Gestational diabetes mellitus among foreign-born women in Sweden: A register-based study on the role of income.

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Abstract

Aim:
The present study aimed to determine if foreign-born women from different countries of birth have a greater risk of GDM compared to Swedish-born women and to what extent income might mediate this relationship.

Methods:
This cross-sectional type study included 835279 women, of which 151,642 were foreign-born and 683637 were Swedish-born women who gave birth to their first singleton child in Sweden between 1997 to 2016. Register data from the Swedish Medical Birth Register, the Swedish Total Population Register, and the Longitudinal Integrated Database for Health Insurance and Labour Market Studies was used. Multiple Logistic Regression analysis and the Karlson-Holm-Breen methods were used to explore the relationship between GDM and country of birth and to estimate the proportion of the association explained by income.

Results:
Foreign-born women demonstrated higher odds ratios for developing GDM than Swedish-born women. South East Asian women showed the highest risk of GDM (OR: 4.40, CI: 4.01-4.81) followed by Africa (OR: 3.42, CI: 3.07-3.81) and Middle East & North Africa (OR: 2.92, CI: 2.67-3.20) respectively. Income partially explained the risk of GDM differences between foreign-born and Swedish-born women, accounting for 26% of the association. However, the proportion explained by income varies from 8.9% to 23.0% by country of birth.

Conclusions:
A disparity exists in the risk of GDM based on country of birth, and Foreign-born women are more likely to have GDM and need additional support, including prenatal care and treatment. Since income only partially explains this association, other factors that may explain the association need to be explored.

Keywords:
Gestational diabetes mellitus; migration; income; country of birth; acculturation; registered-based study.
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Introduction

An emerging global health problem the world is facing today is the rise of gestational diabetes mellitus (GDM). GDM has become a significant concern in the realm of perinatal health, with a projected worldwide prevalence of up to 16%. (Bastola et al., 2021). The estimated global prevalence of GDM varies across different regions, ranging from 5.4% in Europe, 14% in Africa, and 10.1% in Asia (Darbandi et al., 2021; Nguyen et al., 2018). Sweden has also experienced a rise in the number of mothers with GDM; the prevalence rate of GDM rose from 1.9% to 2.6% over 15 years (Fadl & Simmons, 2016). GDM is connected to several detrimental long-term and short-term effects during pregnancy and for future adverse cardio-metabolic health among women and their children. (Seghieri et al., 2020).

The recent surge of foreign-born women in Western nations has posed diverse public health predicaments. (Seghieri et al., 2020). Migration is associated with newly emerging environmental, socioeconomic and cultural hazards, challenges, and risks that render a person's health more susceptible and vulnerable to disease. (Adanu & Johnson, 2009) Additionally, host countries' structural disparities encountered by foreign-born populations, such as lack of social assistance, and uneven distribution of social capital, substantially influence their health outcomes. (Davies et al., 2009). In particular, foreign-born women are considered vulnerable because they may face double discrimination in the host country due to their gender and migration status. (Zaiceva, 2014; Amroussia et al., 2022). As a result, foreign-born women in the childbearing age group are more likely to encounter adverse health consequences in the destination country. (Adanu & Johnson, 2009).

Migration to Sweden has increased significantly in recent decades, similar to other developed countries (SCB, 2023). Due to structural inequalities, foreign-born women residing in Sweden may also face barriers concerning their access to Sexual and Reproductive Health (SRH) services. (Amroussia et al., 2022). Compared to their Swedish-born counterparts, foreign-born women are less likely to receive planned routine checkups like screening tests, ultrasonography and antenatal and postnatal care. (Amroussia et al., 2022; Liu et al., 2019). Pregnant refugee women in Sweden have also exhibited a higher probability of experiencing adverse health
outcomes, such as poor self-rated health, preterm labour, GDM, perinatal and postnatal depression, and anal sphincter tears. (Liu et al., 2019) As such, the provision of rights to maternity treatment and care, which are ensured in Sweden, may not be adequate in ensuring equitable access to such care. (Liu et al., 2019).

A robust correlation exists between socioeconomic position (SEP) and migration and GDM. (Kragelund Nielsen et al., 2022) On the one hand, people with low SEP are more inclined to immigrate in search of improved financial stability, while conversely, modifiable risk factors responsible for GDM are primarily determined by individual SEP. (Liu et al., 2018; Jairam et al., 2023). Additionally, lower SEP is widely known to contribute to abnormal glucose metabolism and its adverse consequences on health. (Badon et al., 2017). In both developing and developed regions, women of lower SEP show an elevated risk of getting GDM. (Liu et al., 2018). Consequently, an inverse association between SEP and GDM has been observed globally (Rönö et al., 2019).

SEP is often measured with three key indicators, namely income, occupation, and education, where income is arguably the most critical determinant as an economic measure of one's social standing and standard of living and also indicative of occupation and education. (Sawchuk, 2019). On average, immigrants, particularly foreign-born women, tend to have lower income levels, which can be attributed to various factors, including health and health-related behaviours. (Jairam et al., 2023). Women who earn less are more likely to lead an unhealthy lifestyle and involvement in risky health behaviour. (He et al., 2021; Laaksonen et al., 2003). As such, a pregnant women's access to material resources required for good health, such as an adequate standard of living, nutritious food, quality neighbourhoods and access to medical resources, may all be determined by her individual or family income. (Song et al., 2017; Jairam et al., 2023) As a result, a higher prevalence of detrimental health behaviours and adverse health outcomes has been found among foreign-born women with low incomes. All of these factors add up to an increase in a woman's chance of developing GDM.

Socioeconomically disadvantaged women face a higher likelihood of experiencing complications during pregnancy such as GDM because they are less likely to seek perinatal and postnatal care. (Kim et al., 2018). Native women with high incomes can afford the necessary expenses for consultation visits and medicines, and health insurance. Conversely, women who earn less are disproportionately represented among those unable to afford "out-of-pocket costs"
for health care. Additionally, cultural and social differences between origin and host countries limit healthcare accessibility in Sweden. (Nimar, 2018). Consequently, inadequate prenatal and antenatal care triggers the risk of GDM in foreign-born women. Thereby, a variation in GDM risk has been found between foreign-born and Swedish-born women, where access to medical treatment is, to some extent, determined by individuals' income and their socio-cultural differences. (Daneshmand et al., 2019; Haigh et al., 2023) Therefore, it is plausible that income could significantly impact the likelihood of developing GDM, particularly in foreign-born women.

Swedish demography is becoming more diverse daily compared to other developed nations. (SCB, 2023). The risk of GDM grows exponentially with sociodemographic factors for instance advanced mother's age, high BMI, smoking and marital status (Zaiceva, 2014). The phenomenon of demographic change significantly influences various aspects of culture, economy, health and welfare systems, which enhance the risk of GDM in Sweden. (The Impact of Demographic Change in a Changing Environment, 2023.) Therefore, given that GDM is among the most prevalent pregnancy complications in foreign-born women, learning about the mediating role of income in foreign-born women and the risk of GDM in Sweden is necessary and relevant (Kragelund Nielsen et al., 2022).

Background

GDM from a public health perspective:

GDM is characterized by elevated blood glucose levels that are initially detected during pregnancy and may or may not resolve following delivery. (Ye et al., 2022). GDM is considered a chronic pregnancy complication which represents a significant public health concern during the perinatal period and poses a potential risk for maternal and child health. As a result, GDM is also considered an indicator of women who may experience worse perinatal outcomes. (Mumtaz, 2000).

