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Inequalities in early-pregnancy BMI among immigrants related to length of residence in Sweden.

A population-based register study

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Abstract

Background: The increase in both global migration and level of overweight/obesity and its relation with health inequalities are convincing reasons to study the immigrants' obesity trends. International studies have shown that the prevalence of overweight/obesity tends to increase with their length of residence in the host country. In early pregnancy, the unhealthy weight gain has negative repercussion for both the mother and the child.

Aims: To examine if there was an association between the women's country of origin and early pregnancy overweight/obesity compared with Sweden-born women and, to examine if their BMI was modified by the length of residence.

Method: using the Swedish population registers for the period 2002-2012, a logistic regression analysis was conducted to estimate odds ratios of overweight/obesity and 95% confidence interval by categories of length of residence, adjusting for covariates. Sensitivity analysis was performed to asses for robustness due to missing data.

Results: The prevalence of overweight/obesity in pregnant women was lower upon arrival but increased since the time of migration in all the groups. However, after 16 years of living in Sweden, two opposite patterns were identified across the groups of women´s country of origin. A large heterogeneity between and possible within the groups was identified.

Conclusions: The results in this study suggest that the host country might play an important role in explaining the changes in body weight among pregnant immigrants by the length of residence. Further studies are needed to disentangle the mechanism that generate health inequalities and help policymaker identify strategies based on evidences.

Keywords: Country of origin, global health, inequalities, length of residence, migration, overweight/obesity, pregnancy.

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Table of contents

List of figure

List of tables

1. Introduction

Migration has increased significantly worldwide in the last decades, especially among healthy young adults at working and reproductive ages (United Nations (UN), 2017). Immigrants have diverse backgrounds and levels of risk and vulnerabilities based on the circumstances surrounding their migration experience. These circumstances often fuel inequalities and may expose immigrants to negative health outcomes (International Organization for Migration (IOM), 2019). The health inequalities can lead to health inequities, which are systematic and unfair differences in the health status across different population groups (World Health Organization (WHO), 2019).

Upon arrival, immigrants' health is often challenged in the host country due to multiple factors. Some of the main challenges are adapting to the new society, learning the language and facing barriers in access to social and health services. They may also experience health problems such as overweight/obesity, which is a risk factor for chronic diseases that are also increasing worldwide (Cunnigham, 2018; WHO, 2018). Considering the negative effect of unhealthy body weight in early pregnancy, studies that analyse pregnant immigrant overweight/obesity are needed.

The prevalence of overweight/obesity in pregnant women is a major concern for global public health (WHO, 2018; Biswas, 2017). This prevalence represents a major challenge due to their association with multiple adverse health outcomes for both the mother and the child (Bjermo et al., 2015; Reiss et al., 2016; Marchi et al., 2015). Although many studies have focused on the incidence of obesity in the global burden of disease or analysed the immigrant's trends; further studies focusing on obesity in pregnancy are needed due to its impact on health (Siega-Riz, 2012; Stubert et al., 2018). Moreover, it also needs to understand the social inequalities in body weight, mainly in pregnant women who have experienced migration.

These increases in both global migration and levels of overweight/obesity and its relation with health inequalities are convincing reasons to study the immigrant's obesity trends. Another reason is that it is related to the called made in the 61st World Health Assembly in 1998, where the relevance to "*asses and analyse trends in migrants health to facilitate the evaluation of access to health care and equity among population groups*" was emphasized (WHO, 2008).

WHO also argues the need for coordination of research to address inequalities in the social determinants of health and design strategies to sustain and improve the health of migrants and those who host and interact with them.

This study examined the relationship between women's country of origin and the risk of obesity/overweight during early pregnancy modified by the length of residence. Length of residence has been used as a proxy of social integration into society (Kearns & Whitley, 2015).

The framework used, for a better understanding and an integrative perspective, was based on the Social determinants of health framework and Acculturation theory. Through these lenses, it is possible to have a critical insight on this health challenge and encompasses health outcomes and its determinants in order to generate informative evidence for interventions and policies.

The results of this study could contribute to addressing the knowledge gap concerning migrant's women reproductive health and their changes in body weight over time, such as increase of BMI. Moreover, it also will add value to the body of knowledge about the characteristics of the environment and its effect on population health.

2. Aim of the study and research questions

This study had two aims. First, to examine if there was an association between the groups of women's country of origin and early-pregnancy overweight/obesity compared with Sweden-born women. Second, to examine if the change in BMI among the immigrants was modified by the length of residence.

The research questions are:

- Are immigrant women with certain groups of origin more likely to be overweight/obese during early pregnancy compared with Sweden-born women?

- Does BMI during early pregnancy among immigrant women tend to converge with the levels of BMI of the Sweden-born pregnant women by length of residence in Sweden?

3. Background (previous research)

3.1 Overweight/obesity in pregnant women

The increase in overweight/obesity worldwide is a major Global health challenge. Overweight and obesity are defined by World Health Organization (2019a) "*as abnormal or excessive fat accumulation that presents a risk to health*". It is defined in terms of body mass index (BMI), a measure of weight relative to height. Obesity has nearly tripled between 1975 and 2016 for both men and women around the globe. In 1975, obesity rates among men have increased by around 3% and among women by over 6%, while overweight has increased by 20% for men and 23% for women over the same period. (WHO, 2019b). Likewise, in 2016, 39% (39% of men and 40% of women) of the adults aged 18 and more were overweight, and 13% (11% of men and 15% of women) were obese (WHO, 2019a, 2019b). These proportions vary between countries, and also within countries based on the level of income, education and gender where individuals from lower socioeconomic positions and educational levels are more likely to be overweight/obese. Women are also more likely to be overweight/obese than men. (Abarca et al., 2017; WHO, 2018).

The causes of overweight/obesity result from a complex combination of individual, societal and structural determinants. These causes can range from genetic, food intake or physical activity to socioeconomic and political factors. The consequences of overweight/obesity are associated with poor health, low the quality of life and, it is recognised as a leading cause of death worldwide (Centers for Disease Control and Prevention (CDC), 2017). Obesity is a risk factor for an expanding number of chronic diseases (i.e. Cardiovascular diseases, Diabetes Mellitus type II, Ischemic stroke, chronic kidneys disease) in the population. The Global Burden of Disease study (GBD) describes that at the Global level, high BMI (≤25kg/m2) contributes to 4.0 million deaths and 120 million disability-adjusted life years (DALYs) from any cause among adults (Abarca et al., 2017).

Furthermore, overweight/obesity among adults has also considerable economic and societal consequences (CDC, 2017). Overweight/obesity and its associated problems represent a direct and indirect cost. Direct cost is related to health services, such as treatment, and indirect cost refers to the cost of decreased productivity due to absence from work and premature mortality and disability (Ibid).

According to Chen, et al. (2018), the prevalence of adult women with overweight increased from 29.8% in 1980 to 38.0% in 2013, in both high and middle-income countries. The same study estimated that almost forty million (39.9 mills.) pregnant women were overweight and around fifteen million (14.6 mills.) were obese in the world in 2014 (Ibid). Among pregnant women, high gestational weight gets a particular relevance due to the increase in the last decades, and its consequences on the health for both the woman and the child. Several studies have demonstrated the link between maternal obesity in the first trimester and obesity in the child and its adverse effects later in life (Gillman, 2012; Leddy et al., 2008; Whitaker, 2004).

In detail, the mother's health is affected by increasing the risk to gestational diabetes, hypertension, preeclampsia and depression. High body weight during pregnancy has also been considered as a significant risk for later obesity in women (Leddy et al., 2008). Excessive gestational weight has also adverse health outcomes for the child. It increases the risk to preterm or large gestational age, birth defects, macrosomia and perinatal deaths (Bjermo et al., 2015; Hanson et al., 2017; Marchi et al., 2015; Reiss et al., 2015; Templeton, 2014). Additionally, the consequences of these health problems will affect the child's development and wellbeing over the lifespan (Biswas et al., 2017; Leddy et al., Merrick, 2013; 2008 WHO, 2018).

As mentioned above, overweight/obesity represents a health hazard, and it affects all population but mainly, vulnerable populations. This study focus on immigrant women who arrived in Sweden and are exposed to a new environment, which can have implications in their body weight.

3.2 Migration and overweight/obesity

Migration, the process of going from one country to settle in another, should be considered among the social determinant of health (Davies, 2009). These determinants are mostly responsible for health inequalities within and between countries. The migration experience varies considerably across the migrant group and from person to person within such groups (Migration Data Portal, 2019).

The process of migration includes different phases. Briefly, the first one refers to the pre-migratory events in the country of origin and traumas; it also includes the push factors for

migration. Then, the movement phase (transition) is characterized by the duration, the circumstances and the conditions of the journey. Next, the arrival and integration phase consists of the adaptation of the person to the new country and its policies; it also implies linguistic and cultural adjustments and the opportunity to access health and social services. Finally, the return stage in which some people decide to return to their country of origin. Moreover, there are crosscutting aspects in this process, such as gender, age, socioeconomic status, genetic factors. In each phase, the person faces different risk and vulnerabilities as well as different needs (Migration Data Portal, 2019; Zimmerman, 2011).

The increase of migration globally has resulted in an expansion of studies investigating the link between the migration processes and the population health. This relationship is complex because immigrants are a very heterogeneous group with diverse backgrounds. They also have different levels of risk and vulnerabilities surrounding their migration experience. Many of the studies that investigate this topic had focused on the acculturation experience among immigrants groups and how it varies depending on the country of origin (as a proxy of ethnicity) and the density of people from the same country in the communities (Gutiérrez et al., 2010).

It has been shown that the circumstances that are involved in the migration process might shape the risk of unhealthy weight gain in immigrants groups (Murphy et al., 2017). Differences in integration, both economic and social, may result in unhealthy behaviours such as diets high in fat, sugar and salt (i.e. ultra-processed food), reduction of physical activity and smoking that lead to adverse health outcomes like overweight and obesity (Antecol & Bedard, 2006). Moreover, the combination of intrinsic and environmental factors may cause the increase in weight; often overweight/obesity rates are beyond the levels of the native population (Delavari et al., 2013; Murphy et al., 2017)

Studies conducted by Goulão et al., (2015) and Lindström & Sundquist (2005) show that the degree to which immigrants acculturate to the major culture after the migration, influences their BMI and increase the risk of becoming overweight/obese. For instance, studies in Europe, the United States and Australia have shown that immigrants are more likely to become overweight/obese with the longer time spent in the receiving country. However, in Canada, this situation is not evident among immigrants (Da Costa et al., 2017; Menigoz et al., 2016; Urquia

et al., 2012). In Sweden, Lindström & Sundquist (2005) state that overweight/obesity was significantly more prevalent in certain immigrants groups, depending on their country of origin (i.e. Former Yugoslavia, Poland and Arabic-speaking countries) compared with the reference group born in Sweden, even after adjusting age and education. This study also showed that the risk of overweight/obesity increases with the length of residence in Sweden in the Arabic speaking group. Thus, some studies show correlations between weight gain and migrating to a new country.

Many authors have also highlighted that it is relevant to consider characteristics of the country of origin and the length of residence when studying differences in BMI. Regarding country of origin, Murphy et al., (2017) describe that there is a variation in the prevalence of overweight/obesity in different population due to genetic components and cultural practices, as well as variation in the degree to which local environment promote weight gain and obesity in the individuals.

Individual factors, such as dietary behaviours, the barrier to engage to physical activity and the experience of stress, together with the social and economic disadvantages increase the risk of overweight/obesity in immigrants (Delavari et al., 2013). Moreover, changes in the body weight vary between groups according to ethnicity, gender and age at the time since migration in the new country (Ibid). Therefore, the unhealthy weight gain is not randomly distributed; in opposition, it may affect mainly vulnerable groups due to the lack of opportunities.

Length of residence also has a positive relationship with body weight gain. Several studies have shown that even though the prevalence of overweight/obesity in immigrants tend to be low on arrival; the risk of becoming overweight/obese increases with their length of residence (Bjermo et al., 2015; Cunningham & Vandenheede, 2018). Cunningham & Vandenheede (2018), suggest that such an increase in body weight may be a result of the exposure to the new environment, behavioural changes and the stress of migration. For example, studies in Australia, Portugal, Spain and the United States have shown that immigrants who were having lower BMI on arrival, over the time of residence, their BMI increased (Menigoz et al., 2016; Da Costa et al., 2017; Gutiérrez et al., 2010).

