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ORIGINAL RESEARCH

Mediators affecting the higher risk of stillbirth among foreign-born women in Sweden: A nationwide cohort study

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Abstract

Introduction: In Sweden, a higher incidence of stillbirth has been observed among women originating from sub-Saharan Africa and the Middle East. In this nationwide cohort of more than 2 million births, we assessed the risk factors for stillbirth among foreign-born women with the aim of understanding which mediators have the largest impact on the elevated risk of stillbirth.

Material and Methods: This was a nationwide cohort study in Sweden including 2 300 391 births between 2000 and 2021. Data from the National Medical Birth Register were linked to data from Statistics Sweden using the personal identity number of the mother. Differences in maternal characteristics were analyzed between women divided into groups based on maternal country of origin. Logistic regression models were made with a forward selection strategy adjusting for potential mediators on the causal pathway from maternal country of origin to stillbirth.

Results: A significantly higher risk of stillbirth was observed among women originating from Eastern Europe, the Middle East/Northern Africa, sub-Saharan Africa, and Asia, with the highest risk observed in women originating from sub-Saharan Africa (OR 2.40, 95% CI 2.16–2.67, *p*-value <0.001). After adjusting for maternal risk factors, fetuses small for gestational age, and socioeconomic factors, women originating from sub-Saharan Africa still had a significantly higher risk of stillbirth (OR 1.28, 95% CI 1.14–1.44, *p*-value <0.001) compared to women originating from Sweden. The risk among the other groups of foreign-born women was, however, equal to the risk among women originating from Sweden. Mediation analysis showed that 31.2% of the effect of sub-Saharan origin on stillbirth was mediated through fetuses small for gestational age, 12.7% through educational level, and 16.9% through disposable income level.

Conclusions: In Sweden, women originating from sub-Saharan Africa face a significantly higher risk of stillbirth even after adjusting for known risk factors. The higher

Abbreviations: ART, assisted reproductive technology; BMI, body mass index; GA, gestational age; ICD, International Classification of Diseases; LGA, large for gestational age; SGA, small for gestational age.

risk is partly mediated by giving birth to fetuses small for gestational age and socioeconomic factors, but it cannot be explained altogether. This disparity may stem from multifactorial causes, including how risk populations utilize health care during pregnancies. Further studies are needed to find preventive measures to decrease the disparity.

KEYWORDS
epidemiology, obstetrics, stillbirth, Sweden

1 | INTRODUCTION

In many high-resource countries, racial and ethnic disparities have been reported to increase the risk for adverse perinatal outcomes.[1] In Sweden, a higher incidence of stillbirth has been observed among women born abroad,[2] especially among women originating from sub-Saharan Africa and the Middle East.[3–5] The elevated risk of stillbirth among women of these origins has also been confirmed in studies from other European countries.[6–8] Studying the effects of maternal origin is complex as different countries use different classifications of ethnicity. In Sweden, race/ethnicity is not registered, unlike in many other countries, which hampers the comparisons of Swedish study results with those from other countries. Instead, Statistics Sweden registers country of origin based on the self-reported country of birth when individuals are listed in the Swedish Population Register, provided they were not born in Sweden. Country of origin is therefore used in Swedish research.

There are many known risk factors for stillbirth, although an individual's specific risk factors have a low probability of predicting stillbirth.[9] In studies from the US, some risk factors for stillbirth are shown to be more common among non-Hispanic Blacks compared to non-Hispanic Whites, such as obesity, low maternal age, late or no attendance to prenatal care, low educational level, previous stillbirth, being pregnant with a fetus small for gestational age (SGA) and short interpregnancy interval. In contrast, other known risk factors, such as smoking and nulliparity, are less frequent among non-Hispanic Blacks.[10] Some risk factors, such as obesity, seem to have a more profound effect in non-Hispanic Blacks compared to non-Hispanic whites[11] and the risk difference increases with increasing body mass index (BMI) with the greatest risk difference observed at BMI greater than or equal to 40.[12] In Sweden, specific studies have not been conducted analyzing which risk factors for stillbirth are more common among foreign-born women.

Understanding which risk factors for stillbirth have the greatest impact on foreign-born women in Sweden is crucial for implementing targeted preventive measures to reduce the stillbirth incidence in these groups. To our knowledge, no study has systematically examined whether the risk factors for stillbirth found more frequently in foreign-born women in Sweden explain their excess risk of stillbirth.

In this nationwide cohort of more than 2 million births, we assessed the risk factors for stillbirth in women with different maternal country of origin with the aim of understanding which mediators have the highest impact on the elevated risk of stillbirth observed among foreign-born women in Sweden.

Key Message

Women from sub-Saharan Africa face a significantly higher risk of stillbirth in Sweden. This disparity is mainly mediated by socioeconomic factors and fetuses small for gestational age. Further research is needed to identify preventive measures and to address these inequalities.