Globally, GDM affects one in every six pregnancies and one in every seven live births. (Alejandro et al., 2020; Kragelund Nielsen et al., 2022) Women who experience GDM exhibit heightened insulin resistance and diminished insulin secretion upon glucose stimulation,
thereby elevating their susceptibility to type 2 diabetes for up to 5 years post-partum. (Hedderson et al., 2010) Additionally, the global prevalence of obesity has escalated to epidemic proportions, leading to an enormous spike in the overall count of expectant mothers with GDM. GDM enhances the likelihood of spontaneous abortion, preeclampsia, cesarean section, hypertension, respiratory distress and preterm birth for mothers and stillbirth, low birth weight and neonatal mortality for the fetus. (Darbandi et al., 2021). Furthermore, GDM imposes a higher risk of unfavourable cardio-metabolic and genetic consequences for both the child and mother. (Ye et al., 2022). In the post-natal period, mothers who suffered from GDM are approximately at 65% higher risk of stroke and risk of other cardiometabolic diseases such as heart failure, obesity, myocardial infarction, type 2 diabetes, peripheral artery disease, CABG, chronic kidney disease and hypertension is more than twice as high. (Yu et al., 2022). Offspring of mothers with GDM exhibit a 3-fold elevation in the incidence of congenital anomalies, including obstructive diseases such as urinary tract obstruction, cardiovascular diseases, absence of kidneys, either single or both, chromosomal abnormality, type 1 diabetes mellitus and perinatal mortality, overweight infants, respiratory problems, and shoulder dystocia. (Darbandi et al., 2021; Yu et al., 2022).

GDM is a complex condition that arises from the interplay of various risk factors, including genetic, epigenetic, and environmental over the life course (Alejandro et al., 2020). It augments the vulnerability to the onset of diabetes and pregnancy complications in subsequent pregnancies for both mother and child (Bastola et al., 2021). Initially, females diagnosed with GDM exhibit a persistent beta-cell dysfunction which has become subsided after pregnancy. However, the progressive, long-term beta-cell dysfunction may result in impaired blood glucose levels, known as type 2 diabetes, in later life. (Fu & Retnakaran, 2022). Later, female offspring of mothers who experienced GDM during their pregnancy are also more likely to get GDM during their pregnancies. (Bastola et al., 2021). Because early exposure to mothers' high blood glucose levels in intrauterine life is linked to early insulin resistance and decreased insulin secretion in the daughter of GDM mothers, which may impact the health of both the daughter of the GDM mother and subsequent generations for later life (Alejandro et al., 2020). Public health practitioners must consider GDM to promote better reproductive and perinatal health in foreign-born women. (Wang et al., 2018).
Migration background and GDM:

Global public health priorities related to health and migration are becoming more widely acknowledged. Migration entails moving from one location to another, either within the same nation or a different country (Kragelund Nielsen et al., 2022). It has significantly grown recently due to people fleeing war, seeking a better living, higher education, and numerous other social and political advancements. According to IOM (International Organization for Migration), the global migrant population has surged in the past fifty years and is around 280 million individuals, constituting 3.6% of the total global populace (McAuliffeM, 2021). Following the migration process, immigrant individuals, especially foreign-born women, may experience differing levels of accessibility to medical and social services, which can result in health inequalities within the same social group and the native population. (Davies et al., 2009). Foreign-born women may be more susceptible to adopting unhealthy behaviours, residing in socioeconomically disadvantaged communities, and being compelled to engage in physically demanding, low-wage work (Davies et al., 2009;). In Sweden, foreign-born women reported adverse health outcomes at a rate three to four times higher than individuals born in Sweden (Hjern, 2012). Also, they exhibited poorer perinatal health outcomes than their counterparts in Sweden. (Fadl et al., 2012;). Hence, the recent influx of foreign-born women to developed countries such as Sweden has brought various public health challenges. (Hjern, 2012). As a result, a pattern of increasing health disparities between foreign-born and Swedish women has been found in the changing composition of the Swedish demography. (Amroussia et al., 2022).

One such challenge is GDM, a frequently encountered complication during pregnancy in reproductive-age foreign-born mothers. (Kragelund Nielsen et al., 2020). Prior research has demonstrated that the migration process might impact the likelihood of developing GDM. (Kragelund Nielsen et al., 2022). As a significant proportion of women who give birth are foreign-born women, obstacles to health care services and lack of follow-up, which is more common among foreign-born women, might play a crucial role in the elevated risk of GDM among them. (Kragelund Nielsen et al., 2022) In other Nordic countries with similar welfare states and health care policies, such as Finland and Denmark, a higher prevalence of GDM cases has been noticed among foreign-born women in recent decades. (Bastola et al., 2021, Kragelund Nielsen et al., 2020). Overall, a widening inequality gap has been observed between foreign-born women and native women regarding the risk of GDM in the Nordic regions.
Factors influencing the higher risk of GDM among foreign-born women: the role of income:

Empirical studies have found an increasing number of "modifiable" and "non-modifiable" risk factors contributing to the observed global increase in GDM cases. (Chen et al., 2019; Rönö et al., 2019; Seghieri et al., 2020). The prominent risk factors that increase the likelihood of GDM are high maternal age, ethnicity, adoption of sedentary lifestyles, obesity, history of an overweight baby in a previous pregnancy, marital status, genetic predisposition, smoking, and family history of diabetes. (G. Li et al., 2020a; Y. Li et al., 2020; Ouyang et al., 2021). "Non-modifiable" risk factors, family history, and genetics play a significant role in developing GDM. (Anand et al., 2017). Regarding modifiable factors, socioeconomic position (SEP) plays a crucial role. (Rönö et al., 2019) Because SEP can potentially impact the occurrence of "modifiable risk factors" directly and indirectly. Therefore, SEP is considered one of the critical determinants of GDM. (He et al., 2021).