Several studies have found that immigrant women tend to become overweight/obese during the adaptation process in the host country (Antiporta et al., 2016; Goulão et al., 2015; Kaushal,

2009). As mentioned before, during pregnancy, this unhealthy increase in body weight is associated with adverse health outcomes for both the women and the child.

Sørbye (2014) and Urquia et al. (2010) found that the longer the time spent in the new country is associated with the risk of preterm birth and increase in the caesarean section. Juarez et al. (2018) demonstrated that unplanned and planned caesarean section tend to increase with the length of residence, suggesting that the characteristic of the environment influence the performing of caesarean section. The previous authors supported this view arguing that the deterioration of maternal health increased with time to exposure to the host country, possible due to the higher consumption of tobacco, alcohol and ultra-processed food together with limitations in accessing health services and health promotion programs.

Other studies related to the length of residence also show the influence of the time since migration with different health outcomes (i.e. cardiovascular disease risk factors) or adoption of unhealthy habits (i.e. smoking and drinking). For example, Koya & Egede (2007) report that longer time of residence in the US results in an increase in odds of obesity, hyperlipidaemia and cigarette smoking among immigrants from a different background; these are risk factors associated with cardiovascular diseases. Other studies focused more on the adoption of unhealthy habits such as increase of smoking, alcohol consumption and drug abuse, showing similar results of increase as they spent more time in the new country (Gfroerer & Tan, 2003; Li & Wen, 2015).

3.3 Global health response: Sustainable Development Goals and Equity perspective

Obesity/overweight and migrants' health, both are becoming concerns that need to be analysed from a global health perspective. According to this perspective, it is important to address underlying social, economic, environmental and political determinants, and engage in global strategies in order to improve health and achieve equity in health for all people worldwide (Beaglehole & Bonita, 2010; Koplan et al., 2009). Currently, Agenda 2030 represents the international strategy to respond to common challenges across countries.

The Agenda 2030 for sustainable development consists of 17 global goals (Sustainable Development Goals (SDG)) that tackle global priorities. This agenda is a global plan to achieve a better and more sustainable future for all (UN, 2019a). The overall aim is to promote human

dignity and prosperity with a particular focus to do not leave anyone behind (Nilsson et al., 2017). The goals are interconnected and indivisible, and balance three dimensions of sustainable development: the economic, social and environmental (Nunes et al., 2016; UN, 2019b). Health has a central position in the agenda due to it is importance for achieving all three pillars of sustainable development and is closely linked with the other goals and targets; additionally through the health approach, it is possible to integrate different sectors to promote health, wellbeing and progress (ISGlobal, 2018).

The study of immigrants' health and their adaptation experience in a new country contribute to the attainment of the goals. Especially, SDG3 (*ensure healthy lives and promote wellbeing for all at all ages*) and SDG 5 (*achieve gender equality and empower all women and girls*), and SDG 10 (*reduce inequality within and among countries*) which has a special focus on migration (10.7) within the goal of reducing inequalities (IOM, 2017b).

Some studies have found that there are many health differences between immigrant and native-born population by time since migration; many of the differences arise from inequalities (Wickramage et al., 2018). These inequalities may be related to barriers in the utilization of health services, socioeconomic status, gender and/or discrimination.

It is relevant to highlight that generally, studies refer to immigrants as a broad group, encompassing all people who immigrate to another country. However, immigrants are a heterogeneous group with specific health needs, vulnerabilities and migration experiences. (IOM, 2017b). Some migrants may be especially vulnerable and exposed to a higher health risk, particularly women and youth in precarious environmental conditions (Ibid).

The analysis of pregnant immigrant women and their risk of becoming overweight/obese tries to address SDG 3, SDG 5 and SDG 10. SDG 3 focus on the reduction of common killers associated with child and maternal mortality as well as the decrease of premature death due to Non-communicable diseases. Likewise, SDG 5 highlights the relevance of ensuring universal access to sexual and reproductive health. Furthermore, SDG 10 emphasises on the relevance to pay attention to the needs of disadvantaged and marginalised populations in order to reduce inequalities (UN, 2017). In order to achieve these goals, it is necessary to design actions that include both the individual's behaviours and social conditions.

Based on the above, the equity perspective is needed insofar as the risk of obesity is strongly associated with the individual's socioeconomic circumstances. Equity, according to WHO (2019), implies that people have equal opportunities to develop and maintain their health, through fair access to resources for health. In order to achieve this, "*the absence of avoidable, unfair, or remediable differences among groups of the society, whether those groups are defined socially, economically, demographically or geographically or by other means of stratification*" is crucial (WHO, 1998, 2019). The Organization for Economic Cooperation and Development (OECD) Report (2017) states that there is a vicious circle of social and health inequalities in which education and socioeconomic background increase the risk of obesity/overweight, and obesity affects the productivity of the person in the labour market. These adverse labour market outcomes reinforce social inequalities.

Phelan et al. (2010), in their studies, explained the association between socioeconomic status and mortality. These authors explained that the socioeconomic inequalities in health are translated in major causes of death and fuelled by risk factors such as poor diet, inadequate exercise and smoking.

In the same view, studies focused on immigrant pregnant women described similar findings where the socioeconomic and migration status affect the birth outcomes (Auger et al., 2009; Racape et al., 2016). However, some studies also show conflicting results where sometimes the outcomes are better and other times worse.

3.4 Summary of literature review

Overweight/obesity among adults is increasing worldwide, mainly affecting vulnerable populations such as immigrant women. Obesity/overweight is a leading cause of non-communicable diseases, which has health implications in the long term. The increase of unhealthy body weight during pregnancy is relevant due to the health consequences in both the mother and the child. Moreover, many of the pregnant women are immigrants whom their adaptation to the new country over time influence their body weight, in many cases in a negative way.

Presented literature shows that there is strong evidence of the impact on socioeconomic status on the development of obesity. It also highlights the role of the migration process and the length

of residence as factors that modify this health outcome. However, it is important to recognise that immigrants and the characteristic of the host country together with the adaptation experience may vary across this population.

In addition, the different health outcomes can be a result of inequalities. Many studies show the connection between health outcomes and disparities among the population, especially between immigrants and the native-born population. Therefore, the present study explores the connections between mother's group of origin, length of residence and employment, and the development of overweight/obesity in order to have a better understanding of the mechanisms that are involved in this health outcome.

4. Immigration, obesity and employment in Sweden

Sweden has become an immigrant country in a rather short period of time. During the last five decades, more people have chosen Sweden as a country of destination (Franzén, 2004). After World War II, Sweden experienced an economic expansion which motivated the recruitment of immigrants in their workforce. The vast majority of immigrants were guest workers, mostly skilled who met the work shortage. The upcoming years, mainly at the beginning of the 70s, there was less need for labour immigrants due to the reduction in workload in the industry (Skodo, 2018). However, the immigration waves still increased in the country as a result of the reception of people fleeing their countries due to wars and civil conflict (Figure. 1) (SCB, 2004).

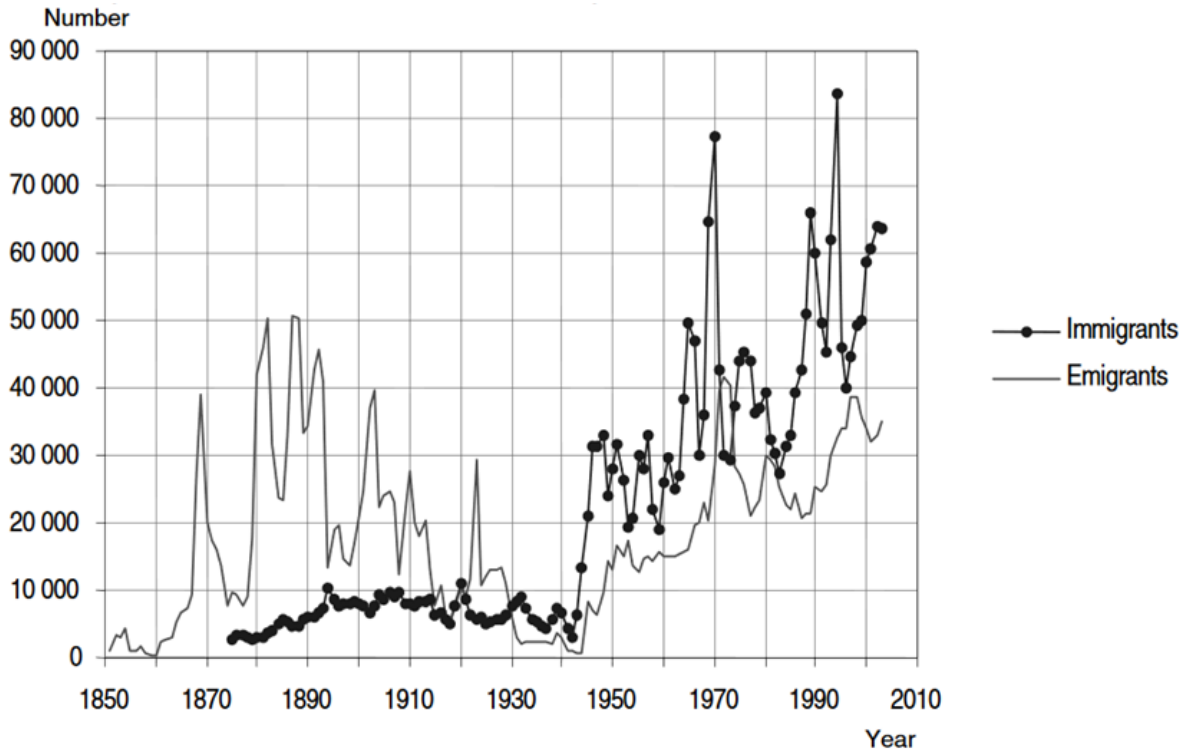


Fig 1. Immigration to Sweden 1875 – 2003 and emigration from Sweden 1851-2003.
Source: Efterkrigstidens invandring och utvandring (SCB, 2004).

Currently, Sweden received people from all over the globe who immigrate for work or seeking asylum. According to Sweden population statistics, immigrants arrived primarily from Middle East (Syrian Arab Republic, Iraq and Iran), Africa (Eritrea and Somalia), South Asia (India and Afghanistan) and Europe (Germany and Finland). Taking into account, the distribution of sex, there are more foreign-born women than men (SCB, 2018; 2019).

Furthermore, health outcomes vary across the immigrants' origin. Some studies state that the group of non-Europeans immigrants in Sweden often show similar or better health than the native population (Juárez & Rostila, 2017). However, with time living in the host country, some immigrant reported poor health, which may be explained by the emerging of disparities among the population (Hjern, 2012). This situation can be the result of the social living conditions and their perception of integration and/or discrimination.

A health outcome of special interest among the immigrant's population is overweight/obesity. In general, the prevalence of overweight and obesity have been increasing among the population in Sweden. Although this prevalence is still lower from an international perspective; in the last decades, obesity in adults has doubled (Neovius et al., 2006). In fact, in 2006 the prevalence of obesity for both men and women was 10%, and in 2016, it increased to 16% (Folkhälsomyndigheten, 2018). This increase in body weight to unhealthy levels are among the five risk factors for healthy years of life being lost (Folkhälsomyndigheten, 2018).

Generally, immigrants often are less obese than natives upon arrival but tend to converge to the obesity prevalence of the native-born population during their adaptation to the new country (Goulão et al., 2015). However, there are different trends in obesity by immigrant's country of origin, migration experience and socioeconomic conditions. A study conducted by Faskunger et al. (2009) showed that there is a strong gradient in the prevalence of obesity among immigrants who live in deprived neighbourhoods in Sweden; mainly those people with low education and low socioeconomic status. In line with the state above, the magnitude of the obesity problem is major in immigrant women who experience economic difficulties.

Among pregnant women, the prevalence of overweight/obesity has increased since 1992. In fact, 32% of Swedish pregnant women were overweight or obese in 2008-2010 (Chen et al., 2018). The study by Lindström & Sundquist, 2005 showed that both overweight and obesity were significantly more prevalent in some countries of birth groups (i.e. Poland and Arabic speaking countries) compared with the reference group born in Sweden. Therefore, this study concludes that there is a difference by country of birth in overweight/obesity, which can be explained by differences in acculturation, education, employment, differences related to socioeconomic inequalities amongst others. This argument is supported by Bjermo et al., 2015 who explained that some of the risk factors of overweight/obesity among Swedish pregnant women were related to country of origin and level of education.