2 | MATERIAL AND METHODS

This was a retrospective nationwide cohort study including 2 300 391 births between 2000 and 2021 in Sweden. After excluding multiple pregnancies and lethal malformations, the study included 2 205 094 births, of which 7401 were stillbirths. Data from the National Medical Birth Register were linked to data from Statistics Sweden using the personal identity number of the mother. The National Medical Birth Register is, since 1982, based on prospectively recorded information from antenatal, obstetric, and neonatal records. It includes approximately 98% of births in Sweden with high quality due to partly automated data extraction from standardized regional electronic health care records.[13]

Stillbirth was defined as antepartum or intrapartum fetal death where the infant was born without signs of life from gestational week 22 + 0 according to the World Health Organization and International Classification of Diseases (ICD)-10 definitions.[14,15]

BMI was based on self-reported or recorded height and measured weight at the first visit at prenatal care. Underweight was defined as BMI less than 18.5, normal weight was defined as BMI 18.5–24.9, overweight was defined as BMI 25–29.9, and obesity was defined as BMI equal to or above 30 according to the World Health Organization.[16]

Gestational age (GA) at birth was determined by first- or second-trimester ultrasound examination or, if ultrasound had not been performed, calculated from the first day of the last menstrual period as stated in the electronic patient record. During the studied time period, the Swedish recommendation for pregnancy dating[17] was

changed in accordance with international guidelines, recommending pregnancy dating in the combined ultrasound and biochemistry testing in gestational week 11+0–13+6, if performed. The combined ultrasound and biochemistry testing is not included in the maternal health care program for all pregnant women in Sweden, but a mid-trimester ultrasound examination is routinely offered to all. We followed the definition of the World Health Organization for preterm and term birth[18] and thus considered a birth preterm if GA at birth was 258 days or less, corresponding to gestational week 36+6. Similarly, if GA at birth was 259 days or more, corresponding to gestational week 37+0 and upward, the birth was considered term.

According to international standards, SGA was defined as birthweight less than the 10th percentile from the gender-specific mean weight for the GA.[19] Similarly, large for gestational age (LGA) was defined as birthweight above the 90th percentile from the gender-specific mean weight for the GA.[19]

Parity and previous obstetric history of intrauterine fetal death were based on self-reported data from the first visit at prenatal care. Parity was defined as being primiparous or multiparous. Maternal smoking was defined as self-reported smoking at the first visit at prenatal care. Invasive prenatal testing was defined as amniocentesis and/or chorionic villus sampling during pregnancy. Assisted reproductive technology (ART) was defined as in vitro fertilization leading to the current pregnancy. Presence of non-lethal malformations was obtained through ICD code Q according to ICD-10 recorded at hospital discharge after delivery.

The maternal medical diagnoses which were adjusted for as potential mediators were obtained through ICD codes recorded at hospital discharge after delivery according to ICD-10[14]: Diabetes mellitus type 1 (ICD code E10 or O24.0), Diabetes mellitus type 2 (ICD code E11 or O24.1), gestational diabetes mellitus (ICD code O24.4), preeclampsia (ICD code O14), essential hypertension (ICD code I10-I15 or O10) and gestational hypertension (ICD code O13).

From Statistics Sweden, we obtained maternal country of origin, highest attained educational level, and disposable income per consumption unit. Maternal country of origin was categorized into seven areas of origin: Sweden, the Nordic Countries/Western Europe/the US/Canada/New Zealand/Australia, Eastern Europe, Middle East/Northern Africa, sub-Saharan Africa, Asia, and South America. The highest attained educational level in the year of the current pregnancy was defined as primary school (up to 9 years of school), secondary school (10–12 years of school) and tertiary education. Disposable income per consumption unit is a weight system used by Statistics Sweden for comparisons of disposable income between different types of households. The household's economic standard is calculated by dividing the sum of all family members disposable income by the consumption weight that applies for the household. The consumption weight is a scale established by Statistics Sweden adapted to Swedish conditions in which a single-person household is equivalent to 1.0 and additional members increase the consumption weight depending on age.[20] We divided the disposable income per consumption unit into quartiles for each respective study year to adjust for economic growth in society, with the lowest income quartile defined as 1 and the highest income quartile as 4.

2.1 | Statistical analyses

Differences in maternal characteristics were analyzed among women divided into groups based on country of origin. Data were presented as mean and standard deviation for continuous variables and as numbers and proportions for categorical variables. Maternal characteristics were compared among women with a live birth and women with a stillbirth in each group of country of origin. We used a *t*-test for comparing age, BMI, GA, and disposable income group and a chi-square test for comparing parity, invasive prenatal testing, previous stillbirth, SGA, LGA, preterm birth, maternal medical diagnoses, smoking, ART, non-lethal malformations, stillbirth, and educational level.

Our primary analysis was an analysis of births with no missing values (complete cases). In total 1 926 637 births were included in the complete case analysis, of which 5890 were stillbirths. Logistic regression models were designed based on a directed acyclic graph (DAG) (Figure 1) with a forward selection strategy adjusting for different potential mediators on the causal pathway from maternal country of origin to stillbirth. After performing a crude logistic regression analysis with stillbirth as the outcome and maternal country of origin as the exposure, we adjusted for age, parity, BMI, previous stillbirth, ART, and smoking. In the second adjusted analysis, we also adjusted for six maternal medical diagnoses (type I diabetes mellitus, type II diabetes mellitus, gestational diabetes mellitus, chronic hypertension, gestational hypertension and preeclampsia). The third adjusted analysis was, in addition, adjusted for giving birth to an SGA fetus. The final analysis was also adjusted for the socioeconomic variables: educational level and disposable income per consumption unit. GA was a collider on the causal pathway from maternal country of origin to stillbirth and was not adjusted for. As some women had more than one birth during the time period, we used a generalized estimating equation to adjust for potential within-individual correlation.

In 12.7% of the births, one or more of the potential mediators were missing. A sub-analysis among the births with missing values was made to compare this group to the complete cases group. BMI was the potential mediator with the highest proportion of missing values at 8.3%. Hence, the logistic regression analyses were re-run, including births with a missing BMI value, in total including 2 025 850 births, of which 6,210 were stillbirths. The logistic regression models were designed as in the complete case analysis but without adjustment for BMI.