SEP refers to "a person's position in the social and economic hierarchy of a given society". (Song et al., 2017). As a socioeconomic measure, income is a reliable indicator of a person's economic status and plays a crucial role in determining an individual's social class and overall well-being in both origin and host country. (He et al., 2021). Because income has a direct link with health outcomes. (Dallongeville et al., 2005; Rönö et al., 2019). Foreign-born women with a lower income are more susceptible to not receiving proper antenatal and prenatal care, leading to adverse outcomes during pregnancy, such as premature labour, preeclampsia, abortion, eclampsia, and GDM. (Kim et al., 2018). Because lower income is associated with fewer health benefits and insufficient antenatal and perinatal care for foreign-born women in the host country. (Braun et al., 2011) As a result, insufficient pre and perinatal care elevated the likelihood of GDM and premature delivery among foreign-born women. (Kim et al., 2018). Besides, a woman's chance of getting metabolic syndrome increases with a low household income. (Dallongeville et al., 2005). Because income shapes the pattern of a foreign-born women's lifestyle, which largely determines the occurrence of metabolic syndrome such as insulin resistance that may lead to the onset of GDM. (Roberts et al., 2013). Therefore, the incidence of metabolic illnesses such as GDM is inversely correlated with income which portrays a primary picture of the connection between a woman's or household's income and GDM (Dallongeville et al., 2005).
On average, foreign-born women tend to have low incomes and a higher likelihood of experiencing socioeconomic disparities in the host country than natives (Miani et al., 2020; Amo-Agyei, 2020). Because foreign-born women frequently encounter disparities regarding labour market segregation, such as limited salary, unemployment, dangerous working conditions, restricted social welfare, and labour union privileges. (Friedrich et al., 2021). The average wage for a foreign-born woman worker in a developed country is 12.6% lower than the average wage for native-born workers. (Amo-Agyei, 2020). Compared to native women, foreign-born women face a reduced likelihood of securing employment in occupations of a higher calibre. As a result, many foreign-born skilled women end up working in low-skilled jobs with low pay. A similar trend has also been observed in Sweden, where the income of foreign-born women in Sweden is relatively low compared to Swedish-born women. (Friedrich et al., 2021). According to (Le Grand & Szulkin, 2002) research, foreign-born individuals earn 2.8% less than their Swedish counterparts. Non-European foreign-born women are barred from accessing the Swedish labour market due to rigorous recruitment methods. As a result, the unemployment rate is 22.8 % higher for foreign-born women in Sweden, which determines foreign-born women's comparative placement within the income distribution. (SCB, 2023; Szaflarski and Bauldry, 2019). Therefore, most foreign-born women face low earnings and higher unemployment, which puts them at the bottom of the social hierarchy and makes them incapable of procuring commodities and amenities required for healthy living and better health. As a result, their income level significantly influences their physical and mental well-being over the life course. (Vacková & Brabcová, 2015; Wang et al., 2018; Daneshmand et al., 2019)

The potential mechanisms through which foreign-born women's income may impact the development of GDM are multifaceted. Income level significantly determines consumption patterns concerning food, lifestyle choices, residential location, and access to healthcare services in the host countries. (Ward et al., 2013). Additionally, mothers' dietary intake has a lasting effect on the health outcomes of both themselves and their offspring. (Song et al., 2017). As a result, it is getting increasingly difficult for low-income families, particularly foreign-born women, to afford nutrient-dense and healthy food options as their prices continue to rise, leading them to opt for cheaper, high-carbohydrate, sugary, and fatty alternatives. (Ward et al., 2013). Because in comparison with Swedish-born women, foreign-born women have a disproportionately high presence in the lower-income segments of society. (Le Grand & Szulkin, 2002). This unhealthy food consumption, poor living environment, inactive lifestyles and limited access to health care stimulate higher insulin secretion, which leads to early insulin
resistance, higher blood cholesterol, centralized deposition of excess adipose tissue, less physical activity, less body strength and abnormal BMI (Bodicoat et al., 2015). These factors not only elevate the likelihood of GDM during pregnancy among foreign-born women but also contribute significantly to pre-pregnancy obesity in women, which is a recognized critical risk factor for GDM. (He et al., 2021).

Income may also indirectly affect the prevalence of GDM in foreign-born women, as it has been identified as one of the significant predictors of the occurrence of psychiatric disorders, which are known to be a contributing factor for GDM. (Sardeye, 2020; Stringhini et al., 2010; Ouyang et al., 2021). Foreign-born women with higher financial strain are at greater risk of experiencing various psychological issues such as stress, anxiety and depression (Sardeye, 2020). Because the low-income level is associated with relative deprivation, lack of social integration and lower social position. As a result, foreign-born women may perceive a higher level of discrimination related to social stratification due to low income. (Gilliver et al., 2014). Consequently, a higher rate of stress, anxiety and depression regarding social position has been observed among foreign-born women in the destination region. (Sardeye, 2020; Sareen et al., 2021) Furthermore, anxiety and depression stimulate the hyperactivity of the chronic hypothalamic-pituitary-adrenal gland, which has the potential to induce hormonal imbalances (higher cortisol secretion) that results in insulin resistance and augment the likelihood of GDM. (Ouyang et al., 2021).

**Migration as a social determinant of health (SDOH): A theoretical framework:**

The SDOH referred to “the conditions in which people are born, grow up, live, work and age”. (Commission on Social Determinants of Health, 2008). SDOH encompass a range of economic, political and social factors that have an enormous impact on the health outcomes of individuals by determining their living condition, socioeconomic position, social network and health behaviour beyond the provision of medical care. (Castañeda et al., 2015; Short & Mollborn, 2015; Davies et al, 2009). Although SODHs have the potential to influence health at the individual level, their uneven distribution across different social groups can lead to health inequalities that follow a specific social pattern. (Honkaniemi, 2022).
Migration can be regarded as both a SODH and a consequence of the SODH. (Castañeda et al., 2015). On the one hand, SDOH determines foreign-born women’s lifestyles, neighbourhoods and health behaviours in both birth and host countries, while on the other hand, the migration process introduces a distinct dimension to foreign-born women’s SODH. Because during and after migration, foreign-born women are more likely to be exposed to several challenges that might impact access to social capital, social position, and financial stability in the destination regions. These factors play an influential role in determining their physical and psychosocial health outcomes in the destination country. (Short & Mollborn, 2015; Davies et al, 2009).

The distribution of SDOH is not similar in both the origin and host country. According to (Acevedo-Garcia et al., 2012), evaluating the social, economic and environmental factors in both the home and destination countries is essential. Because the allocation of SDOH in the origin country reveals a foreign-born women’s childhood and later life experiences and pre-migration circumstances, which could have a prolonged influence on their overall health status. (Davies et al., 2009). Therefore, knowing foreign-born women’s living standards, SEP, access to medical care, health behaviour and physical conditions in the birth country would help to identify several diseases that are more frequent in the immigrant home country than the host country. (Davies et al., 2009). On the other hand, significant SODH, such as the allocation of material resources, social support, education and job opportunity, and financial security required for maintaining better health, is unevenly distributed between foreign-born women and native women, which results in a widening health inequality gap in the society. (Honkaniemi, 2022). In addition, being immigrants, foreign-born women frequently encounter challenges such as xenophobia, discrimination, language difficulties and racism in the host nation that may significantly affect social cohesiveness and integration, receiving medical care and follow-up treatment and labour market integration in the destination country. (Short & Mollborn, 2015; Davies et al, 2009). As a result, the unequal distribution of resources and obstacles faced by immigrant women in the host country may contribute to their increased likelihood of occupying a lower social position, having limited social networks, residing in impoverished neighbourhoods, and experiencing precarious employment situations, higher rates of unemployment, lower educational attainment, and reduced income. These factors negatively affect their physical and mental health and significantly create health inequalities in society. (Davies et al., 2009). Therefore, migration status is related to several established SODH factors and has the potential to moderate the effects of these factors, making foreign-born women more susceptible to developing several diseases.
Apart from social and economic factors, cultural differences between countries also structure health behaviour. (Alifuddin & Widodo, 2022). The process of cultural transformation via which a foreign-born woman adapts new cultural norms, beliefs and behaviour of a new society is known as acculturation. (Allen et al., 2014). According to Berry's model of acculturation, acculturation might be "unidimensional", where foreign-born individuals adapt entirely to the new cultural norms such as eating habits, language, lifestyles, and physical activity in the host country. Thereby, the acculturation process might be potentially led to the adoption of detrimental health behaviours; for instance, traditional dietary habits such as eating more vegetables and fruits are replaced by unhealthy dietary habits like eating food high in sugar and fat may contribute to a higher possibility of gaining excess weight and obesity. (Allen et al., 2014; Castro, 2007). Furthermore, the degree of acculturation is also determined by the health behaviour of foreign-born individuals. The correlation between higher levels of acculturation and increased prevalence of certain metabolic disorders such as diabetes and cardiovascular disorder, and mental health diseases, for instance, depression, stress and anxiety, is observed among foreign-born women (Jin et al., 2017; Castro, 2007; O'Brien et al., 2014). Additionally, risky health behaviour such as smoking is also prevalent in a cultural setting pertaining to tobacco use among foreign-born individuals who have undergone greater acculturation. (Bethel & Schenker, 2005). Therefore, adopting unhealthy and risky health behaviour make foreign-born women more inclined to the development of diseases and contributes to the rising health inequalities in society. All of these risk factors which are influenced by the immigrant’s social determinants are the recognized risk factors for the development of GDM among women (Strandberg et al., 2021; Kragelund Nielsen et al., 2022; Bastola et al., 2021).

