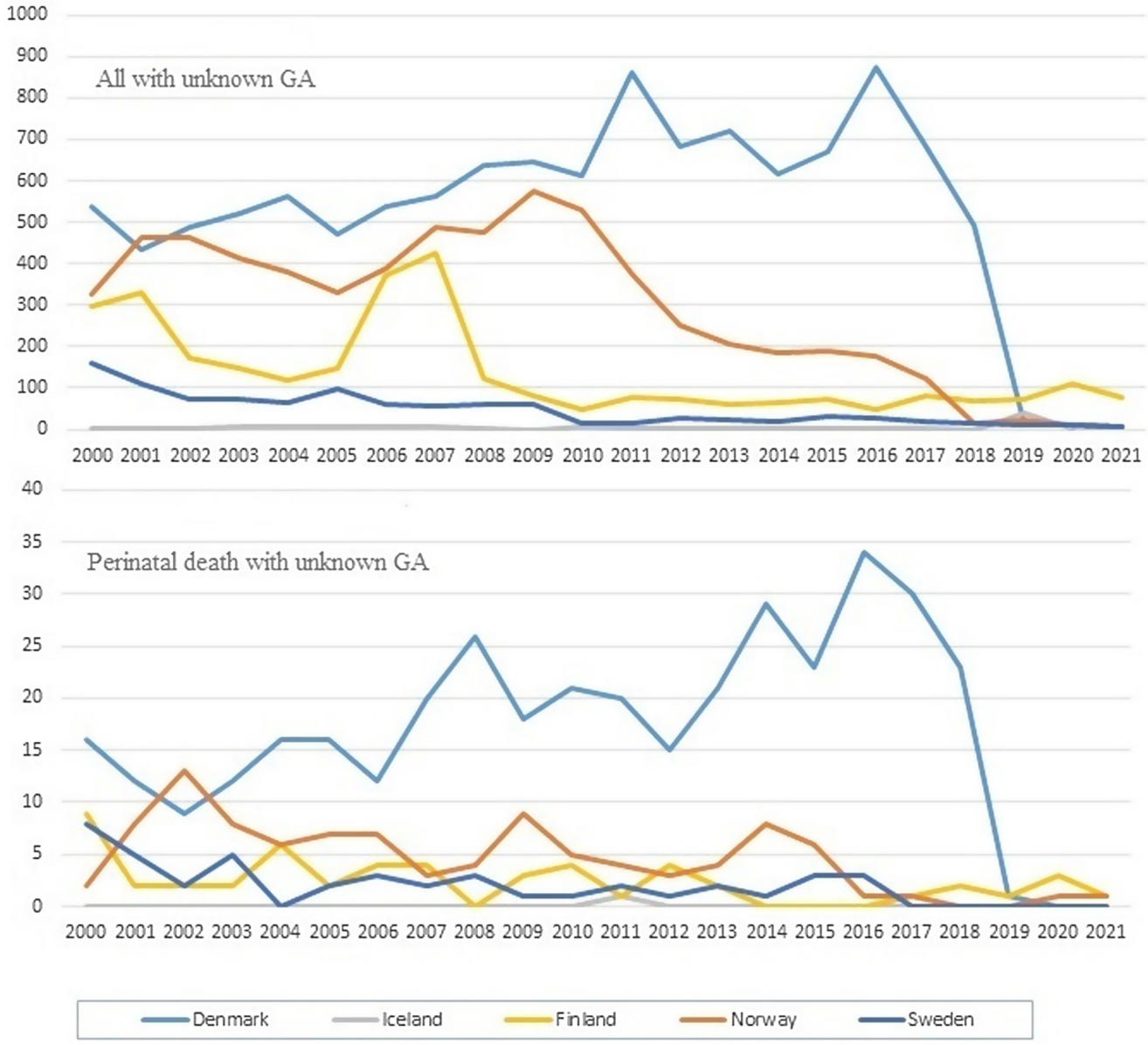

FIGURE 4 The overall numbers of infants with unknown GA as well as the number of perinatal deaths with unknown GA during the study period (2000–2021).

Nordic countries, USA, and Canada. This study raised a suspicion that the observed variation partly was due to differences in birth registration which is supported by our study. The impact of registration practices is supported by Smith et al.[23] who found that the variation in neonatal mortality among periviable infants across seven high in-come countries was partly due to the registration of stillbirth vs. livebirth.

In the present study, we found a difference between the Nordic countries in the handling of PM, where especially the inclusion/exclusions of live birth before 22 weeks and deliveries after induced abortions differ. When using the same definitions, the differences in PMR among the Nordic countries was reduced, yet a difference persisted, which may be due to population demographic and differences in the healthcare approaches of pregnant women and neonates. It may therefore be beneficial to standardize the criteria even more across countries making comparisons more reliable and thereby ensure that observed differences are due to genuine disparities and not a result of registration.