We performed a mediation analysis of the mediators with the most impact on the logistic regression models: SGA, educational level, and disposable income per consumption unit, among the women originating from sub-Saharan Africa, as they still had a significantly higher risk of stillbirth after adjusting for potential mediators in the logistic regression analyses. We defined the proportion

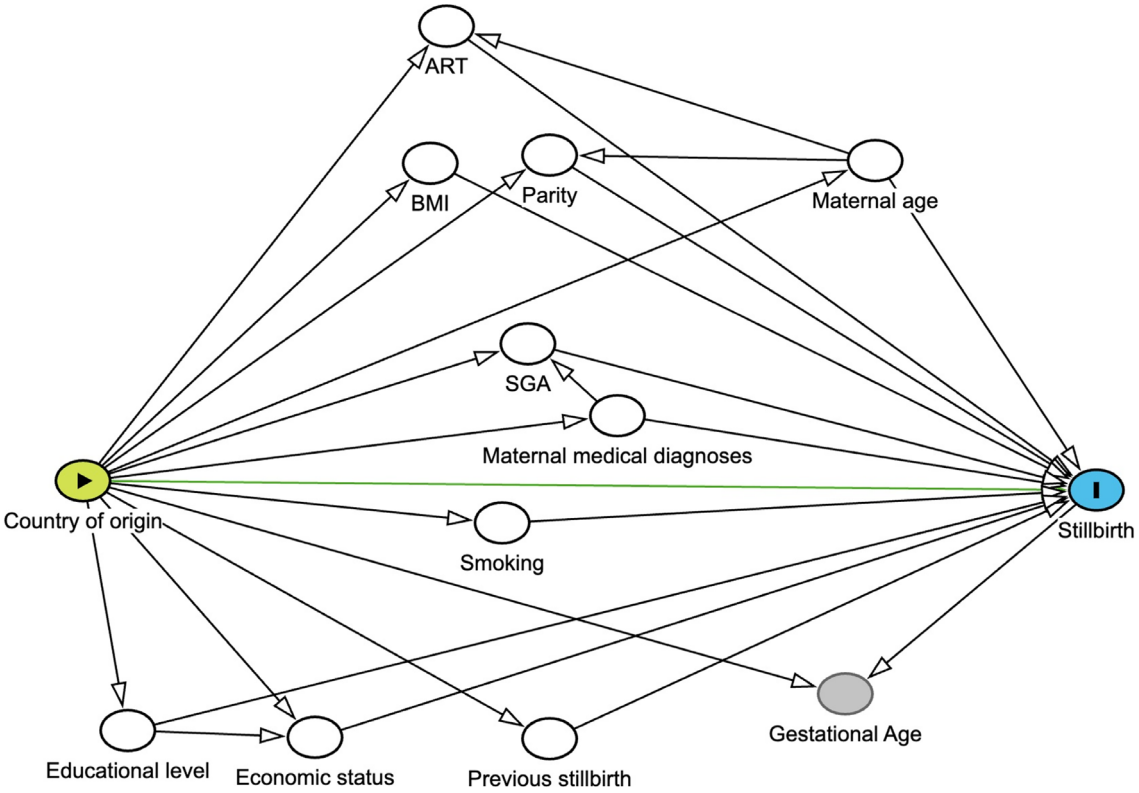

FIGURE 1 Directed acyclic graph with maternal country of origin as exposure and stillbirth as outcome.

explained by a particular mediator as (log OR_1-log OR_2)/log OR_1, where log OR_1 is the log odds ratio for stillbirth for women originating from sub-Saharan Africa from the logistic regression model adjusted for age, parity, BMI, previous stillbirth, ART, smoking, and maternal medical diagnoses (type I diabetes mellitus, type II diabetes mellitus, gestational diabetes mellitus, chronic hypertension, gestational hypertension and preeclampsia) and log OR_2 is the log odds ratio for stillbirth for women originating from sub-Saharan Africa from the above model additionally adjusted for one potential mediator at a time. Bootstrap was used to calculate the confidence interval for the difference in log OR between analyses with and without the added mediators.

All statistical analyses were made with the statistical software R cran version 4.2.1 (https://cran.r-project.org/).

3 | RESULTS

Women originating from the Middle East/Northern Africa and sub-Saharan Africa had a higher incidence of stillbirth compared to women originating from Sweden. Women originating from the Middle East/Northern Africa and sub-Saharan Africa were more often multiparous, had higher BMI, and had experienced previous stillbirth more often, but smoked less. Women originating from sub-Saharan Africa had a slightly longer gestational length than women originating from Sweden and the Middle East/Northern Africa and gave birth preterm less often. Women originating from sub-Saharan Africa and the Middle East/Northern Africa more often gave birth to SGA fetuses and less often to LGA fetuses. Women originating from sub-Saharan Africa and the Middle East/Northern Africa underwent ART and invasive prenatal testing less often than women from Sweden (Table 1).

Women originating from Sweden had diabetes mellitus type I more frequently than women originating from sub-Saharan Africa and the Middle East/Northern Africa, but diabetes mellitus type II and gestational diabetes mellitus were more common among women originating from sub-Saharan Africa and the Middle East/Northern Africa. Gestational hypertension was more common among women originating from Sweden than among women originating from sub-Saharan Africa and the Middle East/Northern Africa, and preeclampsia was equally common among women originating from Sweden and sub-Saharan Africa and less common among women originating from the Middle East/Northern Africa (Table 1).

Among the women experiencing stillbirth, women originating from sub-Saharan Africa had a shorter gestational length than women from all other origins and gave birth to SGA fetuses to a higher extent. Women originating from sub-Saharan Africa and the Middle East/Northern Africa had experienced a previous stillbirth more often, had a higher BMI, and were more often multiparous (Table 2).