**Swedish context and its relevance:**

Developed nations have seen a surge in migration from Western and non-Western countries over the last four to five decades; (Kragelund Nielsen et al., 2022) and Sweden is not exempt from this phenomenon (Seghieri et al., 2020). The trend of female migration has exhibited an upward trajectory in recent times, notably in Sweden, and about 35% of the foreign-born women in Sweden are female; most of them belong to the reproductive age group. (Amroussia et al., 2022; SCB, 2023, Statista, 2023). Approximately 102,000 people immigrated to Sweden in 2022 alone, which is anticipated to be a surplus of more than 100,000 per year. (SCB, 2023).
Among this group, one in four individuals are foreign-born women, which is projected to rise by 18% by 2060. (SCB, 2022). Furthermore, all women in Sweden, including foreign-born, have access to the same quality maternal care because of the country's universal healthcare facility. (NY, 2007). Given the increasing rates of immigration to Sweden with heterogenous migrants group and the potentially more significant risk of GDM in foreign-born women, this study will make an essential contribution to the knowledge base with an investigation into GDM among foreign-born women in Sweden.

Study aim

Aim of the thesis

The study aims to explore the association between women with migration background and gestational diabetes mellitus (GDM) in Sweden and further investigate the role of income in this association compared to women born in Sweden.

Research question:

1. Do immigrant women from different countries of birth have increased odds of GDM relative to Swedish-born women during their first pregnancy in Sweden?
2. To what extent does income explain the differences between foreign-born women and Swedish-born women?
Methods

Data material

The study was conducted by using a combination of register data from the Longitudinal Integrated Database for Health Insurance and Labour Market Studies (LISA), the Total Population Register (TPR) and the Swedish Medical Birth Registers (MBR) from 1997 to 2016. Data on GDM and maternal characteristics were extracted from the MBR, foreign-born women's background data from the TPR, and data on income and sociodemographic variables from the LISA.

A unique, pseudonymized personal identification number was used to link individuals across the three databases. Data collection for the MBR started in 1973 and comprises information on over 98% of all births in Sweden (Cnattingius et al., 2023), LISA has comprehensively integrated data pertaining to migration and socioeconomic factors of individuals aged 16 years or above since 1990 and, from 2010, those aged 15 years or below. (Ludvigsson et al., 2019). Furthermore, since 1991, Statistics Sweden has been responsible for maintaining the Total Population Register (TPR) on behalf of the government. The TPR maintains an ongoing track of significant life events of an individual, for instance, citizenship status, birth, civil status, death, and relocation (Ludvigsson, 2016).

Study design and study population:

The study was cross-sectional and descriptive in nature. The present study utilized secondary data to gather analytical information about exposure, outcomes, and covariates variables from 1997 to 2016 at a singular point in time. Swedish-born women were used as the reference group in this study.

All women residing in Sweden and giving birth for the first time in Sweden from 1997 to 2016 were considered for inclusion in the study population. However, only singleton pregnancies were included in the study where women were aged 18-57. Hence, the unit of analysis was the mother who delivered babies in Sweden during the studied period.

At first, a population of 850,766 women served as the basis for the analytical sample (Figure 1). Among them, foreign-born women were 165,600, and Swedish-born women were 685,166. Then, missing values for exposure variables and covariates were excluded from the initial
analytical sample. Therefore, the final studied sample of 835279 women, where 151642 participants comprised the analyzed sample of a foreign-born group and 683637 individuals represented the Swedish-born cohort.

Figure 1: Flow chart of assembling the analytical sample.
Variables:

Outcome variable:

The outcome variable was Gestational Diabetes Mellitus (GDM). Within perinatal health, GDM has broadly been accepted as a reliable indicator for both mother's and child's health. (Jain et al., 2016). Data for GDM was extracted from the MBR. The identification of cases of GDM was carried out through the utilization of the International Classification of Diseases, Tenth Revision (ICD-10) code O24.4. GDM was a categorical variable and was operationalized in a dichotomous manner. Therefore, GDM had only two values where 0 indicated "No" and 1 indicated "Yes".

The primary method of GDM screening in Sweden is to check random blood glucose levels among all pregnant women during the first antenatal visit. (Fadl & Simmons, 2016). If any pregnant woman is diagnosed with a higher blood glucose level (≥9.0 mmol/L) with conventional risk factors, she undergoes a repetitive random blood glucose assessment. Therefore, blood glucose levels are checked randomly four to six times during pregnancy in Sweden. However, in cases where abnormal RBS is observed early in pregnancy, an oral glucose tolerance test (OGTT) is performed. If the OGTT results are considered normal, it is recommended to repeat the test at 28-32 weeks of gestation. (Fadl & Simmons, 2016).

The Swedish National Board of Health implemented the 2013 criteria established by WHO as a suggested method for diagnosing cases of GDM in pregnant individuals in 2015. (Fadl H, Saeedi, 2019). According to WHO, the diagnostic criteria for GDM is fasting blood glucose ≥ 5.1 mmol/L, 1 hour after ≥ 10.0 mmol/L, and/or 2 hours later ≥ 8.6 mmol/L after having 75 g glucose in oral glucose tolerance test (OGTT). (Fadl H, Saeedi, 2019).

Exposure variables:

The exposure variable was foreign-born women's country of birth (COB). COB referred to the women's birthplace, so women born outside Sweden were considered foreign-born and born in Sweden were counted as Swedish-born mothers, who gave birth between 1997 and 2016. Later, the International Diabetes Federation regional classification was used for the categorization of foreign-born women by country of birth.
This classification method accounts for differences by region in the risk for GDM (Sun et al., 2022). The foreign-born women study population was divided into eight groups: Africa, Middle East and North Africa, Europe, South and Central America, North America and Caribbean, Western Pacific, Southeast Asia and Sweden.

**Mediator variable: Income:**

Information on disposable individualized family income from LISA was used to assess income which was conceptualized as an individual's remaining financial resources for spending after deducting income tax and dividing the accumulated income of the entire household among all household members was used for statistical analysis. (Ludvigsson et al., 2019). Disposable income was divided into three quantiles. Individuals in the highest quantile (more than or equal to 66.7 %) were classified as having a high income, those in the middle quantile (33.4% - 66.6 %) as having a medium income, and those in the lowest quantile (at or below 33.3%) as having a low income. For statistical analysis, high-income groups were considered as a reference category.