As mentioned earlier, an important determinant in the obesity rates can be the socioeconomic status. Socioeconomic status refers to income, education and employment (Berkman et al., 2014). In particular, employment plays a bidirectional effect on body weight. Some evidence shows that employment affects the body weight while other states that being overweight/obese decrease the opportunities of being employed (Chen et al., 2018; Faskunger et al., 2009). In this relationship, it is important to consider the characteristics of both the employment and the persons or ethnic groups, which also may play a role in the increase on the body weight.

In Sweden, the employment rates are significantly lower among foreign-born than among the native-born population (SCB, 2018). Employment status can be categorized as unemployed; short part-time, long part-time and full-time. Unemployment among foreign-born women is higher, especially in those with low education and limited working experience (Migrationsverket, 2018).

Based on the above and in connection to the SDGs, Sweden faces some challenges concerning the reduction of inequalities in areas such as health and wellbeing between different groups in the society. Additionally, it is crucial to tackle issues regarding unhealthy habits due to their connection with ill health, disabilities and premature death. Finally, it is relevant to strengthen actions to reduce discrimination in immigrants' everyday life. (Swedish Government, 2017).

5. Theoretical framework

The theoretical framework for this study integrates the Social determinants of health framework and Acculturation theory. Through these theories, a grounding base is provided from which the knowledge about health in pregnant immigrants, their relation with the context and their experience to adapt to the new environment is constructed.

Firstly, the conceptualisation of health is relevant in this study in order to have a better understanding of the perspective from which the topic is analysed. WHO (1948) defines health as "a *state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity*" which aims to promote a holistic view of health. This view emphasises the relevance of the personal characteristics and the direct effect that the social environment have in the person's health and wellbeing (Larson, 1999). Health is strongly connected to other rights and social determinants, and plays an essential role in achieving other objectives in life such as improved education and employment. These individual's objectives can contribute to the social health and progress (Whitehead & Dahlgren, 2006).

Furthermore, everybody has the right (Art. 12, International Covenant on Economic, Social and Cultural Rights (ICESCR)) to the enjoyment of the highest attainable health in society without distinction of race, religion, political belief, economic and/or social condition (Office of the United Nations High Commissioner for Human Rights (OHCDR), 1976). According to the Universal Declaration of Human Rights, Art. 25:

(1) Everyone has the right to a standard of living adequate for the health and wellbeing of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.

(2) Motherhood and childhood are entitled to special care and assistance. All children, whether born in or out of wedlock, shall enjoy the same social protection (UN, 1948).

Nevertheless, some populations in the society are excluded to the enjoyment of this right due to socioeconomic and environmental conditions that exacerbate inequalities. Based on the principle of non-discrimination, the state and authorities must recognise these groups, their specific needs and the underlying social determinants in order to tackle the inequalities and ensure their rights (OHCDR, 2008).

While immigrants are not inherently vulnerable, they may become vulnerable to Humans Rights violations (OHCHR, 2019). The conditions that are surrounding the migration process often fuel health inequities and expose the immigrants to health risk and adverse health outcomes (IOM, 2019).

The conceptualisation of health is very complex. It requires an understanding of the large scale of social factors that influenced at different levels individual, cultural and structural (Larson, 1999). Additionally, it is also relevant to analyse the interaction of these factors in order to have a broader picture of health.

5.1 Social determinants of Health framework

Social determinants of health are factors that affect the health of individuals and communities (Whitehead & Dahlgren, 2006). These factors are connected to political, socioeconomic, environmental and lifestyle conditions, which can either, increase or decrease the health status. Additionally, the determinants that generate inequalities in health among the population, which are also unfair and avoidable, are defined as determinant of social inequalities in health (Ibid).

Whitehead & Dahlgren (1991) explain the determinants of health using the rainbow model (appendix 1). In the first layer, the model illustrates the individuals' characteristics and their connection with their peers and community. In the second, it highlights the living and working conditions, which influences individual's capacity to maintain their health. Finally, the third layer corresponds to the broader socioeconomic, cultural, environmental and political conditions. All these determinants will interfere in the capacity of the individual to make decisions that will later on influence in their heath.

Furthermore, the model states two categories of social determinants: structural and intermediary determinants. The structural determinants refer to the socioeconomic and political

context. In the political context, it includes components of governance, macroeconomic, social, public policies, and values. It also contemplates socioeconomic positions like education, occupation, social class, ethnicity and gender. At the global level, it is also relevant to consider the environmental conditions (i.e. war and civil conflict) and socioeconomic and political context such as agreements and trades that can shape the countries conditions and vulnerabilities. The intermediary determinants correspond to environmental condition, socio-psychological factors, behavioural and biological factors (Hosseini et al., 2017; Institute of Medicine, 2002).

Even though the determinants are interconnected, each determinant may affect communities and people differently. The crosscutting determinants, such as social cohesion and social capital, promote the relationship between the two categories of determinants, which affect health and welfare. Moreover, the structural factors influence health by affecting intermediary factors (Ibid).

The identification of social patterns and its characteristics is relevant due to their connection with health and wellbeing; it also leads to the identification of intervention's gaps as well as vulnerable groups who are at greater risk of poor health (Blane, 1995). This understanding of social determinants allows us to tackle them in the most effective way and to address the priority points that generate and maintain social and health inequalities (Whitehead & Dahlgren, 2006).

In accordance with Whitehead and Dahlgren, the Fundamental cause theory proposed by Link and Phelan (Link & Phelan. 1995) highlights the relevance of understanding the social conditions and resources as causes of diseases. This theory argues that key resources determine to which extend the person can avoid the risk for morbidity or improve their health condition. However, these resources (i.e. knowledge, money, power and prestige) are unequal distributed across the social groups, which might be an underlying mechanism of behavioural changes that can lead to different health outcomes.

In this study, its focus relies on migration, socioeconomic status and health behaviours as determinants that systematically generate differences in pregnant women's health outcomes. Firstly, migration experience has the potential to impact health; it can improve the health status

as well as expose the immigrants to health risk (Castañeda et al., 2015; International Organization for Migration (IOM), 2017a; Jacobsen, 2014)

Migration is considered a social determinant of health for its potential to impact health and wellbeing of individuals and communities (IOM, 2017b; Migration Data Portal, 2019). The impact on health varies across immigrant groups and may differ from the host population. Additionally, migration processes may exacerbate health vulnerabilities and risk behaviours because of difficulties to access health services or the process of integration into a new society.

Immigrant's socioeconomic conditions are related to their migration and health status. Migrants tend to live in cheap housing and are more likely to have poor and more stressful jobs. Some groups experience marginalization and reduction of their opportunities for social mobility. Moreover, being immigrant influences their behaviour and decisions. As a result, some authors (Castañeda et al., 2015) argue that immigration must be treated as a health determinant itself.

Secondly, socioeconomic status not only has an immediate effect on the physical and mental health of the individual but it has a long-term effect on families and communities. As mentioned above, the socioeconomic status is a determinant of health inequalities. Particularly, employment status has a great impact on health and health equity. Bambra et al., (2010) highlights the linkages between unemployment and health and suggests that ill-health can be both cause and consequence of unemployed. Additionally, employment is connected with social status and feeling of belonging that allows the person to actively participate in society and improve wellbeing (Institute of Medicine, 2002). Some authors (Robila 2018, Berkman, 2014) have stated that employment is an important factor in securing integration into society due to opportunities to learn the culture and build a future. In opposition, unemployment may lead to loss of social support and networks.

Furthermore, employment is considered a distal cause (or a structural determinant) which might shape individual health behaviours by influencing whether they can afford certain living condition and receive social support (Link & Phelan, 1995). Moreover, labour market regulations and policies define the working conditions. Therefore, employment is a complex but critical determinant in order to maintain a healthy lifestyle, but also to promote a healthy environment.

Thirdly, health behaviours refer to decisions made by people based on their opportunities and information, which affect their physical and mental wellbeing (Farhud, 2015). According to Link and Phelan (1995), these health behaviours are the relatively proximal cause of the disease, in which the focus relies on the individual. WHO (1999) had shown that unhealthy behaviours such as smoking, poor diets, lack of exercise and/or stress contributes to the development of non-communicable diseases. However, the context and the socioeconomic conditions can expose people to different risk factors as well as constrain their possibilities to make healthy decisions.

During time since migration, people are exposed to social and cultural system of the new country. As mentioned earlier, culture implies a way of living, which includes health behaviours and lifestyle. Over time, immigrants become socialized into this new culture, which can lead to changes in their behaviour (Sobal, 2001). Nevertheless, the experience of learning and adapting to a new country also varies significantly depending on the country of origin. Since people live and work in this set of social conditions, it is crucial to understand and address them from an integrative perspective in order to strengthen and promote health equity in society.

5.2 Acculturation theory

The combination of factors from both the country of origin and destination impact the health of immigrants and their communities (Acevedo et al., 2012). The acculturation theory investigates the changes that take place as a result of contact between cultural groups, this theory mainly analyses the experience of individuals living in countries other than the country of origin (Berry, 1997; Schwarts et al., 2010). These changes involve the acquisition, maintenance and modifications of cultural practices, values and identities (Schwarts et al., 2010). Acculturation is associated with the adoption of the language and behaviours of the native population within the host country. It also takes into consideration their integration into the society (i.e. labour force). The degree of acculturation has been associated with health outcomes that can be either positive or negative (Argys, 2019).

The acculturation experience can vary from person to person. According to Berry (1997), these variations are usually related to the individual's attitudes and personal behaviours, which take place in everyday life. Four acculturation experience have been defined: integration (interest

to adopt the receiving culture and keep the original culture), assimilation (adopts the receiving culture and discard the own cultural identity), separation (avoid interaction with others, holding the own culture) and marginalization (reject both the origin and the receiving culture) (Schwarts et al., 2010). Several studies have shown that integration is the best way to have psychological and sociocultural adaptation, whereas assimilation and separation are typically associated with intermediate levels of adaptation and marginalisation have the poorest outcomes (Berry, 1997).

According to this theory, the acculturation process and exposure to the environment causes that immigrants tend to adopt native-born behaviours that could affect their health outcome. In addition, the country of origin and socioeconomic status might also influence the changes in immigrants' health (Goulão et al., 2015). These changes usually take place over time since migration suggesting that living in the host country and adopt the new culture play a role in explaining the changes in health. For this reason, many authors had agreed to use length of residence as a proxy for acculturation.

However, this theory and its application in research must be interpreted with caution because not all the changes in health outcomes are related to the adoption of cultural behaviours of the host countries. Immigrants and native-born population in the host country are highly heterogeneous which made complex to conclude that the changes in health are due to the exposure to the contact between cultures.

Furthermore, length of residence suggests that the conditions in the receiving countries play a role in the changes in the health outcome among immigrants. The structural determinants, policies and/or economic conditions may explain these changes, and they go beyond the culture itself.

The theories mentioned above will be grounded knowledge for the understanding of this study. Each theory adds valuable information to discussion the main topics as well as promote a better understanding of how the determinants are interconnected (Figure 2) among them and within the topics, and together influences the immigrant's health and the production of inequality.

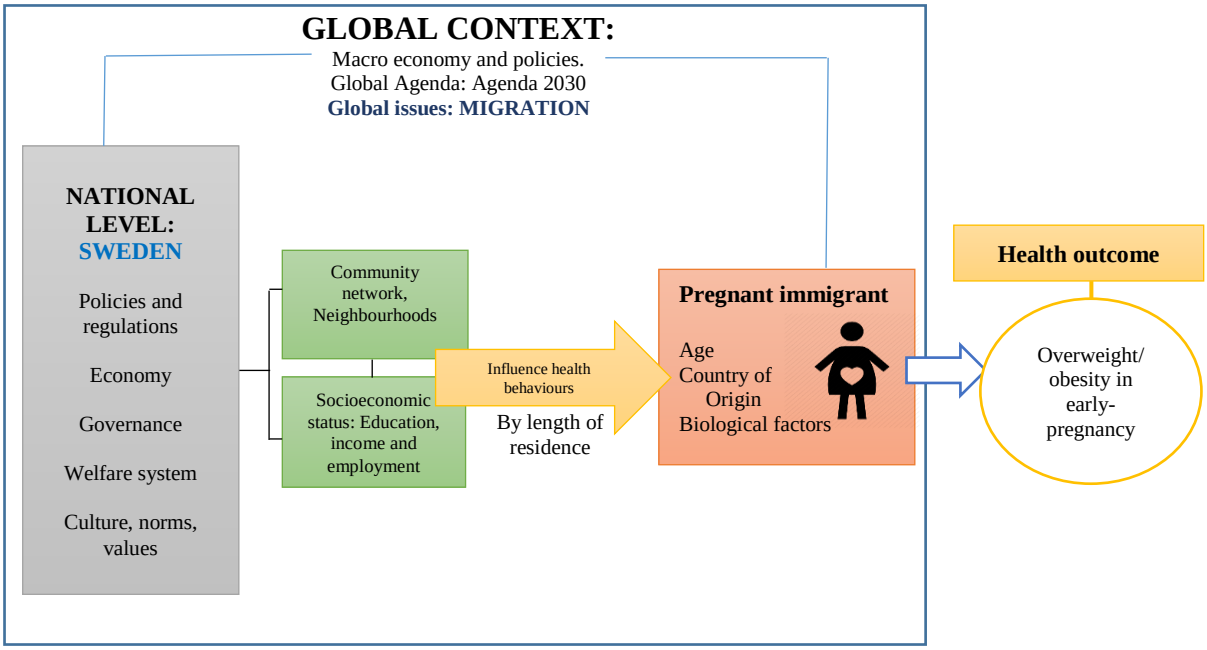


Figure 2. Illustration of the theoretical components related to this study.