In the crude logistic regression analysis, a significantly higher risk of stillbirth was observed among women originating from Eastern Europe, the Middle East/Northern Africa, sub-Saharan

TABLE 1 Maternal characteristics of women with singleton births in Sweden 2000–2021 divided into groups of maternal country of origin.

	Sweden	Nordic Countries/Western Europe/US/Canada/NZ/ Australia	Eastern Europe	Middle East/Northern Africa	Sub-Saharan Africa	Asia	South America
n	1 513 907	51 372	92 709	139 167	56 973	50 369	22 140
Age mean (SD)	30.41 (4.96)	32.33 (4.91)	30.20 (5.13)	30.21 (5.48)	30.65 (5.55)	31.50 (4.95)	31.64 (5.33)
BMI mean (SD)	24.74 (4.68)	24.44 (4.65)	24.35 (4.43)	25.73 (4.67)	26.23 (5.38)	23.27 (4.01)	25.71 (4.95)
GA in days mean (SD)	279 (12)	279 (12)	279 (13)	278 (12)	280 (14)	276 (13)	277 (13)
Primiparous, *n* (%)	667 013 (44.1)	20 837 (40.6)	36 770 (39.7)	42 535 (30.6)	14 563 (25.6)	22 075 (43.8)	8771 (39.6)
Invasive prenatal testing, *n* (%)	49 248 (3.3)	2458 (4.8)	2700 (2.9)	3888 (2.8)	829 (1.5)	1600 (3.2)	984 (4.4)
Previous stillbirth, *n* (%)	9902 (0.7)	344 (0.7)	762 (0.8)	1993 (1.4)	1463 (2.6)	408 (0.8)	184 (0.8)
SGA, *n* (%)	115 104 (7.6)	4579 (8.9)	8257 (8.9)	17 253 (12.4)	8690 (15.3)	6448 (12.8)	2094 (9.5)
LGA, *n* (%)	168 015 (11.1)	5011 (9.8)	8133 (8.8)	9476 (6.8)	3539 (6.2)	3906 (7.8)	2173 (9.8)
Preterm birth, *n* (%)	69 432 (4.6)	2105 (4.1)	3995 (4.3)	5872 (4.2)	2309 (4.1)	3295 (6.5)	1209 (5.5)
Diabetes mellitus type 1, *n* (%)	8874 (0.6)	158 (0.3)	168 (0.2)	262 (0.2)	152 (0.3)	97 (0.2)	44 (0.2)
Diabetes mellitus type 2, *n* (%)	1025 (0.1)	41 (0.1)	103 (0.1)	447 (0.3)	388 (0.7)	235 (0.5)	50 (0.2)
Gestational diabetes mellitus, *n* (%)	17 594 (1.2)	731 (1.4)	2048 (2.2)	5844 (4.2)	2625 (4.6)	2286 (4.5)	515 (2.3)
Smoker, *n* (%)	101 053 (6.7)	3377 (6.6)	9794 (10.6)	6478 (4.7)	1017 (1.8)	1604 (3.2)	810 (3.7)
Preeclampsia, *n* (%)	45 700 (3.0)	1250 (2.4)	1868 (2.0)	2190 (1.6)	1730 (3.0)	1215 (2.4)	651 (2.9)
Chronic hypertension, *n* (%)	6961 (0.5)	297 (0.6)	372 (0.4)	378 (0.3)	247 (0.4)	193 (0.4)	82 (0.4)
Gestational hypertension, *n* (%)	24 396 (1.6)	738 (1.4)	978 (1.1)	829 (0.6)	516 (0.9)	481 (1.0)	203 (0.9)
Assisted reproductive therapy, *n* (%)	50 301 (3.3)	2062 (4.0)	3218 (3.5)	3422 (2.5)	605 (1.1)	1980 (3.9)	738 (3.3)
Non-lethal malformations, *n* (%)	51 284 (3.4)	1760 (3.4)	2941 (3.2)	4433 (3.2)	1859 (3.3)	1439 (2.9)	703 (3.2)
Stillbirth, *n* (%)	4255 (0.3)	138 (0.3)	312 (0.3)	560 (0.4)	383 (0.7)	171 (0.3)	71 (0.3)
Disposable income group mean (SD)[a]	2.69 (1.05)	2.63 (1.19)	2.16 (1.10)	1.60 (0.93)	1.42 (0.78)	2.24 (1.13)	2.21 (1.11)
Educational level							
Primary, *n* (%)	116 670 (7.7)	3774 (7.4)	13 213 (14.3)	40 962 (29.4)	27 618 (48.5)	9341 (18.5)	3010 (13.6)
Secondary, *n* (%)	626 823 (41.4)	12 332 (24.0)	34 111 (36.8)	45 231 (32.5)	18 612 (32.7)	15 042 (29.9)	8726 (39.4)
Tertiary, *n* (%)	770 414 (50.9)	35 266 (68.6)	45 385 (49.0)	52 974 (38.1)	10 743 (18.9)	25 986 (51.6)	10 404 (47.0)

Note: Data are presented as mean and standard deviation (SD) for continuous variables and as numbers and proportions for categorical variables.

Abbreviations: BMI, body mass index; GA, gestational age; LGA, large for gestational age; SGA, small for gestational age.

[a]Disposable income group mean: the disposable income per consumption unit divided into quartiles for each respective study year, with the lowest income quartile defined as 1 and the highest income quartile defined as 4.