**Covariates:**

Maternal age, year of childbirth, and marital status were included as covariates that may impact the studied association. Covariates data were obtained from LISA. Mother's age at the time of delivery was categorized into four groups: 18-24, 25-29 (reference category), 30-34 and 35-57. The year of childbirth was conceptualized as the calendar year when the mother gave birth. The year of childbirth variable was included as a categorical variable, and four distinct categories were created by dividing the year of birth into 5-year intervals; 1997-2001 (reference category), 2002-2006, 2007-2011 and 2021-2016. Marital status was categorized according to whether a woman cohabited or lived with a partner or herself. Women who cohabited or lived with partners were coded as married, and those who lived alone were coded as unmarried. In the original data set, it was divided into seven categories; married, unmarried, divorced, widow, registered partner, divorced partner and surviving partner. Afterwards, it was split into two categories to facilitate operationalization. One group was labelled married, which included only married and registered partners, and the other category was labelled unmarried, where the rest of the categories were combined. The reference category was married women.
Statistical analysis:

The data was analyzed using two types of statistical methods; descriptive statistics and multiple logistic regression analysis. Therefore, the analytical strategies followed three stages of analysis for exploring the risk of GDM in foreign-born women by COB. The analysis began with a description of all studied variables. Firstly, continuous variables were studied by measuring the mean, median, and standard deviation and the categorical variables were analyzed by measuring their frequencies and percentages.

To examine the association between COB and GDM, multiple logistic regression analysis was run to calculate odd ratios (OR) and 95% confidence intervals. Initially, a simple logistic regression analysis was carried out to investigate the relationship between COB and GDM. Then, multiple logistic regression analyses were conducted to estimate the odd ratios and 95% confidence intervals by comparing two different models. Model 1 was controlled for the mother's age, year of childbirth and marital status and model 2 was controlled for the mother's age, year of childbirth, marital status and income.

The inclusion of the mother's age and year of childbirth served to control for potential cohort and calendar effects. Because the prevalence of GDM seems to follow a positive trend with age and year of childbirth, additionally, it is widely acknowledged that advanced maternal age is one of the critical risk factors for GDM, and most women tend to migrate into their reproductive years between the ages of 20 and 35. (Zaiceva, 2014). Besides this, in terms of marital status, unmarried women exhibit a higher degree of geographical mobility than their married counterparts. (Riosmena, 2009). Conversely, research has indicated that married women are more susceptible to the onset of GDM. (Yaping et al., 2022). Therefore, marital status was also adjusted in Model 1 to make a comparable group. Finally, income as an SES indicator was adjusted in Model 2.

The Karlson-Holm-Breen (KHB) method was used to estimate the mediating influence of income on the relationship between foreign-born women's COB and GDM. It calculates the portion of the association explained by any additional variable in the model (Almquist et al., 2021). The statistical analysis was conducted by using the statistical software Stata version 17.

Ethical approval:

The Public Health Science Department at Stockholm University granted permission to utilize the registered data for this study. The data was stored on an encrypted server protected by
Results

Descriptive statistics:

Table 1 presents an overview of the study population's descriptive characteristics. A total of 835 279 women were studied, of whom (81.85%) were born in Sweden and (18.15%) were foreign-born. A substantial variation in the prevalence of GDM has been observed based on COB. The overall risk of GDM was (0.9%), with (0.6%) observed among Swedish-born women and (0.3%) among foreign-born women.

In COB regions, notable differences in the comparable group size were observed between different categories. The largest group of women who were foreign-born was from Europe (7.5%), followed by the Middle East and North Africa (3.7%), Southeast Asia (2.3%) and Africa (2.0%) respectively. Notably, it can be observed that individuals hailing from Poland, Finland, Yugoslavia, and Bosnia Herzegovina held a prominent position in Europe, while women from Iraq constituted a significant proportion of the group in the MENA region. Moreover, the African region had exhibited the largest population of individuals from Somalia, while SEA & WP predominantly consisted of individuals hailing from Thailand, China, India and Pakistan. The North American and Caribbean cohorts exhibited the lowest representation, contributing a mere (0.4%) of the total sample. Similarly, the South and Central American and Western Pacific groups displayed marginal participation, accounting for (1.1%) and (1.2%) of the sample, respectively.

Swedish-born women demonstrated the lowest proportion of GDM (0.7%), while women from South East Asia demonstrated the highest risk for GDM cases at (3.0%), followed by African (2.3%), Western Pacific (2.2%), and Middle East & North Africa (2.0%), respectively. In addition, when comparing the risk of GDM solely in women who were foreign-born, it was observed that European (1.1%), North American, and Caribbean (1.3%) females exhibited a lower prevalence of GDM than their foreign-born counterparts. However, still the European
(1.1%), North American, and Caribbean (1.3%) showed a higher number of GDM cases than Swedish women (0.7%). Overall, the risk of gestational diabetes mellitus (GDM) was observed to be (1.7%) among women who were foreign-born.
Table 1. Descriptive statistics of background characteristics by region of birth for all singleton pregnancies from 1997 to 2016 (number and crude percentage) in Sweden.

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>81.85%</td>
<td>2.00%</td>
<td>7.52%</td>
<td>3.74%</td>
<td>0.40%</td>
<td>2.32%</td>
<td>0.95%</td>
<td>1.23%</td>
</tr>
<tr>
<td></td>
<td>GDM</td>
<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>679053 (99.33%)</td>
<td>4584 (0.67%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Income</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>185116 (27.08%)</td>
<td>248113 (36.29%)</td>
<td>250408 (36.63%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mother Age</td>
<td>&lt;25</td>
<td>25 – 29</td>
<td>32 – 34</td>
<td>≥ 35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>148638 (21.74%)</td>
<td>260559 (38.11%)</td>
<td>200066 (29.26%)</td>
<td>74374 (10.88%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>147457 (21.57%)</td>
<td>172621 (25.25%)</td>
<td>182988 (26.77%)</td>
<td>180571 (26.41%)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Marital status</td>
<td>Married</td>
<td>Unmarried</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>163042 (23.85%)</td>
<td>520595 (76.15%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Income levels also varied depending on the COB. (Table:1). A significant proportion of foreign-born women demonstrated low-income levels, with Middle Eastern and North African women ranking highest at (77.9%), followed by African women at (74.2%), South East Asian women at (64.9%), and European women at (53.0%). The majority of them had given birth between 2012 and 2016, and more than 50% of women from these regions were married. The descriptive analysis also showed a significant difference in the ages of women from various regions. About 33% of women in Europe and Southeast Asia were aged 25-29, while most women in the Middle East and North Africa (38.6%) were younger (18-24). Additionally, more than 60% of African women were found to be under 25 years of age. Conversely, approximately 74% of Swedish-born women had medium and high incomes and also had the highest proportion of unmarried (76.15%). Most Swedish-born women had given birth between the ages of 25 and 29. The North American and Caribbean women demonstrated the greatest proportion of high-income (31.9%) among foreign-born women, with a majority (35%) in the age group of 32 - 35 years. More than half of women (52.2%) in the Western Pacific region were found to have low incomes. Additionally, over 70% of women in this region belonged to the middle age group and gave birth within the age range of 25 to 35.