One of the challenges in perinatal epidemiology, especially when comparing extreme preterm and post-term deliveries across countries, is the differences in methods used for estimation of due date.[24] The standard method to determine GA in the Nordic countries is ultrasonography, but the timing of the scan differs across the countries (first or second trimester). Differences in early growth and other factors like maternal obesity, can lead to misclassification of GA, which may result in systematic bias.[24,25] Dating of pregnancy in first trimester instead of second trimester has been found to significantly increase in the rate of late term and post-term deliveries

and a significantly decrease in the rate of pre-term deliveries.[26] This variation in the estimation of GA[26] across the Nordic countries must be considered comparing PMR, especially in deliveries around the threshold for viable GA and can also have an impact on the survival rates in early GA, where even small inaccuracies on a few days in estimating the GA have a high impact.

The inclusion of induced abortions in perinatal mortality has an impact on the PMR. A study from 2008 examined the impact of induced abortions on very preterm mortality in 10 regions from nine European countries and found that induced abortions accounted for one-tenth of all registered very preterm births with great variation across observed regions.[27]

Until September 2022, induced abortions have been included in the reported PMR in Denmark and accounts for approximately 0.13% of all deliveries registered in MBR. When excluding these and the infants born before GA 22+0 with sign of life, we found a significant decrease in the PMR in Denmark, which illustrates the need for a uniform definition in studies of PMR in extremely preterm deliveries. A study by Delnord et al.[28] suggested standardizing comparison between countries by excluding births between 22+0 and 23+6 weeks of gestation and cases of termination of pregnancy. Excluding cases at GA ≤ 24+0 will omit a substantial portion of care provision, especially considering survival focused care in these GA is increasing.

The present study has both strengths and limitations to consider. First, a strength is the use of validated nationwide data from Denmark, Finland, Iceland, Norway and Sweden covering a time frame of >20 years. This comprehensive dataset gives the opportunity to examine the patterns and changes in perinatal mortality over two decades and enables comparisons across the Nordic countries. Nevertheless, certain limitations should be considered when interpreting the results. Datasets of this size potentially contain systematic errors, and systematic reporting differences can occur even within a single country. The use of aggregated data based on GA and with no information about BW meant that we could not cross-check cases of PM. It would be beneficial to include data on birthweight so this can be investigated in relation to the GA, especially in the early GA on viability of life. Furthermore, different methods for estimation of GA are important to take into consideration.

Although healthcare systems are considered comparable, they can differ significantly in facility quality, care practices and provider expertise. This study presents national data, but variations in clinical practices at the provider and facility levels are not reported. These variations may contribute to differences in PMR within each country. Future research could investigate national differences at the provider and facility levels, which may provide valuable insights. At this level, the classification of a birth as a miscarriage, stillbirth or livebirth has consequences. This classification affects access to resources such as maternity and paternity leave, funeral coast and the official birth and death registration.[17] Furthermore, it can impact the acknowledgment of parents who have lost a newborn. It could be important to investigate how such issues affect health care professionals' registration of these cases.

In this study, we only included cases of early neonatal death within first week of life. Due to advancements in neonatal intensive care, it is increasingly possible for, especially, the younger neonates to survive beyond the first week and potentially die later. These cases are not reported in our study, potentially leading to an overestimation of the survival rate at each gestational age. This could potentially explain the lower PMR observed in the early gestational ages in Sweden. Future research should include newborns who dies after 7 days.

5 | CONCLUSION

This comprehensive study based on all deliveries in Denmark, Finland, Iceland, Norway, and Sweden showed a decreasing trend in the PMR from 2000 to 2021. Furthermore, we demonstrated national differences in PMR, both for the total birth cohorts as well as within different GA categories. The study illustrates how differences in the registration practice of perinatal deaths may impact PMR, especially in the group of extremely preterm born infants. This illustrates the importance of harmonization in data and supports the need for further standardization of birth registration to ensure the validity of international comparisons.

AUTHOR CONTRIBUTIONS

This study is initiated by Lone Krebs and Maria Jeppegaard. Maria Kongerslev Frølich and Lene Friis Eskildsen contributed to the idea development. Maria Jeppegaard wrote the project protocol. Maria Kongerslev Frølich, Liv Cecilie Vestrheim Thomsen, Anna Heino, Eileen Liu, Johanna Gunnarsdottir, Rupali Rajendra Akerkar, Mikael Ohlin, Karin Källén, Kari Klungsøyr and Mika Gissler has contributed with delivery of data. Lone Krebs, Maria Kongerslev Frølich, Liv Cecilie Vestrheim Thomsen, Anna Heino, Eileen Liu, Johanna Gunnarsdottir, Rupali Rajendra Akerkar, Mikael Ohlin, Karin Källén, Kari Klungsøyr and Mika Gissler hos contributed to the analytic strategy of the study and consultancy about epidemiological methods. Maria Jeppegaard performed the statistical analysis, interpreted the results, and wrote the manuscript draft. All authors have read the manuscript critically several times and have approved the final draft. All authors accept responsibility for the paper.

CONFLICT OF INTEREST STATEMENT

All authors declared no conflicts of interest.

ETHICS STATEMENT

All data were provided from NOMBIR in anonymized and aggregated form and no ethical approval was required for this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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