TABLE 2 Comparison of women in Sweden with singleton live births and stillbirths 2000–2021 divided into groups of maternal country of origin.

	Sweden		Nordic Countries/Western Europe/US/Canada/NZ/ Australia		Eastern Europe		Middle East/Northern Africa		Sub-Saharan Africa		Asia		South America	
	Live births	Stillbirths	Live births	Stillbirths	Live births	Stillbirths	Live births	Stillbirths	Live births	Stillbirths	Live births	Stillbirths	Live births	Stillbirths
n	1 509 652	4255	51 234	138	92 397	312	138 607	560	56 590	383	50 198	171	22 069	71
Age mean (SD)	30.41 (4.96)	30.80 (5.44)[a]	32.33 (4.91)	32.69 (5.24)	30.20 (5.13)	31.02 (5.38)[a]	30.21 (5.47)	31.95 (5.71)[a]	30.65 (5.55)	31.20 (5.92)	31.50 (4.95)	31.89 (4.79)	31.64 (5.33)	33.14 (5.99)[a]
BMI mean (SD)	24.74 (4.67)	26.36 (5.84)[a]	24.44 (4.65)	25.58 (5.82)[a]	24.34 (4.43)	25.80 (4.91)[a]	25.73 (4.66)	27.24 (5.11)[a]	26.22 (5.37)	27.33 (5.52)[a]	23.27 (4.00)	25.05 (4.52)[a]	25.71 (4.95)	26.72 (5.37)
GA in days mean (SD)	279 (12)	246 (39)[a]	279 (12)	241 (40)[a]	279 (12)	245 (41)[a]	278 (12)	246 (40)[a]	281 (13)	239 (42)[a]	276 (13)	241 (42)[a]	277 (13)	241 (41)[a]
Primiparous, *n* (%)	664 940 (44.0)	2073 (48.7)[a]	20 770 (40.5)	67 (48.6)	36 627 (39.6)	143 (45.8)[a]	42 332 (30.5)	203 (36.2)[a]	14 440 (25.5)	123 (32.1)[a]	21 984 (43.8)	91 (53.2)[a]	8741 (39.6)	30 (42.3)
Invasive prenatal testing, *n* (%)	48 995 (3.2)	253 (5.9)[a]	2450 (4.8)	8 (5.8)	2684 (2.9)	16 (5.1)[a]	3864 (2.8)	24 (4.3)[a]	818 (1.4)	11 (2.9)[a]	1588 (3.2)	12 (7.0)[a]	980 (4.4)	4 (5.6)
Previous stillbirth, *n* (%)	9785 (0.6)	117 (2.7)[a]	341 (0.7)	3 (2.2)	757 (0.8)	5 (1.6)	1966 (1.4)	27 (4.8)[a]	1444 (2.6)	19 (5.0)[a]	400 (0.8)	8 (4.7)[a]	181 (0.8)	3 (4.2)[a]
SGA, *n* (%)	113 361 (7.5)	1743 (40.7)[a]	4515 (8.8)	64 (46.4)[a]	8116 (8.8)	141 (45.2)[a]	16 993 (12.3)	260 (46.4)[a]	8459 (14.9)	231 (60.3)[a]	6375 (12.7)	73 (42.7)[a]	2061 (9.3)	33 (46.5)[a]
LGA, *n* (%)	167 716 (11.1)	299 (7.0)[a]	4996 (9.8)	15 (10.9)	8113 (8.8)	20 (6.4)	9443 (6.8)	33 (5.9)	3525 (6.2)	14 (3.7)[a]	3893 (7.8)	13 (7.6)	2169 (9.8)	4 (5.6)
Preterm birth, *n* (%)	67 259 (4.5)	2173 (51.1)[a]	2026 (4.0)	79 (57.2)[a]	3829 (4.1)	166 (53.2)[a]	5596 (4.0)	276 (49.3)[a]	2089 (3.7)	220 (57.4)[a]	3205 (6.4)	90 (52.6)[a]	1172 (5.3)	37 (52.1)[a]
Diabetes mellitus type 1, *n* (%)	8800 (0.6)	74 (1.7)[a]	157 (0.3)	1 (0.7)	167 (0.2)	1 (0.3)	259 (0.2)	3 (0.5)	151 (0.3)	1 (0.3)	96 (0.2)	1 (0.6)	44 (0.2)	0 (0.0)
Diabetes mellitus type 2, *n* (%)	1017 (0.1)	8 (0.2)[a]	41 (0.1)	0 (0.0)	102 (0.1)	1 (0.3)	444 (0.3)	3 (0.5)	379 (0.7)	9 (2.3)[a]	234 (0.5)	1 (0.6)	50 (0.2)	0 (0.0)
Gestational diabetes mellitus, *n* (%)	17 543 (1.2)	51 (1.2)	731 (1.4)	0 (0.0)	2037 (2.2)	11 (3.5)	5825 (4.2)	19 (3.4)	2615 (4.6)	10 (2.6)	2276 (4.5)	10 (5.8)	512 (2.3)	1 (1.4)
Smoker, *n* (%)	100 541 (6.7)	512 (12.0)[a]	3368 (6.6)	9 (6.5)	9757 (10.6)	37 (11.9)	6454 (4.7)	24 (4.3)	1008 (1.8)	9 (2.3)	1598 (3.2)	6 (3.5)	808 (3.7)	2 (2.8)
Preeclampsia, *n* (%)	45 545 (3.0)	155 (3.6)[a]	1246 (2.4)	4 (2.9)	1854 (2.0)	14 (4.5)[a]	2175 (1.6)	15 (2.7)	1704 (3.0)	26 (6.8)[a]	1206 (2.4)	9 (5.3)[a]	649 (2.9)	2 (2.8)
Chronic hypertension, *n* (%)	6921 (0.5)	40 (0.9)[a]	294 (0.6)	3 (2.2)	370 (0.4)	2 (0.6)	373 (0.3)	5 (0.9)[a]	241 (0.4)	6 (1.6)[a]	192 (0.4)	1 (0.6)	81 (0.4)	1 (1.4)
Gestational hypertension, *n* (%)	24 338 (1.6)	58 (1.4)	734 (1.4)	4 (2.9)	971 (1.1)	7 (2.2)	821 (0.6)	8 (1.4)[a]	509 (0.9)	7 (1.8)	478 (1.0)	3 (1.8)	203 (0.9)	0 (0.0)
Assisted reproductive therapy, *n* (%)	50 116 (3.3)	185 (4.3)[a]	2056 (4.0)	6 (4.3)	3202 (3.5)	16 (5.1)	3404 (2.5)	18 (3.2)	599 (1.1)	6 (1.6)	1976 (3.9)	4 (2.3)	734 (3.3)	4 (5.6)
Non-lethal malformations, *n* (%)	51 222 (3.4)	62 (1.5)[a]	1758 (3.4)	2 (1.4)	2939 (3.2)	2 (0.6)[a]	4425 (3.2)	8 (1.4)[a]	1847 (3.3)	12 (3.1)	1438 (2.9)	1 (0.6)	699 (3.2)	4 (5.6)
Disposable income group mean (SD)[b]	2.69 (1.05)	2.52 (1.06)[a]	2.63 (1.19)	2.56 (1.21)	2.16 (1.10)	1.99 (1.08)[a]	1.60 (0.93)	1.43 (0.79)[a]	1.42 (0.78)	1.31 (0.69)[a]	2.24 (1.13)	2.05 (1.11)[a]	2.21 (1.11)	2.28 (1.08)
Educational level														
Primary, *n* (%)	116 194 (7.7)	476 (11.2)[a]	3764 (7.3)	10 (7.2)	13 158 (14.2)	55 (17.6)	40 765 (29.4)	197 (35.2)[a]	27 410 (48.4)	208 (54.3)[a]	9308 (18.5)	33 (19.3)	3001 (13.6)	9 (12.7)
Secondary, *n* (%)	624 853 (41.4)	1970 (46.3)[a]	12 298 (24.0)	34 (24.6)	33 979 (36.8)	132 (42.3)[a]	45 069 (32.5)	162 (28.9)	18 494 (32.7)	118 (30.8)	14 983 (29.8)	59 (34.5)	8702 (39.4)	24 (33.8)
Tertiary, *n* (%)	768 605 (50.9)	1809 (42.5)[a]	35 172 (68.6)	94 (68.1)	45 260 (49.0)	125 (40.1)[a]	52 773 (38.1)	201 (35.9)	10 686 (18.9)	57 (14.9)	25 907 (51.6)	79 (46.2)	10 366 (47.0)	38 (53.5)