6. Methods

6.1 Study design

This is a cross-sectional population-based register study. The data for this study is from the Swedish population registers linked nominally by Statistics Sweden (SCB), and covers the period between 1992 and 2012. The register data is from the Swedish Medical Birth Register (MBR) and the Longitudinal Integration Database for Health Insurance and Labour Market Studies (Swedish acronym; LISA). Additionally, the population register was used to retrieve information on the country of origin of the women and her length of residence in Sweden.

6.2 Data sources

a. Swedish Medical Birth Register (MBR)

The Swedish medical birth register includes data on practically all deliveries in Sweden. According to Cnattingius et al (1990), this register covers 99% of all births in Sweden and compile maternal information and characteristics of the pregnancy, including the BMI in early pregnancy. The information available is collected from medical records from the prenatal, delivery and neonatal care (Socialstyrelsen, 2003).

b. Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA)

The LISA database integrates existing data from the labour market, educational and social sectors. It includes all individuals 16 years of age and older that were registered in Sweden, using a unique personal identification number. Each year the data is updated with a new annual integrated version (SCB, 2019; Sjöberg & Blomquist, 2013).

These national registers were linked using a unique personal identification number the year when the child was born with exception of the socioeconomic variables (i.e. household income and maternal employment), which were estimated for the year before birth. The reason to measure these variables the year before was to account for a possible reduction of the income or changes in the employment status due to the parental leave benefits.

6.3 Study population

The total population consist of 2,117,454 women who gave birth in Sweden during 1992 and 2012. From this total population we exclude observations with missing information on country of birth (*n= 6,682*), women age (*n=9*), family situation (*n=119,451*), women's employment (*n=22,836*), women's education (*n=2,168*), BMI (*n=164,847*), smoking (*n=27,551*) and length of residence in Sweden (*n=1,909*). The final sample consisted of 1,771,821 observations; 315,992 from immigrant women and 1,455,829 from Sweden-born (Figure 3).

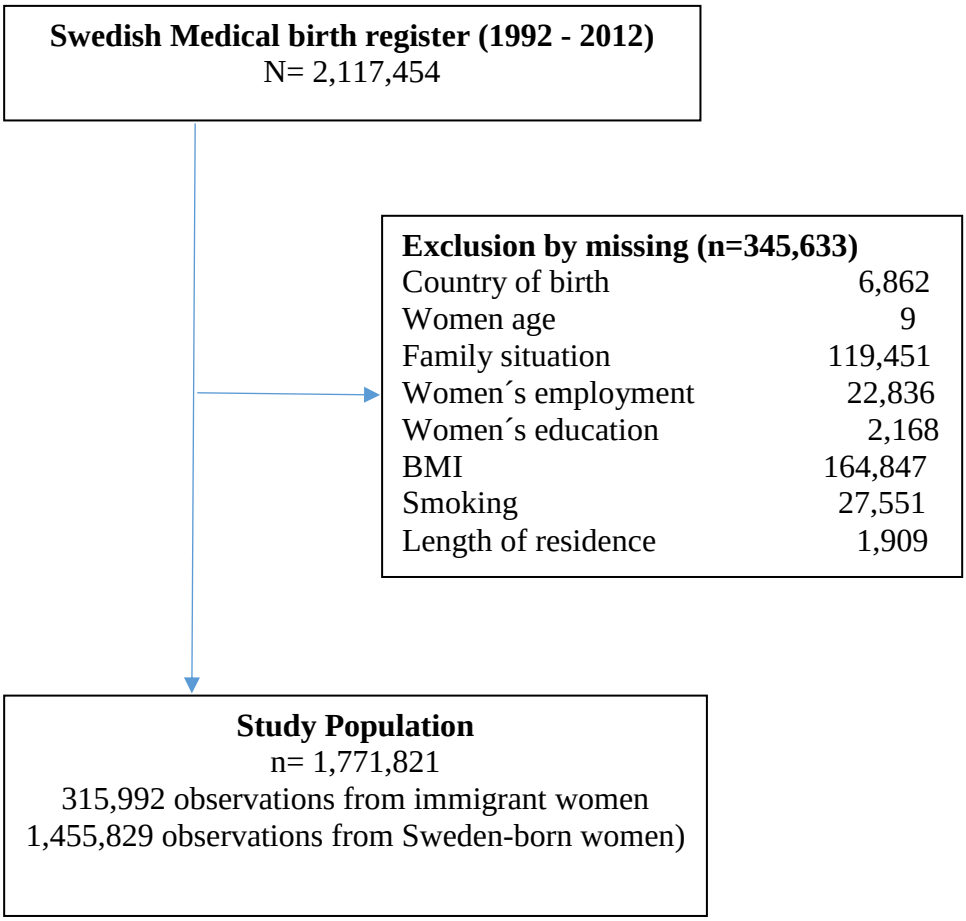


Figure 3. Flowchart and study population

Exposure, outcome variables and background factors

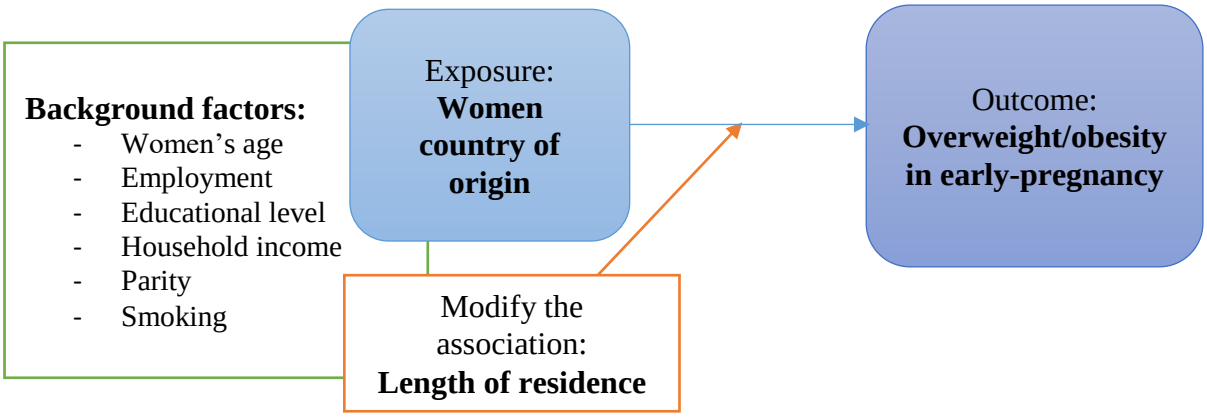


Figure 4. Exposures and outcomes diagram.

As figure 4 shows the relation between the exposure, outcome and covariates. Women's country of origin was the exposure variable and early pregnancy overweight/obesity was the main outcome of interest. Women´s country of origin was categorized into twelve groups according to the different countries of birth among the population: Sweden as a reference group; Europe (North-Central); Latin America; Eastern Europe, Russia, Former Yugoslavia and Turkey; Middle East; Africa; South-East Asia; South Asia; New Zealand, Australia, Oceania and North America; Afghanistan; Ethiopia and Eritrea. The categorization was arbitrary taking into account the geographic proximate and the similar patterns of maternal early-pregnancy BMI by length of residence; these patterns were identified in the preliminary assessment of the data (Appendix 2).

Maternal early- pregnancy BMI was categorized into four groups: underweight (<18.5 Kg/m^2), normal weight (18.5 - 24.9 Kg/m^2), overweight (25.0 – 29.9 Kg/m^2) and obese (≥30.0 Kg/m^2). This classification takes into account the WHO recommendations (WHO, 2019).

Length of residence, which was hypothesized to be the variable that modifies the relationship between the exposure and the outcome, was calculated by subtracting the year of birth of the women's child to the women´s year of arrival to Sweden, and classified into less than six years (<6), six to fifteen (6 to 15) years and sixteen years or more (≥16). The advantage of having a classification which considers more than two categories of length of residence, compared to

previous studies, is that allows to identify general trends over time (i.e. if the countries tend to converge with the reference group or not).

Based on previous knowledge and assumptions, in this study some background factors were preselected which were potentially associated with the outcome. The variables that were considered in the analysis were women age (≤24 years or younger, 25-29, 30-34, ≥35 years of age); women education (low, medium, high); women family situation (cohabiting with the father or single/other) due to their connection with emotional and economic support; women employment (yes/no); parity (1,2,3 or >4); women self-reported of smoking (non-smokers, 1 to 9 cigarettes/day, more or equal to 10 cigarettes/day) that was collected at the first antenatal visit, and household disposable income including salary, parental leave and other benefits, collapses in quintiles.

6.4 Statistical analyses

Descriptive analysis for sociodemographic characteristics was conducted for immigrant women and Sweden-born women; for the immigrant population, the sociodemographic characteristics were also provided taking into account the length of residence.

Multivariable Logistic regression models were generated in order to assess the association between women's country of origin and overweight/obesity during early-pregnancy, considering the effect of length of residence. Odds ratios (ORs) and 95% confidence intervals were calculated and used as the measurement of association. In order to have a binary outcome, a dummy variable of BMI was created (High (>25kg/m2) and Normal), and women's country of origin was combined with length of residence into a single variable as the exposure. The models were categorized by length of residence using the combined variable, which allows using Sweden-born women as a reference group. The models were adjusted including background variables.

This proposed approach to study duration effects using cross-sectional data has been extensively used in the literature (Juárez & Hjern, 2017; Sørbye et al., 2014; Urquia et al., 2010) and, although it has limitations to approximate longitudinal effects, it has been suggested to be useful (Juárez & Hjern, 2017).

Two main models were used to estimate the possible associations, using the Sweden-born population as the reference group. Firstly, it was run a crude model that estimate the association between the combined variable of women's country of origin and length of residence and BMI. Then, this model was adjusted; the first model included women's age, family situation and parity and the second model was an extension of model one and included employment and smoking to adjust for changes in socioeconomic status and/or behaviours as part of their adaptation experience.

Smoking was included in the models as a variable that might affect the relation between the combined variable of women's country of origin and BMI. Some studies have shown that smoking had been associated with the individual BMI through the reduction of appetite and control weight, in opposition, quit smoking lead to weight gain (Audrain & Benowitz, 2011; Faeh et al., 2008).

It was fitted additional models to examine for socioeconomic differences as a possible explanation of BMI in early pregnancy; the analyses were adjusted for employment, education and income one at the time (Appendix 7). However, due to small changes in ORs, model 2 is the one that is shown below.

All the analyses were performed using the SPSS Statistics software package, version 25 (SPSS Inc., Chicago, IL, USA).

6.5 Sensitivity analyses

Sensitivity analysis is a "*method to determine the robustness of an assessment by examining the extension by changes in method, models, and values of unmeasured variables or assumptions*" (Thabane et al., 2013). This analysis plays an important role in assessing the influence of key assumptions about the missing data.

Robustness refers to the strength of a statistical model. It was relevant to asses for it in order to ensure an appropriate interpretation of the results taking into account underlying conditions that may have an impact on the conclusions (National Research Council, 2010).

Due to a large number of missing in the variable of interest (BMI), it was necessary to perform a sensitivity analysis. Through this method was possible to assess for possible assumptions. Specifically, in this study, the strategies use was imputing the missing of the BMI variable to a High BMI in the dummy variable. The imputation was based on the influence of missing in High BMI in the outcomes. Based on the results, it was possible to determine the robustness of the findings in this study (Council, 2010; Thabane et al., 2013).