**Analytical results:**

Table 2 shows the minimally adjusted and fully adjusted odd ratios (OR) and 95% confidence intervals (CI) for GDM among foreign-born women by COB relative to Swedish-born. The findings from Model 1 showed increased odds of GDM in all groups of foreign-born women compared to their Swedish-born counterparts. In particular, among foreign-born women, those from South East Asia demonstrated the highest odds for GDM. Women from South East Asia showed over four times increased odds of GDM compared to Swedish (OR: 4.40, CI: 4.01-4.81). Similarly, African women exhibited the second highest odds ratios for GDM, indicating an over three-fold increase in the likelihood of GDM relative to Swedish women (OR: 3.42, CI: 3.07-3.81). Although the Middle East & North African and Western Pacific women exhibited lower odds of GDM compared to the other regions mentioned above, their likelihood of developing GDM was twice as high as individuals born in Sweden (OR: 2.92, CI: 2.67-3.20) & (OR: 2.92, CI: 2.55-3.35) respectively.
Table 2: Minimally adjusted and fully adjusted logistic regression models for having GDM by COB and income.

<table>
<thead>
<tr>
<th>COB</th>
<th>Model 1&lt;sup&gt;a&lt;/sup&gt; OR (95% CI)</th>
<th>Model 2&lt;sup&gt;b&lt;/sup&gt; OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Africa</td>
<td>3.42 (3.07-3.81)</td>
<td>2.83 (2.53-3.16)</td>
</tr>
<tr>
<td>Europe</td>
<td>1.54 (1.41-1.67)</td>
<td>1.39 (1.28-1.51)</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>2.92 (2.67-3.20)</td>
<td>2.48 (2.25-2.72)</td>
</tr>
<tr>
<td>North America &amp; Caribbean</td>
<td>1.58 (1.16-2.14)</td>
<td>1.46 (1.07-1.98)</td>
</tr>
<tr>
<td>South East Asia</td>
<td>4.40 (4.01-4.81)</td>
<td>3.75 (3.42-4.12)</td>
</tr>
<tr>
<td>South &amp; Central America</td>
<td>1.48 (1.19-1.84)</td>
<td>1.34 (1.07-1.66)</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>2.92 (2.55-3.35)</td>
<td>2.60 (2.26-2.99)</td>
</tr>
<tr>
<td>Mother Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>0.76 (0.71-0.81)</td>
<td>0.69 (0.64-0.74)</td>
</tr>
<tr>
<td>25-29</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>30-34</td>
<td>1.21 (1.14-1.28)</td>
<td>1.32 (1.24-1.40)</td>
</tr>
<tr>
<td>≥ 35</td>
<td>2.05 (1.92-2.19)</td>
<td>2.26 (2.12-2.42)</td>
</tr>
<tr>
<td>Year of Child Birth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002-2006</td>
<td>1.09 (1.01-1.18)</td>
<td>1.17 (1.08-1.23)</td>
</tr>
<tr>
<td>2007-2011</td>
<td>1.25 (1.16-1.34)</td>
<td>1.43 (1.33-1.54)</td>
</tr>
<tr>
<td>2012-2016</td>
<td>1.28 (1.19-1.38)</td>
<td>1.57 (1.45-1.69)</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Unmarried</td>
<td>0.90 (0.86-0.95)</td>
<td>0.92 (0.88-0.97)</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>Ref.</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>1.53 (1.43-1.63)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>1.73 (1.62-1.86)</td>
</tr>
</tbody>
</table>

a. Model 1 is minimally adjusted and is adjusted for the mother’s age, year of childbirth and marital status.
b. Model 2 is adjusted for the mother’s age, year of childbirth and marital status and income.

European and North American & Caribbean women and South & Central American women were also found to have a higher risk of GDM (OR: 1.54, CI: 1.41-1.67), OR 1.58 (1.16-2.14) and (OR:1.48, CI:1.19-1.84) respectively. Women from South & Central America showed the lowest OR among foreign-born women (OR:1.48, CI:1.19-1.84), though they still showed increased odds of GDM relative to Swedish-born women.
Model 2 was the fully adjusted model where income as a potential mediator was included. The odds ratios for GDM decreased marginally in Model 2 among all foreign-born groups. Although the odds ratio for GDM decreased in Model 2, still all foreign-born women showed greater odds ratios for GDM than Swedish-born women.

Model 2 revealed an inverse association of women’s income with GDM risk. Odd ratios for GDM were highest among women with the lowest income levels. Therefore, a gradient of income in the odds ratios for GDM was observed in Model 2. The risk of GDM among low-income women was almost double that of the high-income group (OR: 1.73 CI: 1.62-1.86). Additionally, women who represented the middle-income group had higher odds than the high-income group and lower odds of GDM than the lower-income group. (OR: 1.53, CI: 1.43-1.63). Regarding covariates, in both Model 1 and 2, odds ratios for GDM increased with the mother’s age and by year of childbirth. Furthermore, unmarried women showed lower odds for GDM relative to married women in both models.

Table 3 demonstrates findings from the KHB method analyses to estimate the proportion of the relationship between COB and GDM that was explained by the included covariates and by income specifically. The total proportion explained by income was 25.5% for all foreign-born women.

A variation in the different groups by COB in terms of the contribution that income made to the association was observed. The highest proportion of the studied relationship among European women explained by income was 23.0%, followed by South America and Central America at 22.8% and Middle East & North Africa at 20.18%, respectively.

Among the Western Pacific women, the lowest portion of risk explained by income was observed (8.9%). The differences in the explanatory proportion of studied association by income were 20.2% in the Middle East & North Africa, 16.6% in Africa, 10.8% in South East Asia and 9.2% in North America & Caribbean.
Table 3: Karlson-Holm-Breen (KHB) method estimates of the percentage of risk explained by income in the relationship between COB and GDM.

<table>
<thead>
<tr>
<th>GDM</th>
<th>Proportion explained by all covariates (%)</th>
<th>Proportion explained by income (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>COB (overall)</td>
<td>34.86</td>
<td>25.46</td>
</tr>
<tr>
<td>Africa</td>
<td>17.89</td>
<td>16.53</td>
</tr>
<tr>
<td>Europe</td>
<td>32.22</td>
<td>22.95</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>16.62</td>
<td>20.18</td>
</tr>
<tr>
<td>North America &amp; Caribbean</td>
<td>39.93</td>
<td>9.17</td>
</tr>
<tr>
<td>South East Asia</td>
<td>13.93</td>
<td>10.81</td>
</tr>
<tr>
<td>South and Central America</td>
<td>35.80</td>
<td>22.80</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>20.01</td>
<td>8.89</td>
</tr>
</tbody>
</table>

Discussion

The thesis aimed to investigate whether foreign-born women have a greater risk of GDM than Swedish-born women and to what extent income can explain any observed differences in risk. All foreign-born women demonstrated higher odds ratios for developing GDM than Swedish-born women. The most significant risks were shown among women born in Southeast Asia, Africa, the Middle East and North Africa, and the Western Pacific regions. Income partially (25.4%) explained the risk of GDM in foreign-born, but the explained portion differed by COB. Depending on COB, income explained the most significant proportion of the risk of GDM among European women (22.95%), followed by South America and Central America (22.8%)
Results in comparison with previous research:

The current study shows a lower prevalence of GDM for women born in Sweden than for foreign-born women, which is in accordance with other Nordic research conducted in Norway, Denmark and Finland. (Bastola et al., 2021, Strandberg et al., 2021; Kragelund Nielsen et al., 2020). The observed association of elevated risk for GDM among foreign-born women relative to Swedish-born is in accordance with the prior empirical studies’ results. The GDM risk has been higher among non-European women living in Canada, the United States, Finland, Norway, Denmark and Sweden. (Bastola et al., 2021; Kragelund Nielsen et al., 2020; Strandberg et al., 2021; Fadl et al., 2012). Furthermore, (Bastola et al., 2021; Strandberg et al., 2021) discovered that foreign-born women from Southeast Asia, particularly from Pakistan, Bangladesh, Afghanistan, India, and Sri Lanka, showed the highest risk of GDM, regardless of country of migration, which was consistent with the findings of the current thesis. Specifically, studies conducted in Finland and Norway revealed a threefold GDM risk in women of South Asian origin, which is almost similar to the present thesis results. (Bastola et al., 2021; Strandberg et al., 2021).