Note: Data are presented as mean and standard deviation (SD) for continuous variables and as numbers and proportions for categorical variables.

Abbreviations: BMI, body mass index; GA, gestational age; LGA, large for gestational age; SGA, small for gestational age.

[a]Significant difference in maternal characteristics between stillbirth and live birth in the groups of maternal country of origin.

[b]Disposable income group mean: the disposable income per consumption unit divided into quartiles for each respective study year, with the lowest income quartile defined as 1 and the highest income quartile defined as 4.

Africa, and Asia, with the highest risk observed in women originating from sub-Saharan Africa (OR 2.40, 95% CI 2.16–2.67). After adjusting for age, parity, BMI, smoking, previous stillbirth, ART, and maternal medical diagnoses, the risks changed only slightly (Table 3).

When adjusting for fetuses SGA, the elevated risk among women originating from sub-Saharan Africa decreased but was still higher compared to the women originating from Sweden (OR 1.63, 95% CI 1.46–1.82). The women from the Middle East/Northern Africa and Eastern Europe also had a significantly higher risk (OR 1.13, 95% CI 1.03–1.24 and OR 1.17, 95% CI 1.04–1.31 respectively) but the women originating from Asia had a risk equal to that of women originating from Sweden (Table 3).

After adjusting for the socioeconomic mediators: educational level and disposable income per consumption unit, the elevated risk among women originating from sub-Saharan Africa was still significantly higher compared to women originating from Sweden (OR 1.28, 95% CI 1.14–1.44) but the risk among women originating from the Middle East/Northern Africa and Eastern Europe was equal to that of women originating from Sweden (Table 3).

The above logistic regression analyses were also made without adjusting for BMI, thus including births where information on maternal BMI was missing. The logistic regression analyses showed similar results (Table S1). In the crude logistic regression analysis, the elevated risk of stillbirth was at most decreased by 0.04, not changing any significant results. In the final adjusted logistic regression analysis, women from sub-Saharan Africa had the same significantly higher risk for stillbirth as in the complete case analysis.

The number of births with any missing value was 278 457, hence excluded from the primary logistic regression analyses of complete cases. In the group with any missing value, the incidence of stillbirth was higher compared to the complete case group (0.5% compared to 0.3%). Origin from sub-Saharan Africa was also higher in the group with any missing value (7% compared to 3%). The variables most commonly missing were BMI, smoking, and educational level (65.4%, 33.0% and 31.6% respectively).

Mediation analysis showed that 31.2% (95% CI 30.0–32.4) of the effect of sub-Saharan origin on stillbirth was mediated through SGA fetuses, 14.9% (95% CI 11.9–18.0) through educational level, and 18.8% (95% CI 16.4–21.2) through disposable income per consumption unit.