6.6 Ethical considerations

This study used data from existing register that had been collected from different authorities in Sweden. The information is anonymous and therefore, informed consent was not required. Furthermore this study has ethical permission from the Central Ethical Review Board of Stockholm in 2013 (Decision no 2013/1058-32).

7. Results

The characteristics of the studied population can be observed in table 1. The group of women's country of origin were mainly from Europe (24.3%), Middle East (24.2%) and Eastern Europe (18.2%). Groups in less proportion were from South Asia (2.8%) and New Zealand, Australia, Oceania and North America (1.3%). Based on length of residence and percentage of immigrants, the highest percentage was the Middle East and Africa in the measure less than fifteen years; Eastern Europe had their largest percentage between six to fifteen years, and Latin American and Europeans had their highest percentage of immigrants in the measure over sixteen years since migration.

Compared to the Sweden-born women, with a statistically significant different (p value < 0.05), immigrant women were more likely to be unemployed (56.2% vs 17.6%), have low income (44.6% vs 13.5%) and low education (32.3% vs 9.9%); have more than two children (27.8% vs 18.9%), and to be single mother (8.2% vs 4.7%). However, immigrant women either do not smoke (88.4% vs 90.6%) or smoke less (9.4% vs 11.5%).

By length of residence, the percentage of immigrant women in the lowest quintiles decrease while in the higher quintiles increase; lowest education also decreases, but high education remains stable; unemployment also decreases. Nevertheless, smoking increases by time since migration.

Table 1. Sociodemographic characteristics for women giving birth in Sweden 1992-2012 (N=1,771,821).

	Sweden	**Immigrants**	**Immigrants by length of residence in Sweden***		
	n=1,455,829	n=315,992	<6 n= 141,579	6-15 n= 104,423	≥16 n= 69,990
	n (%)	n (%)	n (%)	n (%)	n (%)
Groups of women´s country of origin					
Europe (North & Central)		76,721 (24.3)	28,284 (20.0)	23,095 (22.1)	25,342 (36.2)
Latin America		19,358 (6.1)	5,629 (4.0)	6,181 (5.9)	7,548 (10.8)
Eastern Europe, Russia & Turkey		57,504 (18.2)	25,202 (17.8)	21,675 (20.8)	10,627 (15.2)
Middle East		76,606 (24.2)	40,754 (28.8)	26,542 (25.4)	9,310 (13.3)
Africa		31,173 (9.9)	18,211 (12.9)	10,755 (10.3)	2,207 (3.2)
South-East Asia		29,427 (9.3)	13,440 (9.5)	8,078 (7.7)	7,909 (11.3)

South Asia		9,005 (2.8)	2,668 (1.9)	1,768 (1.7)	4,569 (6.5)
New Zealand, Australia, Oceania, North America		4,225 (1.3)	1,826 (1.3)	1,339 (1.3)	1,060 (1.5)
Afghanistan		3,231 (1.0)	2,014 (1.4)	1,108 (1.1)	109 (0.2)
Ethiopia		5,593 (1.8)	1,933 (1.4)	2,632 (2.5)	1,028 (1.5)
Eritrea		3,149 (1.0)	1,618 (1.1)	1,250 (1.2)	281 (0.4)
Women age					
<=24	484,726 (33.3)	96,580 (30.6)*	47,380 (33.5)	28,096 (26.9)	21,104 (30.2)
25-29	225,166 (15.5)	61,573 (19.5)*	36,827 (26.0)	15,292 (14.6)	9,454 (13.5)
30-34	490,718 (33.7)	94,160 (29.8)*	37,230 (26.3)	34,959 (33.5)	21,971 (31.4)
>=35	255,219 (17.5)	63,679 (20.2)*	20,142 (14.2)	26,076 (25.0)	17,461 (24.9)
Family Situation					
Cohabitant	1,387,845 (95.3)	290,110 (91.8)*	132,223 (93.4)	93,723 (89.8)	64,164 (91.7)
Single/ Other	67,984 (4.7)	25,882 (8.2)*	9,356 (6.6)	10,700 (10.2)	5,826 (8.3)
Parity					
1	634,048 (43.6)	117255 (37.1)*	63,250 (44.7)	28,564 (27.4)	25,441 (36.3)
2	545,662 (37.5)	110822 (35.1)*	50,505 (35.7)	36,244 (34.7)	24,073 (34.4)
3	20,1261 (13.8)	52427 (16.6)*	17,427 (12.3)	22,863 (21.9)	12,137 (17.3)
>=4	74,858 (5.1)	35488 (11.2)*	10,397 (7.3)	16,752 (16.0)	8,339 (11.9)
Women´s education					
Low	144,524 (9.9)	101,954 (32.3)*	57,143 (40.4)	33,174 (31.8)	11,637 (16.6)
Medium	712,686 (49.0)	109,889 (34.8)*	35,143 (24.8)	39,613 (37.9)	35,133 (50.2)
High	598619 (41.1)	104,149 (33.0)*	49,293 (34.8)	31,636 (30.3)	23.220 (33.2)
Women employment					
Yes	1,200,319 (82.4)	138,389 (43.8)*	31,548 (22.3)	56,001 (53.6)	50,840 (72.6)
No	255,510 (17.6)	177,603 (56.2)*	110,031 (77.7)	48,422 (46.4)	19,150 (27.4)
Family disposable Income (Quintiles)					
1 (Lowest)	195,909 (13.5)	140,820 (44.6)*	78,453 (55.4)	44,437 (42.6)	17,930 (25.6)
2	289,060 (19.9)	69,924 (22.1)*	30,473 (21.5)	23,821 (22.8)	15,630 (22.3)
3	321,563 (22.1)	40,361 (12.8)*	12,982 (9.2)	14,502 (13.9)	12,877 (18.4)
4	330,199 (22.7)	32,052 (10.1)*	9,178 (6.5)	10,943 (10.5)	11,931 (17.0)
5 (Higher)	319, 098 (21.9)	32,835 (10.4)*	10,493 (7.4)	10,720 (10.3)	11,622 (16.6)
Smoking (Cigarette/day)					
No	1287605 (88.4)	286,289 (90.6)*	131,994 (93.2)	94,436 (90.4)	59,859 (85.5)
1-9	115201 (7.9)	21,284 (6.7)*	7,235 (5.1)	7,253 (6.9)	6,796 (9.7)
>10	53,023 (3.6)	8,419 (2.7)*	2,350 (1.7)	2,734 (2.6)	3,335 (4.8)

*A two-sided p-value of < 0.05 was considered statistically significant.

Figure 5 illustrates the frequencies of BMI categories by women' origin. The trends of BMI by women's origin were quite similar. Overall, the majority of the population had normal BMI. However, the percentage of normal BMI was slightly lower in immigrant women compared to the Sweden-born women. In contrast, immigrant women had slightly higher percentage being underweight (3.9 % vs 2.3%), overweight (26.1% vs 23.4%) and obese (11.0% vs 10.0%).

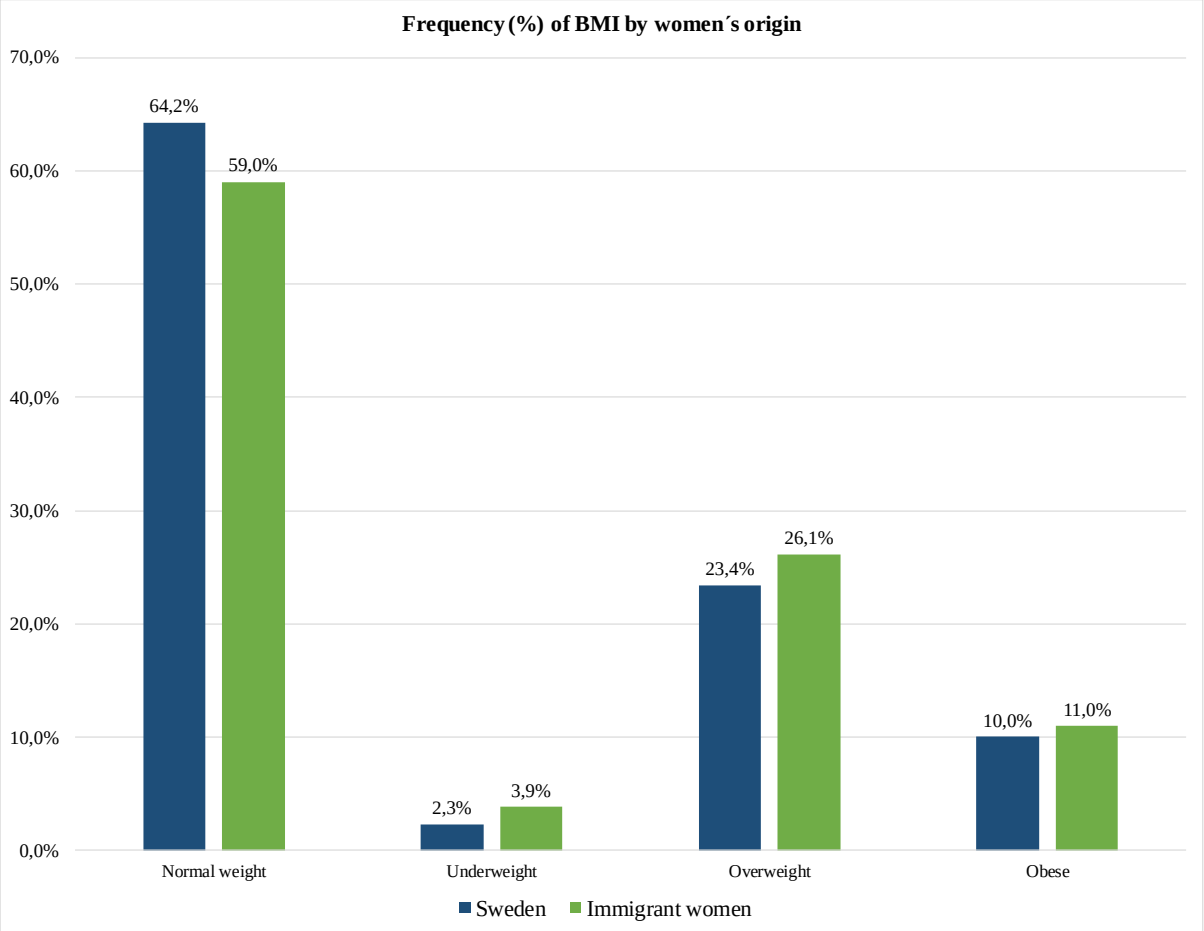


Figure 5. Bar graph showing the frequency of BMI categories by Mother´s origin. (n= 1,771,821; Sweden-born women= 1,455,829, immigrant women= 315, 992)

Taking into consideration the groups of women's country of origin, figure 6 shows the prevalence of high BMI. The results indicate that in most groups, 60% or more of the women were normal weight in early pregnancy. Nevertheless, greater prevalence of high BMI was observed in Africa (excluding Eritrea and Ethiopia) (53% vs 47%), Latin America (58% vs 42%) and the Middle East (55% vs 45%).

In contrast, South East Asia (82% vs 18%) and Eritrea (70% vs 30%) showed higher percentage of normal BMI compared with the reference group. The rest of the groups showed prevalence similar to the Sweden-born population.