Traditionally, South East Asian women have always been either underweight or of average weight (Bastola et al., 2021). However, despite the acknowledgement that obesity enhances the risk for GDM, it has been observed that South East Asian women still developed a higher rate of GDM even in the absence of abnormal BMI. Therefore, they might have a genetic predisposition towards GDM compared to other regions. Their body composition and tendency of central fat distribution could be one reason for the higher risk of GDM. Their body is more likely to store fat in the abdomen or on the viscera, which enhances insulin resistance and abnormal glucose mechanism in the body. (Bastola et al., 2021). An additional factor may be that the genetic variant rs7903146, T2D and PRS were significantly linked with the prevalence of GDM in women, commonly found in Asian women. (Lamri et al., 2022, Bastola et al., 2021). Furthermore, African and Middle East and North African women also showed a greater risk of GDM, which is consistent with several comparative research conducted in Nordic regions and the USA that has demonstrated that the Middle East and North African and African women
exhibit a considerable proportion of the risk of GDM. (Bastola et al., 2021; Hedderson et al., 2010; Strandberg et al., 2021.) One possible explanation could be their individual beliefs, which are influenced by the origin countries. According to (Hjelm et al., 2021), a person's beliefs regarding health and diseases are tailored by their birth country's culture and social determinants. Middle East women viewed GDM and other pregnancy complications as temporary and expressed hesitancy and unwillingness in seeking medical care more than Swedish-born counterparts in the host countries. (Hjelm et al., 2021). As a result, they were reluctant to seek medical care in the destination countries. In addition, host country factors such as language barrier restricted their access to medical facilities and follow-up treatment. (Hedderson et al., 2010). Another possible explanation would be the increased prevalence rate of obesity in Africa, and Middle East & North Africa. Because over the thirty years, the traditional diet of the population has been gradually replaced by a more industrialized diet in the Middle East & North Africa and Africa. (Toselli et al., 2014; Sarant, 2013). Because in these two regions, the availability of low-cost food items such as processed, fatty and sugary food has increased, leading to higher consumption of calorie-dense foods and decreased dietary fibre intake. Middle East and North African women also lead a sedentary lifestyle with relatively less physical activity. (Sarant, 2013). Then, after immigration, they mostly tend to adopt inactive lifestyles and health behaviour such as smoking and alcohol consumption again in the destination country, which may potentially elevate the susceptibility to obesity and which, in turn, raise the likelihood of developing GDM among Middle East & North African and African women (Toselli et al., 2014; Sarant, 2013).

The current thesis also aimed to determine the extent to which income might explain GDM risk differences among foreign-born women relative to Swedish-born women in Sweden. Previous research has shown income to be related to the risk of GDM among general populations. (Rönö et al., 2019). Also, other Nordic and Non-European studies observed a negative association between the risk of GDM and income. (Anna et al., 2008, Bener et al., 2011). The current thesis results also revealed an income gradient in the risk of GDM in foreign-born women residing in Sweden.

The current thesis has found that income partially explains the greater risk of GDM observed in foreign-born women relative to Swedish women, which is varied by their COB. The KHB method estimates the percentage of increased risk that income explains in the relationship between foreign-born COB and GDM. No previous literature has explained the extent of the
risk of GDM in foreign-born women by income based on their COB. However, limited research has shown that SES partially explain the risk of GDM in foreign-born women by COB. (Kragelund Nielsen et al., 2020; Braun et al., 2011). Their research findings almost follow the current thesis where income explained a modest amount of the association among foreign-born accounts for 25.6%.

The present thesis also found different explanatory proportions of income by COB ranging from 8.9% to 23.0%. Another study conducted in Australia revealed almost similar results based on SEP; SEP partially explains the risk of GDM depending on COB. However, they also found that maternal age and body weight significantly affect COB and GDM relationship. (Anna et al., 2008) Therefore, apart from income, a combined interplay of risk factors, different reasons for migration, and host countries' factors might also be crucial for explaining the studied association. Various factors, including obesity, reasons for migration such as regional origins, conflicts, cultural, political, and socioeconomic disparities, as well as host country factors such as regulations and policies encountered by foreign-born women during the immigration process, may serve as critical determinants in elucidating the disparities in the prevalence of GDM between foreign-born and Swedish-born women, beyond the influence of income. (Davies et al., 2009).

The rationales behind immigration, particularly from developing countries, were multifaceted. Factors such as SDOH considered a driving force for immigration, such as poor living conditions, poor diet, unhealthy neighbourhoods and exposure to adversity, such as environmental and political subjugation and conflict, are influential. (Bauer et al., 2020). All of these pre-migration factors have an impact on physical and mental illness, such as stress which adds up to an additional risk among foreign-born women for developing GDM. (Badon et al., 2017; Davies et al., 2009).

Upon arrival, foreign-born women undergo the process of acculturation which determined foreign-born women's health behaviour and shape the health outcome in the destination country. (Ogunwole et al., 2022). Empirical research has found a positive link between higher levels of acculturation and a higher risk of diabetes among Hispanic populations. (O'Brien et al., 2014). Foreign-born women quickly adapted to unhealthy diets, risky health behaviour, smoking and inactive lifestyle, which leads to pre-pregnancy abnormal BMI and obesity and makes foreign-born women more prone to develop GDM. (Chen et al., 2019). Because the prevalence of obesity among foreign-born women is typically lower upon arrival in the host
country but tends to escalate progressively over time. (Ogunwole et al., 2022). Moreover, in Sweden, the rate of obesity is three times higher among foreign-born women than among Swedish-born women. (Faskunger et al., 2009). Additionally, the proportion of Swedes categorized as obese rose from 5% to 10% according to their body mass index from 1980 to 2005. (Faskunger et al., 2009). So, being overweight or obese significantly contributes to glucose intolerance and insulin resistance by adiposity and enhances insulin secretion early stage of life, which can later cause GDM (Yen et al., 2019). Furthermore, increased exposure to high-calorie food in the host countries may result in chronic metabolic diseases and insulin resistance. (Ogunwole et al., 2022). A positive correlation has been observed among mothers between an unhealthy diet and an elevated risk of GDM, with more consumption of red meat and fast food which is more prevalent in industrialized countries. (Quan et al., 2021).