4 | DISCUSSION

In Sweden, the risk of stillbirth is significantly higher among women originating from sub-Saharan Africa even after adjusting for known risk factors for stillbirth. The Swedish cost-free maternal health care system does not sufficiently mitigate the risks in this population.

The results in our study are in coherence with other international studies. In a large global meta-analysis from 2022, Black women had poorer perinatal outcomes, including stillbirth, than White women after adjusting for maternal characteristics (OR 2.16, 95% CI 1.46–3.19).[21]

One of the risk factors with the highest impact on stillbirth is carrying and giving birth to an SGA fetus in the current pregnancy.[22,23] Preventing the development of SGA fetuses is complex. There are some known modifiable risk factors; for example, insufficient gestational weight gain, smoking, and certain infections[23] which are all monitored by the Swedish cost-free maternal health care system. However, most cases of SGA in Sweden are, with today's knowledge, not preventable. Instead, identification and intensive monitoring, including consideration of delivery timing, are used to minimize the risk of stillbirth among SGA fetuses. In our study, SGA fetuses were shown to be more common among all foreign-born women, especially among women originating from sub-Saharan Africa, where the proportion of SGA fetuses was 15.3% compared to women originating from Sweden, where the proportion of SGA fetuses was 7.6%. Ideally, the higher incidence of SGA fetuses among women originating from sub-Saharan Africa should have led to a shorter mean gestational length due to the previously described active management when an SGA fetus is identified. Instead, women from sub-Saharan Africa had a slightly longer mean gestational length compared to women of all other origins. This emphasizes the need for better monitoring of fetal growth during pregnancy, especially in high-risk groups.

Among the women experiencing stillbirth, the mean gestational length among women originating from sub-Saharan Africa was shorter, and they had a higher proportion of preterm stillbirth compared to women from other origins. Similar findings have been reported by the Stillbirth Collaborative Research Network Writing Group, showing that the elevated risk of stillbirth in Black women occurs mainly in early gestational weeks (<24 weeks).[10] This has also been confirmed by Willinger et al., who estimated the probability of having a stillbirth in each pregnancy interval for non-Hispanic Black women compared to non-Hispanic White women. Even though an increased hazard was observed at every studied gestation interval for non-Hispanic Black women compared to non-Hispanic White women, the greatest increase of risk of stillbirth was between 20 and 23 weeks' gestation with a stillbirth hazard of 2.75, decreasing to 1.57 at 39–40 weeks' gestation.[24] In Sweden since 2021, women from sub-Saharan Africa are regarded as a prioritized group when selecting which women should be induced because of prolonged pregnancy in gestational week 41+0.[25] However, as the elevated risk is also present in earlier gestational lengths, this recent change of policy may not be sufficient to lower the incidence of stillbirth among women originating from sub-Saharan Africa.[24]

In our study, adjusting for maternal medical conditions did not change the elevated risk of stillbirth for foreign-born women, which suggests that the national maternal and antenatal health care system sufficiently monitors women with medical conditions with known elevated risk for stillbirth. Surprisingly, in our material, the incidence of preeclampsia was the same among women originating from Sweden compared to women originating from sub-Saharan Africa, which is

TABLE 3 Logistic regression model with stillbirth as the outcome and maternal country of origin as the exposure of all singleton births in Sweden 2000–2021 (complete cases).

	Sweden	NordicCountries/US/WesternEurope/NZ/Australia			Eastern Europe			Middle East/NorthAfrica			Sub-Saharan Africa			Asia			South America		
	OR	OR	95% CI	*p*-value	OR	95% CI	*p*-value	OR	95% CI	*p*-value	OR	95% CI	*p*-value	OR	95% CI	*p*-value	OR	95% CI	*p*-value
Crude logistic regression analysis	1.0 (ref.)	0.96	0.80–1.14	0.6	1.20	1.07–1.34	0.002	1.43	1.31–1.57	<0.001	2.40	2.16–2.67	<0.001	1.21	1.04–1.41	0.016	1.14	0.90–1.45	0.3
Adjusted for age, parity, BMI, previous stillbirth, ART and smoking	1.0 (ref.)	0.92	0.78–1.09	0.4	1.22	1.08–1.36	<0.001	1.44	1.32–1.57	<0.001	2.34	2.10–2.60	<0.001	1.29	1.11–1.51	0.001	1.08	0.85–1.37	0.5
Adjusted for mediators above and maternal medical diagnoses[a]	1.0 (ref.)	0.93	0.78–1.10	0.4	1.23	1.10–1.38	<0.001	1.47	1.34–1.60	<0.001	2.37	2.13–2.64	<0.001	1.31	1.12–1.53	<0.001	1.09	0.86–1.38	0.5
Adjusted for mediators above and fetuses small for gestational age	1.0 (ref.)	0.88	0.74–1.04	0.1	1.17	1.04–1.31	0.008	1.13	1.03–1.24	0.008	1.63	1.46–1.82	<0.001	1.06	0.91–1.23	0.5	0.97	0.77–1.24	0.8
Adjusted for mediators above, educational level and disposable income	1.0 (ref.)	0.87	0.73–1.04	0.1	1.09	0.97–1.22	0.2	0.95	0.87–1.05	0.3	1.28	1.14–1.44	<0.001	0.97	0.83–1.13	0.7	0.90	0.71–1.14	0.4

Abbreviations: ART, assisted reproductive therapy; BMI, body mass index.