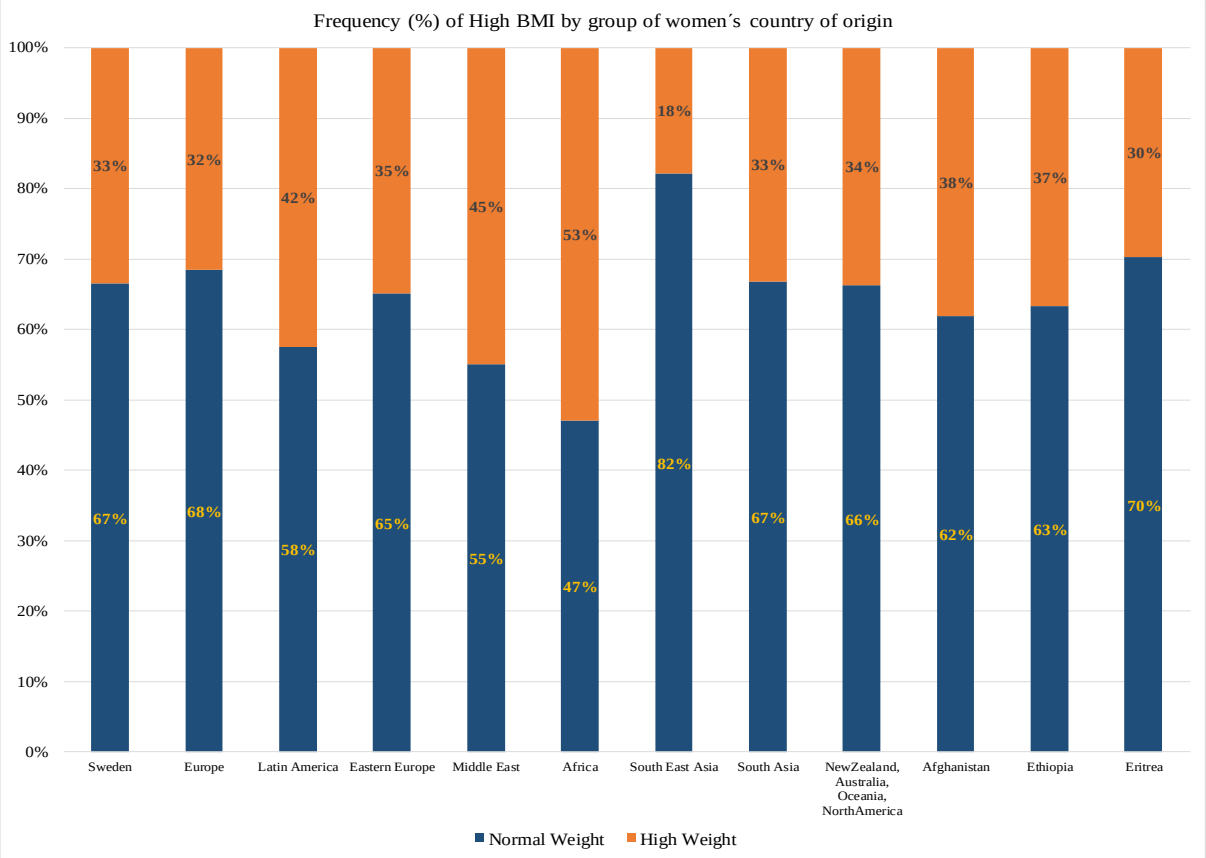


Figure 6. Bar graph showing the frequency of high BMI (dummy variable) by groups of women's country of origin. (N= 1,771,821; Swedish- born women n = 1,455,829, immigrant women n = 315, 992).

The prevalence of immigrant women for high BMI during early pregnancy by the group of women's country of origin and length of residence is presented in table 2 (Further details Appendix 3). Among the Sweden-born women, 66.6% had normal BMI and 33.4% BMI in accordance with overweight/obesity. In general, among the immigrant women, the length of residence showed two trends. One group showed higher prevalence of overweight/obesity by length of residence (Europe, Latin America, South East Asia, Afghanistan, Eritrea and Ethiopia), while another group (Eastern Europe, Middle East, Africa, South Asia, New Zealand, Australia, Oceania and North America) showed an increase of the prevalence in the first fifteen years of length of residence but showed a decrease after sixteen years. Overall all migrants who spent between 6-15 years in Sweden showed an increased on overweight/obesity compared to newly arrived (<6 years).

In particular, Afghanistan showed a steady increase in overweight/obesity by length of residence, which means a different pattern from the Middle East. Equally, the cases of Eritrea and Ethiopia differs from Africa's trend due to the increase of prevalence of overweight/obesity by length of residence in Sweden.

Table 2. Prevalence of high BMI during early-pregnancy by groups of women's country of origin and length of residence in Sweden 1992- 2012. (N= 1,771,821).

Groups of women´s country of origin	Body Mass Index (BMI)	Sweden	Immigrants by length of residence in Sweden*		
		n= 1,455,829 n (%)*	<6 n= 141,579 n (%)	6-15 n= 104,423 n (%)	≥16 n= 69,990 n (%)
Sweden	Normal weight	969,146 (66.6)			
	High weight	486,683 (33.4)			
Europe	Normal weight		20,806 (73.6)	15,910 (68.9)	15,803 (62.4)
	High weight		7,478 (26.4)	7,185 (31.1)	9,539 (37.6)
Latin America	Normal weight		3,747 (66.6)	3,624 (58.6)	3,772 (50.0)
	High weight		1,882 (33.4)	2,557 (41.4)	3,776 (50.0)
Eastern Europe	Normal weight		17,450 (69.2)	13,381 (61.7)	6,609 (62.2)
	High weight		7,752 (30.8)	8,294 (38.3)	4,018 (37.8)
Middle East	Normal weight		23,550 (57.8)	13,271 (50.0)	5,334 (57.3)
	High weight		17,204 (42.2)	13,271 (50.0)	3,976 (42.7)
Africa	Normal weight		9,328 (51.2)	4,279 (39.8)	1,054 (47.8)
	High weight		8,883 (48.8)	6,476 (60.2)	1,153 (52.2)
South East Asia	Normal weight		11,564 (86.0)	6,594 (81.6)	6,004 (75.9)
	High weight		1876 (14.0)	1,484 (18.4)	1,905 (24.1)
South Asia	Normal weight		1,920 (72.0)	1,095 (61.9)	2,998 (65.6)
	High weight		748 (28.0)	673 (38.1)	1,571 (34.4)
New Zealand/ Australia/ Oceania/ North America	Normal weight		1,225 (67.1)	865 (64.6)	712 (67.2)
	High weight		601 (32.9)	474 (35.4)	348 (32.8)
Afghanistan	Normal weight		1,361 (67.6)	582 (52.5)	55 (50.5)
	High weight		653 (32.4)	526 (47.5)	54 (49.5)
Ethiopia	Normal weight		1,301 (67.3)	1,630 (61.9)	610 (59.3)
	High weight		632 (32.7)	1,002 (38.1)	418 (40.7)
Eritrea	Normal weight		1,194 (73.8)	844 (67.5)	175 (62.3)
	High weight		424 (26.2)	406 (32.5)	106 (37.7)

*A two-sided p-value of < 0.05 was considered statistically significant.

For the multivariable association analyses, three different models were considered, and the results are described in table 3. The crude model analyses the association between the combined variable of groups of women's country of origin and BMI. There was a statistical association in most of the groups (Europe, Eastern Europe, Middle East, Africa, South East Asia and Ethiopia). However, in migrant women from Latin America, Afghanistan and Ethiopia with a length of residence less than six years, no difference in the probability to have High BMI was observed compared with the Sweden-born women. Eritrea with a length of residence more than six years had no statistically significant difference compared to the reference group to have high BMI. The groups of New Zealand, Australia, Oceania and North America showed no difference in having high BMI compared to the Sweden-born at any time of length of residence.

Overall, most of the groups showed Odds Ratios (ORs) higher than 1 in length of residence more than six years, which means that having high BMI is more likely to occurs among these groups.

The second model was further adjusted for women's age, family situation and parity. According to the results, most of the groups reduce their ORs that means that the groups were becoming more similar to the reference group, but still they showed a similar pattern as the crude model.

The third model was an extension of the second model that was adjusted for employment and smoking. The association still significant between the combined variable and high BMI in most of the groups with the exception of the group of New Zealand, Australia, Oceania and North America. The main patterns in the different groups were still the same as the two previous models.

Regarding length of residence, after adjusted by employment and smoking, some of the groups showed a steady rise during the time (Europe, Latin America, South East Asia, Ethiopia, Eritrea and Afghanistan). However, the other groups (Eastern Europe, Middle East, Africa, South Asia, New Zealand, Australia, Oceania and North America) show an increase in the second period (6-15 years) and then, after 16 years shows a decrease.

Overall, all the groups showed an increase of the probability to become obese/overweight with a length of residence between 6-15 years in comparison with the Sweden-born pregnant women.

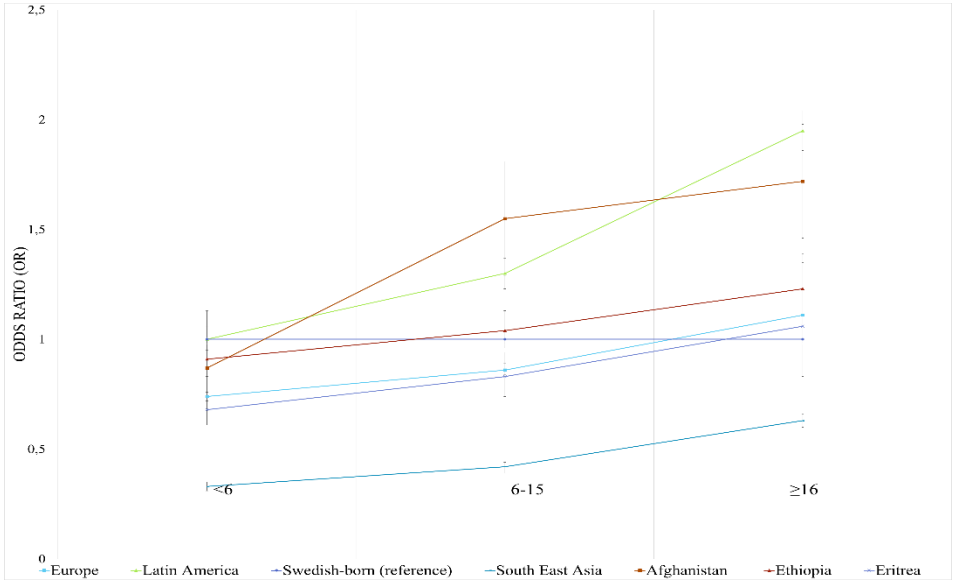
Table 3. Multivariable association of combined variable of groups of women's country of origin and length of residence and high BMI.

COMBINE VARIABLE: Group of women´s country of origin and length of residence		**N**	**Crude Model**		**Model 1**		**Model 2**	
			OR	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**
Sweden (ref)		1,455,829	**1**		**1**		**1**	
Europe	<6	28,284	0.72	(0.70, 0.74)	0.74	(0.72, 0.76)	0.71	(0.69, 0.72)
	6 to 15	23,095	0.90	(0.87, 0.93)	0.86	(0.84, 0.89)	0.85	(0.82, 0.87)
	≥16	25,342	1.20	(1.17, 1.23)	1.11	(1.08, 1.14)	1.09	(1.06, 1.12)
Latin America	<6	5,629	1.00	(0.95, 1.06)	1.00	(0.95, 1.06)	0.96	(0.91, 1.01)
	6 to 15	6,181	1.41	(1.34, 1.48)	1.30	(1.23, 1.37)	1.29	(1.23, 1.36)
	≥16	7,548	1.99	(1.91, 2.09)	1.95	(1.86, 2.04)	1.95	(1.87, 2.04)
Eastern Europe	<6	25,202	0.89	(0.86, 0.91)	0.87	(0.85, 0.90)	0.81	(0.79, 0.83)
	6 to 15	21,675	1.23	(1.20, 1.27)	1.15	(1.12, 1.18)	1.11	(1.08, 1.15)
	≥16	10,627	1.21	(1.16, 1.26)	1.12	(1.07, 1.16)	1.10	(1.05, 1.14)
Middle East	<6	40,754	0.69	(0.67, 0.70)	1.41	(1.38, 1.44)	1.31	(1.29, 1.34)
	6 to 15	26,542	1.99	(1.94, 2.04)	1.72	(1.68, 1.76)	1.65	(1.61, 1.69)
	≥16	9,310	1.48	(1.42, 1.55)	1.37	(1.32, 1.43)	1.35	(1.30, 1.41)
Africa	<6	18,211	1.90	(1.84, 1.95)	1.70	(1.65, 1.76)	1.62	(1.57, 1.67)
	6 to 15	10,755	3.01	(2.90, 3.13)	2.32	(2.23, 2.42)	2.29	(2.21, 2.39)
	≥16	2,207	2.18	(2.00, 2.37)	1.82	(1.67, 1.98)	1.83	(1.69, 1.99)
South East Asia	<6	13,440	0.32	(0.31, 0.34)	0.33	(0.31, 0.35)	0.31	(0.30, 0.33)
	6 to 15	8,078	0.45	(0.42, 0.47)	0.42	(0.39, 0.44)	0.41	(0.39, 0.44)
	≥16	7,909	0.63	(0.60, 0.67)	0.63	(0.60, 0.66)	0.63	(0.60, 0.66)
South Asia	<6	2,668	0.78	(0.71, 0.84)	0.82	(0.75, 0.89)	0.77	(0.71, 0.84)
	6 to 15	1,768	1.22	(1.11, 1.35)	1.16	(1.05, 1.27)	1.14	(1.03, 1.25)
	≥16	4,569	1.04	(0.98, 1.11)	1.08	(1.01, 1.15)	1.08	(1.01, 1.15)
New Zealand, Australia, Oceania, North America	<6	1,826	0.98	(0.87, 1.08)	1.02	(0.93, 1.13)	0.98	(0.90, 1.09)
	6 to 15	1,339	1.09	(0.98, 1.22)	1.05	(0.94, 1.18)	1.05	(0.93, 1.17)
	≥16	1,060	0.97	(0.86, 1.11)	0.92	(0.81, 1.05)	0.92	(0.81, 1.05)
Afghanistan	<6	2,014	0.96	(0.87, 1.05)	0.87	(0.79, 0.96)	0.82	(0.75, 0.90)
	6 to 15	1,108	1.80	(1.60, 2.03)	1.55	(1.38, 1.75)	1.51	(1.34, 1.70)
	≥16	109	1.96	(1.34, 2.85)	1.72	(1.18, 2.52)	1.73	(1.18, 2.53)
Ethiopia	<6	1,933	0.97	(0.88, 1.06)	0.91	(0.83, 1.00)	0.88	(0.80, 0.96)
	6 to 15	2,632	1.22	(1.13, 1.32)	1.04	(0.96, 1.13)	1.05	(0.97, 1.14)
	≥16	1,028	1.37	(1.21, 1.55)	1.23	(1.08, 1.39)	1.24	(1.09, 1.41)
Eritrea	<6	1,618	0.71	(0.63, 0.79)	0.68	(0.61, 0.76)	0.65	(0.58, 0.73)
	6 to 15	1,250	0.96	(0.85, 1.08)	0.83	(0.74, 0.94)	0.85	(0.75, 0.95)
	≥16	281	1.21	(0.95, 1.54)	1.06	(0.83, 1.35)	1.09	(0.85, 1.38)