After immigration, foreign-born women are more likely to experience several challenges in adjusting to a new culture, loss of family ties, lack of social integration and support, and obstacles in access to healthcare services, such as language barriers and service providers' perspectives on foreign-born women. (Nimar, 2018; Bozdağ & Bilge, 2019). These post-immigration challenges adversely affect foreign-born women's physical and mental health. (Gilliver et al., 2014; Ogunwole et al., 2022). In addition, the prevalence of mental health issues among foreign-born women in Sweden is higher compared to Swedish-born. (Sardeye, 2020). Certain diseases are more prevalent among foreign-born women, such as cardiometabolic diseases, anxiety, psychotic disorder, stress and depression. (Sardeye, 2020). As a consequence, stress can affect individuals eating habits and often lead to an unhealthy diet, resulting in excessive weight gain and obesity among foreign-born women. (Tseng & Fang, 2011; Ogunwole et al., 2022). On the other hand, psychiatric disorders such as stress may elevate the frequency of smoking among foreign-born women by reducing the ability to abstain from smoking. (Reiss et al., 2015; Salama et al., 2022; McKee et al., 2011). Both smoking and obesity are recognized as major contributory factors for the development of GDM in women. (Zaiceva, 2014) Therefore, to better understand the explanatory factor behind the underlying cause of GDM in foreign-born women, it is imperative to conduct longitudinal analyses, which will incorporate more detailed data about the factors mentioned earlier. (Ogunwole et al., 2022).
Strengths and limitations of the Study:

The strengths of this thesis included its emphasis on a comparatively less explored public health domain. Another strength was the large study population and use of link register information that assured the data quality, higher statistical power and generalization of the study findings to nations whose healthcare systems are identical to Sweden. (Bastola et al., 2021). The MBR, LISA, and TPR databases are routinely utilized in Swedish public health and medical research to facilitate the investigation and enhance comprehension of health and treatment progression. (Cnattingius et al., 2023; Ludvigsson et al., 2019). Also, using linked register data allowed a negligible susceptibility to selection bias because there was no chance of non-responsive and insufficient follow-up data. (Thygesen & Ersbøll, 2014). In addition, the large study population size allowed us to study the risk of GDM among foreign-born women from a variety of geographic and cultural backgrounds worldwide. Moreover, rigorous standards for inclusion and exclusion criteria ensured the acquisition of a thoroughly defined and reliable study population. (Bastola et al., 2021).

The lack of information before immigration on GDM markers (Strandberg et al., 2021), such as any previous drug history, family history, type of pregnancy, like spontaneous or with medication or IVF, and previous history of diabetes unavailable, which might have contributed to the GDM risk disparities between foreign-born women and Swedish-born women. (Bastola et al., 2021). In addition, data on previous pregnancy, particularly among foreign-born women outside Sweden, were also unavailable. As a result, it might be possible that individuals are erroneously categorized as first-time parents when they might have had prior children before relocating to Sweden. It could affect the probability of post-pregnancy weight gain and leads to obesity in the second pregnancy, which is an acknowledged risk factor for GDM. Furthermore, the findings presented in this study were limited to first-generation foreign-born women due to studies aim. Hence, this study could not be generalizable to individuals who fall under second-generation foreign-born women, parents from different COB and foreign-born women with multiple pregnancies. Furthermore, to comprehend the risk of GDM in foreign-born women by COB, it was imperative to conduct analytical studies according to foreign-born women’s COB. However, foreign-born groups could not be classified according to their country-specific origin or ethnicity because the TRP database contains data on foreign-born women from only 52 countries worldwide.
Discussing methodological considerations in the thesis is crucial to comprehending the reliability and validity of a study's outcomes. The data used in this study was secondary and was not collected solely for the intent of this particular investigation, resulting in a reduced possibility of selecting variables to test the studied relationship based on available data. (Sikder, 2012). As a result, this study lacked crucial information on choosing variables on migration and GDM risk factors, including but not limited to the reason for migration, language proficiency, poor dietary habits, and insufficient physical activity. These factors may have affected the observed disparities between the groups. Another potential constraint of this methodology was that the assessment of income was conducted solely at a single time point. Because examining a singular instance of data diminished the protracted impact of income on GDM. As a result, the potential effects of income on health might differ depending on whether it was experienced over an extended period or for a shorter duration. A study with cross-sectional nature conducted in Britain revealed that long-term income holds greater significance for an individual's health than their current income. (Andersen et al., 2005). Therefore, a longitudinal study is essential to investigate the role of income in future research.

Possible implications of the findings:

This study provides insight into foreign-born women's perinatal health in Sweden by demonstrating a greater likelihood of GDM in foreign-born women relative to Swedish-born. The results underscore the significance of considering the influence of the birth country when conducting assessments of risk for GDM among foreign-born women. Therefore, this study can be used as a framework for future research to investigate additional potential factors contributing to the higher risk of GDM among that specific foreign-born population. (Kragelund Nielsen et al., 2022). This thesis results also showed that certain regions have a higher prevalence of GDM among foreign-born women than other regions and the Swedish. Therefore, those regions can be identified as high-risk regions for GDM. (Bastola et al., 2021). As a result, women from high-risk GDM countries will be aware of their health and lifestyle and take proper healthcare facilities before and during pregnancy and even after pregnancy to prevent GDM. Additionally, an OGTT test early in pregnancy should be mandatory, especially for women from high-risk countries when they become pregnant. (Kragelund Nielsen et al., 2020). As cultural differences exist between regions, a culturally appropriate approach to managing GDM during pregnancy could be beneficial for minimizing the likelihood of GDM among foreign-
born women. (Bastola et al., 2021). Also, for future research, comparing the potential variations in adverse outcomes associated with GDM by COB will be plausible. Moreover, this thesis could be helpful for better design, structure, and implementation of policies in the public health field and interventions to reduce the possibility of GDM among foreign-born women in the host country. Furthermore, income only explained the risk of GDM in this study partially; therefore, looking for other risk factors, particularly dietary patterns and physical activity, which influence obesity, a recognized risk factor for GDM, could explain the differences between foreign-born and native (Bastola et al., 2021). Therefore, it can be said that the variation in GDM occurrence cannot be attributed entirely to foreign-born women's COB and their income. More study is required to see what additional factors could explain the chances of GDM among foreign-born women. For further research, the present thesis result will be useful in identifying the region-specific prevalence of GDM in women who were foreign-born residing in Sweden and the explanatory factor. Because this study fills a significant gap and makes an insightful addition to the existing body of literature on GDM in Sweden by focusing specifically on foreign-born women in the context of global health.

**Conclusion:**

In perinatal health, GDM is regarded as an adverse health outcome and a severe public health problem because it encompasses more significant health hazards for both child and mother during pregnancy and paves the way for post-pregnancy complications for both. (Strandberg et al., 2021). Overall, a higher likelihood of GDM among women who were born outside Sweden is found, with income as a partial mediator of the association. Southeast Asian, African, Middle East & North African women are the most susceptible in the foreign-born group to the development of GDM. Therefore, it is imperative to offer additional support and treatment facilities to pregnant women with a migrant background. Furthermore, as demonstrated in this thesis, foreign-born women within the childbearing age exhibit an elevated susceptibility to GDM. Consequently, it is essential to develop health promotion, prevention and treatment strategies for this population.
References


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