[a]Diabetes mellitus type I and II, gestational diabetes mellitus, chronic hypertension, gestational hypertension, and preeclampsia.

not in agreement with current knowledge.[26] This might suggest a problem with underdiagnosing maternal medical conditions among women originating from sub-Saharan Africa. We also found that among women originating from sub-Saharan Africa, the use of ART and invasive prenatal testing was much lower compared to women born in Sweden, which might suggest that the knowledge and usage of these procedures are not available to the same extent as for women born in Sweden and Europe. Regarding the use of ART, similar findings have been made in the US.[27] Sociocultural, emotional, infrastructural, geographic, and economic barriers have been suggested as explanations, but more research is needed to properly understand why this disparity exists.

Interestingly, among women originating from sub-Saharan Africa who experienced stillbirth, preeclampsia, gestational diabetes mellitus, and diabetes mellitus type 2 were more common than among women originating from Sweden experiencing stillbirth. Gestational diabetes mellitus was also more common among women originating from the Middle East/Northern Africa who experienced stillbirth compared to women originating from Sweden. One potential explanation could be that the maternal medical condition is first observed at the time of stillbirth among foreign-born women, possibly due to potential underdiagnosing during pregnancy, as previously discussed. The possibility of preventing stillbirth among foreign-born women associated with maternal medical conditions would then have been less. The potential mechanisms behind the mentioned findings warrant further investigations.

Our results indicate that a higher educational level and higher income level seem to be protective against stillbirth among all foreign-born women, as the elevated risk of stillbirth is reduced in all groups compared to women born in Sweden after adjusting for socioeconomic mediators. This is in line with earlier international studies that show a lower risk of stillbirth among women with a higher educational level.[28,29] In a study from the United States, the influence of a higher educational level on reducing the risk of stillbirth was much less for Black women compared to White women, but as race/ethnicity is not registered in Sweden, it is hard to compare these results.[24]

A strength of this study is the large number of included births from national registers with high coverage and quality. As stillbirth is a rare outcome, large materials with high-quality data are needed to enable group comparisons. It is noteworthy that the large material will lead to significant p-values when comparing maternal and pregnancy characteristics between groups of different maternal origins, although the effect sizes are not always of clinical significance. We have discussed the differences that we consider clinically significant and important.

This study is based on national registers, and missing data is therefore a weakness when analyzing the results. We chose to perform our primary analyses on complete data cases, which could potentially lead to loss of precision and introduce bias. As we found very small or unchanged results when we performed a sub-analysis that also included the births where the information on BMI was missing (the mediator missing to the largest extent), we draw the conclusion that even with a complete case analysis, the bias is estimated to be low.

Another weakness is that gestational weight is, in the case of a stillbirth, estimated at delivery and not at the time of death. As the gestational weight is compared to the gender-specific mean weight for the GA, this might lead to an overestimation of SGA fetuses.

Even after adjusting for many known risk factors, an excess risk of stillbirth is present among women originating from sub-Saharan Africa. Why this reported health care disparity for stillbirth exists is debated and probably multifactorial.[11] The effect and impact of socioeconomic status on perinatal outcomes among women from different origins is not fully understood but seem to increase the disparity, which is also shown in our study.[30] A systematic review on migrant women found health disparities between migrants and receiving-country nationals in perinatal health outcomes, especially regarding perinatal mortality.[31] Understanding how the difference in length of stay in the receiving country affects the risk of stillbirth might clarify which groups of foreign-born women are at highest risk.

Racial discrimination has been suggested as a significant risk factor for adverse birth outcomes, but more research is needed to understand the mechanisms by which racial discrimination has an impact.[1] Other explanations that have been proposed are the risk of miscommunication due to language barriers, insufficient information, different cultural beliefs and practices, a lack of patient-caregiver trust, and less use of health care services during pregnancy.[32–35] In a study from the south of Sweden, foreign-born women were found to have a late first visit in antenatal care compared to Swedish-born women. They also had fewer unplanned visits to a physician at the delivery ward during pregnancy.[36] Another Swedish study found that women born in Somalia living in Sweden less often contacted obstetric care for reduced fetal movements.[37] Larger studies focusing on how risk populations use health care during pregnancies are needed to confirm these findings and thereby hopefully find measures to further reduce the disparity in stillbirth.

5 | CONCLUSION

In Sweden, women originating from sub-Saharan Africa face a significantly higher risk of stillbirth even after adjusting for known risk factors for stillbirth. The higher risk is mainly mediated by carrying and giving birth to an SGA fetus in the current pregnancy and socioeconomic factors. This disparity may stem from multifactorial causes, including how risk populations utilize health care during pregnancies but also how health care providers respond to foreign-born women, especially women from sub-Saharan Africa. Further studies are needed to explore this disparity and find preventive measures to decrease the higher risk of stillbirth among women originating from sub-Saharan Africa.

AUTHOR CONTRIBUTIONS

All authors participated in the study design. Ingela Hulthén Varli, Hanna Åmark, and Minna Lundén applied for the ethical permit and amendments. Minna Lundén and Hanna Åmark retrieved data and performed data analysis. All authors participated in data interpretation. Minna Lundén drafted the initial version of the manuscript, which was revised by all authors who also approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

None.

ETHICS STATEMENT

Ethical approval for this study was obtained from the Swedish Ethical Review Authority on June 24, 2020 (Dnr 2020-01855), with an amendment approved on December 22, 2021 (Dnr 2021-05788-02) enabling the possibility to include all births in Sweden up until 2020 and an amendment approved on August 3, 2022 (Dnr 2022-03758-02) enabling a longer study period including all births up until the application for register data was made.

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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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