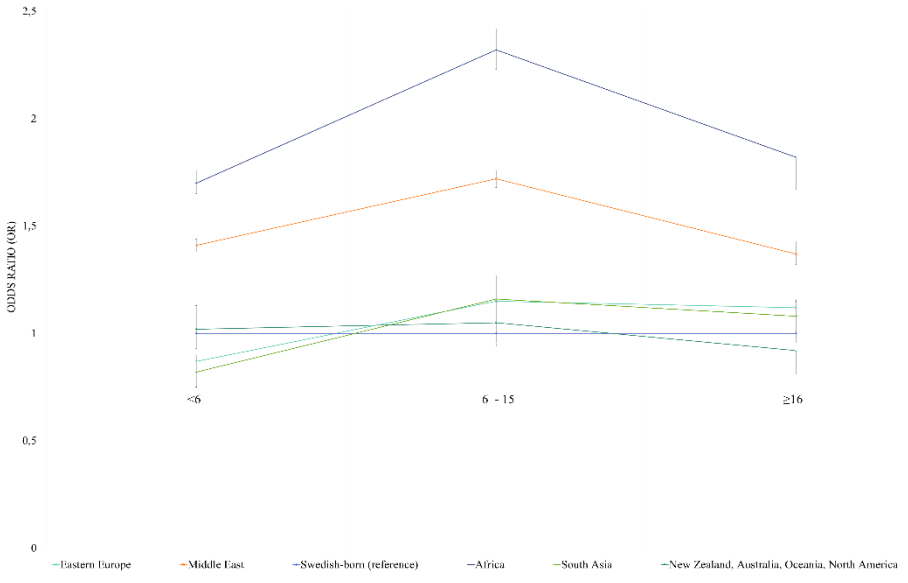
Results adjusted for women's age, family situation and number of children (Model 1); and adding employment and smoking to model 1 variables (Model 2).
Ref= reference category; OR= Odds Ratio; CI= Confidence Interval.

In figure 7 illustrates OR for BMI during early-pregnancy by length of residence among immigrant women compared to the Sweden-born women. The Model 1 (A-B) were adjusted for women's age, family situation and parity. Model 2 (C-D) was an extension of model 1, adding employment and smoking. What can be clearly seen in the graphs was two patterns. One was upward which illustrates that the BMI in immigrant women tend to increase by length of residence (A-C) in certain countries even after adjusted for covariates. The second pattern (B-D) was a mix trend, which increase on the first years and decrease after 16 years or more.

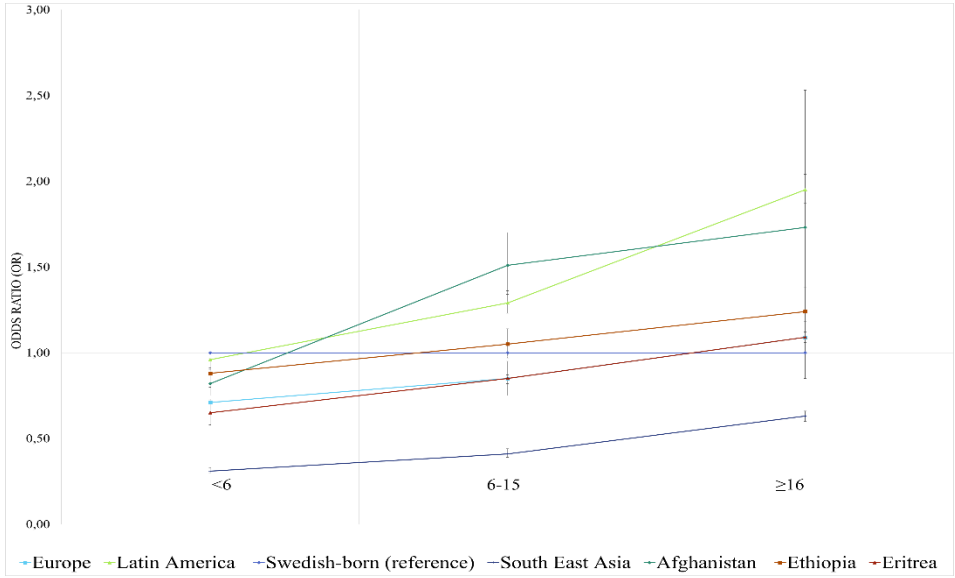
(A) Model 1. Upward trend of women's country of origin by length of residence; Sweden-born as reference



(B) Model 1. Mix- trend of women's country of origin by length of residence; Sweden-born as reference



(C) Model 2. Upward trend of women's country of origin by length of residence; Sweden-born as reference



(D) Model 2. Mix- trend of women's country of origin by length of residence; Sweden-born as reference

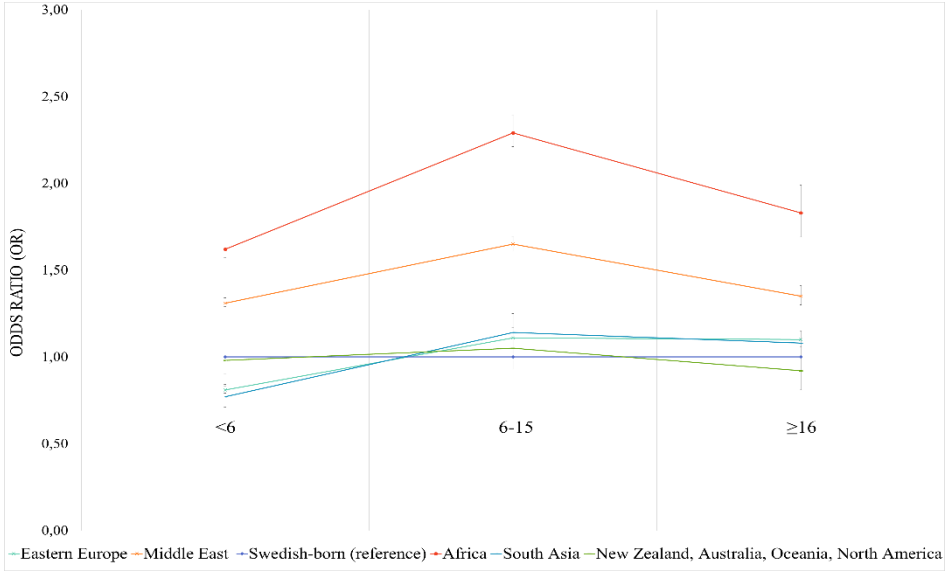


Figure 7. Groups of women's country of origin by length of residence and high body weight in early-pregnancy in Sweden 1992-2012. (n= 1,771,821) Logistic Regression.
(A-C) Upward trend, (B-D) Mix- trend. Model 1 (A-B) adjusted for women's age, family situation and parity. Model 2 (C- D). Extension of model 1 adding employment and smoking.

7.1 Sensitivity analysis

The sensitivity analysis was conducted to assess the impact of the relatively large shared of missing in the BMI variable (7.8%) (Appendix 4). An extreme scenario was considered where it is assumed that all the missing corresponds to high BMI in the dummy variable. Based on the above the study population was 1,929,746 (Sweden-born: 1,584,269 and immigrants: 345,477).

Firstly, is important to clarify that the missing values in BMI were almost equally distributed between immigrant women and Sweden-born women (8.5 % vs 8.1%). Based on the length of residence of immigrant women 50.5% of the missing correspond to the period less than six years, follow by six to fifteen years (30.%) and then, by equal or more than sixteen years (19.5%). The groups of women´s country of with more missing information were New Zealand, Australia, Oceania and North America (13.8%), Ethiopia (13.0%) and Eastern Europe (10.2%). However, the sensitivity analyses show that the main results were robust (i.e. are in line with the main findings).

The data showed that the prevalence of high BMI is higher in immigrants women compared with the Sweden-born women (42.5% vs 38.8%). The trends in both the prevalence and the multivariable logistic regression models showed the main two pattern, one upward (Europe, Latin America, South East Asia, Afghanistan, Eritrea and Ethiopia) and the other one, a mix trend (Eastern Europe; Middle East; Africa; South Asia). Patterns that follows the same previous regression models that exclude the missing in BMI. However, the group of New Zealand, Oceania, Australia and North America represented an exception since, in the sensitivity analysis, they showed a downward pattern. This is explained by the fact that missing data was concentrated in the first years, which can lead to a modification of the trend.

8. Discussion

8.1 Summary of results

The first question of this study was to examine the association between groups of the women´s country of origin and overweight/obesity in early pregnancy. A statistical association between these variables was founded in some groups but not all. For example, Africa (minus Ethiopia and Eritrea) is associated with higher prevalence of overweight/obesity, while South East Asia shows the opposite (higher prevalence of normal weight).

The second question aimed to examine if immigrant women tend to converge with the levels of BMI of the Sweden-born pregnant women by length of residence. The overall results showed that high BMI was higher in immigrant women compared to the Sweden-born women. By increasing the length of residence, immigrant women tend to converge with the levels of BMI of the host population. Immigrants who spent 6-15 years in Sweden showed an increase in overweight/obesity compared to newly arrived (those in category of residence ≤5). However, after 16 years of length of residence, in this study was found two opposite trends across the country of origin. One trend shows a steady increase in the prevalence of overweight/obesity over time (Europe, Latin America, South East Asia, Afghanistan, Ethiopia and Eritrea), while the other is a mix-trend with an increase in the first 15 years and then a decrease (Eastern Europe, Middle East, Africa, South Asia and New Zealand, Australia, Oceania and North America).

The results of this thesis suggest that overweight/obesity in early-pregnancy tend to increase among immigrants in their first years since migration; however, this trend was not equal across the countries of origin after 16 years. Moreover, the underlying mechanism that can influence the increase in body weight was not yet well identified.

8.2 Consistency with previous research studies

This study provided evidence about the increase of BMI by length of residence in different groups of women's country of origin in the period that compared the measures of less than 6 and 6 to 15 years. This result was in line with previous findings that confirm a positive association between a higher prevalence of overweight/obesity in immigrants and the length of residence in the host country (Kaplan, 2004; Lindström & Sundquist, 2005; Menigoz, 2018)[1]. However, after sixteen years or more, it was possible to identify two opposite patterns (upward and downward) across the groups of women's country of origin. This result was contrary to the findings described in a study conducted by Da Costa et al. (2017) in Portugal, which stated that for long term immigrants (=15 years), the odds of being overweight increased.

The different patterns of health outcome by country of origin were highlighted in previous research (Gutiérrez et al., 2010; Hosper et al., 2007; Sørbye, 2014) that argued that the difference of results could be explained by the characteristics of the countries and the variety of reasons to migrate. The length of residence also plays different roles, either positive or negative, in the adaptation to the new society and the health outcomes. Additionally, the complex interactions among the factors during the migration process and the reception in the host countries can also influence the immigrant women's health.

Furthermore, the findings of this study were consistent with previous studies. Malmusi (2014) describes that among immigrants, the prevalence of unemployed, low income and low education are higher than those in the host population; characteristics that were also found in this study. These characteristics were considered underlying determinants that influence health outcomes and can drive the increase of inequalities within the population (Castañeda et al., 2015).

Among the immigrant population, the prevalence of overweight/obesity was higher for African and Latin American women´s group of origin. This result was also found by Bjermo (2015) who described that women born in Africa, Middle East and Latin America had a higher risk compared to Sweden-born women. One possible explanation could be that these groups have

[1] For example immigrants from Mexico, Central and South America and Caribbean living in United States (Kaplan, 2004); immigrants from former Yugoslavia, Poland and Arabic speaking countries living in Sweden (Lindström & Sundquist, 2005); Immigrants from Oceania, Southern & Eastern Europe, South East Asia, North East Asia, Americas and Sub-saharan Africa living in Australia (Menigoz, 2018).

been more affected by the adaptation to the new country and, socioeconomic disadvantages. In line with that explanation, Goulão et al. (2015) explained in their study that Hispanics could be exposed to social and physical environments that constrain their access to healthy food and physical activity. African's immigrants, primarily sub-Saharan African, often gains weight due to the constraint to access healthy food because the limited availability and high cost (Bjermo, 2015; Goulão, 2015).

On the other hand, the groups of women's country of origin that showed a mixed trend (downward in more than 16 years), for example, Africa could be explained by their age of arrival. A woman who arrived in Sweden as a child could have experience different assimilation process and tend to converge readily with the host population. Previous studies hypothesized that age at migration together with critical developmental periods in life course (i.e. childhood or adolescence) influence the immigrant's health and assimilation in the society (Bates & Teitler, 2008; Leão et al., 2009; Li & Wen, 2015). To confirm this hypothesis, further research is needed.

The reasons to migrate and resources that they have to rebuild their life projects might play an important role in the adaptation of the immigrant in the host country. In this study, I did not have access to this information; therefore, I could not make the distinction between those who were forced to migrate and those who migrated for labour reasons. This information was highly relevant due to labour immigrants may be relatively quickly integrated into the Swedish society while refugees may face unemployment or informal employment and marginalization, in addition to traumatic experiences from their country of origin (Leão et al., 2009).

Regarding changes in lifestyle and socioeconomic conditions, this study did not have strong evidence to show that these factors drive the increase in body weight. However, many previous studies (Da Costa et al., 2017; Sørbye, 2014) found that overweight/obesity was associated with changes in lifestyle socioeconomic status and adaptation by the length of residence in the receiving country. According to Lindström and Sundquist (2005) the higher prevalence of overweight/obesity among immigrants in Sweden was found in lower socioeconomic status and lower educational groups; primarily due to the adoption of unhealthy western lifestyle combined with unemployment rates.

Interestingly to consider based on the above is the double influence of employment and smoking on body weight. In a study conducted in the United States, it was found that employees who worked >50 hours/week had 32% higher odds of obesity than those who worked <30hours/week (Goulão et al., 2015; Park et al., 2014). Many immigrants are more likely to work longer hours and have two or more jobs to support themselves, and these extended working hours might increase unhealthy eating habits such as snacking and skipping meals. Moreover, the type of work might also increase stress-induced overeating and physical inactivity. Certain employment conditions can lead to high body weight due to less time to prepare food and more purchasing power to buy unhealthy prepared food high in fat and sugar. However, unemployment can also be associated with overweight/obesity due to their connection with unhealthy lifestyles. The economic insecurity can lead to anxiety and depression, but also it has been associated with food choices that promote weight gain (Monsivais et al., 2015).

Smoking can be used as a weight control while smoking cessation can lead to gain weight. Many authors (Audrain et al., 2011; Bush et al., 2014) explain that smoking is often used as a strategy to control appetite and a behaviour alternative to eating, resulting in decreased food intake. On the other side, the weight gain after smoking cessation may be as a result of a decrease in the metabolic rate and increase calories intake. The mentioned above may suggest that it is required an in-depth analysis of these variables in the relation between women's country of origin and overweight/obesity affected by these variables.

To conclude, it is clear that the first years of residence increases the risk of overweight/obesity in the immigrant's women. However, it requires further studies that disentangle what factors drive the differences observed among immigrants compared to the Sweden-born population.

8.3 Overweight/obesity in early pregnancy among immigrants explained by theoretical model

This study highlight that structural and intermediary determinants are factors that might affect pregnant immigrant's health, especially regarding their body weight. These determinants are causally related, and the understanding of their links and implications will facilitate the design of interventions in order to tackle the determinants that produce or perpetuate inequalities in health.

Based on the determinants of health theory, particularly on the macro level (global and general socioeconomic, cultural and environmental conditions), Sweden is an important receiving country, which hosts people from all over the world. It is also recognized as a welcoming country with high living standards and strong protector and advocator of Human Rights. The Swedish national policies and regulation try to address human rights and ensure the wellbeing and integration of the immigrant population (Karlsdottìr, 2018; OECD, 2016).

In contrast, the economy, political situation and social conditions in many countries are becoming an important driver of migration. Some people migrated in order to improve their living conditions while other people are forced to do it. Even though in this study this circumstance was not studied, the social determinants of health argues that the structural determinants (socioeconomic and political conditions) influence many aspects of the individual´s health.

Country of origin was one of the main characteristics established in this study to predict the health outcome; because it can be assumed that the general context influences every one of the individuals born in the same country in the same way. For example, immigrants from the same group may share similar conditions such as reasons of migration, discrimination or socioeconomic disadvantages (Mulinari et al., 2015). However, in this study was reflected that women's country of origin might not be a clear predictor of health outcomes. Mulinari et al. (2015) found in their research about birthweight that maternal country of birth may not provide accurate information to intervene at the individual level, because of the large variability in individual birthweight within each country of origin. Therefore, compromising the evidence for considering this variable as a health's predictor.

Furthermore, all the groups of the women´s country of origin present an increase in the prevalence of overweight/obesity by length of residence. The change in body weight had been explained in previous studies as a result of the acculturation experience where the women try to adapt and learn the new culture and adopt behaviours and practices (Antecol & Bedard, 2006; Delavari et al., 2013). However, although in this study we could not disentangle the mechanisms behind BMI changes by length of residence, other mechanisms that may explain these changed could be linked to social disparities, structural determinants and/or diversity within the groups. Likewise, even though culture is relevant to explain behavioural changes, culture also can be shaped by the socioeconomic and political condition of the country.

Even though in this study, it was not possible to identify the role of structural determinants. According to the fundamental cause theory, proposed by Link & Phelan (1995), highlights that crucial resources to avoid risks behaviours are linked with the socioeconomic status; because they do not only facilitate the access to health services but also promote the integration into healthy environments.

Regarding changes in lifestyle, it was identified that smoking increase by the length of residence among the immigrant women; this change evidence that during the adaptation process, many women adopt unhealthy behaviours. Some groups of the maternal country of origin might adapt more readily to a new culture than other groups. These differences in adaptation may result in different health outcomes. Moreover, some characteristics of the environment such as neighbourhoods, also promote the gain of unhealthy weight due to lack of facilities to access healthy food or adequate places to exercise. In this study was no possible to study their living conditions. However, as it was mentioned earlier, the circumstances where the people live and work influence their health.

Taken together, these results suggest that there are structural and intermediary determinants in the host country, which goes beyond the culture, that affect immigrant women health. Moreover, more qualitative studies that address the individual characteristics and understand the communities dynamic are needed, as well as, apply a different theoretical framework in the understanding of this thematic (i.e. Determinants of health and/or Fundamental cause theory).

8.4 Methodology considerations

Repeated cross-sectional study are useful to evaluate changes in the prevalence of overweight/obesity among immigrants compared to the Sweden-born population. It have been showed that this design have many advantages in following trends over the time, primarily, to analyse population or group changes (Rafferty et al., 2015). Moreover, the use of a large data set increase the quality of the evidence.

Despite this study use a large and reliable data, the amount of missing in the variable BMI was considerably high (7.8%). The sensitivity analysis conducted to explore the level of the problem demonstrated that the association between length of residence and overweight/obesity was quite robust remaining the same patterns after this analysis.

One of the challenges was the grouping of the immigrant's origin. In this study was use a geographic proximate and the similar patterns of maternal early-pregnancy BMI by length of residence. This categorization is based on similarities among the population, but it may overlook internal differences in the group of origin. This concern is share with Menigoz et al.(2016) who also recognize that grouping may mask heterogeneity. Nevertheless, to discuss health inequalities in society and design intervention that impact large populations, it is necessary to analysis some health issues at the population level (Juárez & Hjern, 2017).

Age at arrival is strongly associated with length of residence. Therefore, in order to avoid problems of multicollinearity which drive to wrong statistical inferences, this covariate was not take into account (Vittinghoff et al., 2011).

The results of this study could be confounded by unmeasured confounders. A confounder is variable associated with the risk factor and causally related to the outcome (Katz, 2006). However, based on the exposure, mainly regarding country of origin, and the information available, was no possible to identify possible associations resulted from confounder bias.

9. Strengths and limitations

The strengths of this study include the population-based design, which is a reliable data collected since 1990 in a systematic way. The length of measure allow for following trends and identifying different patterns. Additionally, the data is high both in quality and in completeness of the information on the exposure and the outcomes. The above provide a solid base for performing statistical analysis. Furthermore, register data is also reliable because the information is not subject to bias arising from self- reported information and can avoid the problem of selection bias.

Nevertheless, the present study also has limitations. The use of cross-sectional data allow comparing differences in outcomes between individuals with differences duration of residence. However, it also have the limitation to follow-up the individual in order to identify the effect of the length of residence in their health.

Regarding to the data collection, the employment variable codified as a dummy variable (yes/no). This categorization is problematic due to the different characteristics of employment, mainly underemployment and its influence in body weight. Another relevant variable that might be less precise is length of residence because in the case of refugees the information refers to the date they were granted their residence permit and not when they arrive in the country. Therefore, length of residence for many immigrants may be under-estimated.

Furthermore, register data does not identify which immigrants have already spent time in a third country before arriving to Sweden, which also influence their health. This situation highlight another limitation, which is the generalization of immigrants by not taking into account the migration status (i.e. refugees, asylum seeker or labour migrant).

10. Implications for future research and policy

The analysis of this study indicates that immigrant pregnant women living in Sweden tend to increase their body weight by length of residence. This finding are valuable for Global public health analysis because it exemplifies the role that the environment plays in the health of the individuals and the production of inequalities among the population. Although the exact underlying mechanism for this are still unclear, the Social determinants of health framework has explained that many factors are interlinked and affected the health of individuals and communities. The Social determinants of health framework that can be apply in future research in order to understand from a broader perspective the results. Moreover, further research should focus on determining the mechanisms that are involved in this unhealthy weight gain in order to tackle them through adequate interventions and policies.

This study also contributes to further research on overweight/obesity by the length of residence among the immigrant population. By studying length of residence is possible to identify disparities in health between immigrants and the native-born population over time. Likewise, this study contributes to recognize the health diversity and social inequalities across populations and individuals, which are relevant to take into consideration while conducted research studies and designing interventions and/or policies.

11. Conclusions

This study aimed to examine the association between groups of maternal countries of origin and overweight/obesity in early pregnancy. Adittionally, if there was a change, to examine if it was modified by the length of residence.

There is not conclusive evidence about groups of maternal country of origin as a predictor of this increase. This increase in body weight may be explained considering, on the one hand, the role of the structural determinates and the heterogeneity among immigrants and native-born that influence the increase of disparities among the population. On the other hand, after a long period of living in the receiving country, the population behave as a second immigrant generation, especially those who arrived in the country as a child.

This study showed that there is an increase in early-pregnancy overweight/obesity since time of migration in all the groups of women's country of origin compared to the Sweden-born women. However, after 16 years of living in the receiving country, it was identified two patterns, one that shows a steady increase in high BMI (Europe, Latin America, South East Asia, Afghanistan, Ethiopia and Eritrea) while the other one showed a decrease (Eastern Europe, Middle East, Africa, South Asia and New Zealand, Australia, Oceania and North America).

An additional relevant finding was that women's country of origin might have different health trends even in the same region due to the diverse background or living experiences. This situation needs to be explored in-depth before performing the traditional grouping of the countries such as geographic.

Finally, these findings support the importance of analysing trends in immigrant's health and promote a further studies to have a better understanding of the mechanism that generates the inequalities among the population in order to improve their health conditions and opportunities.

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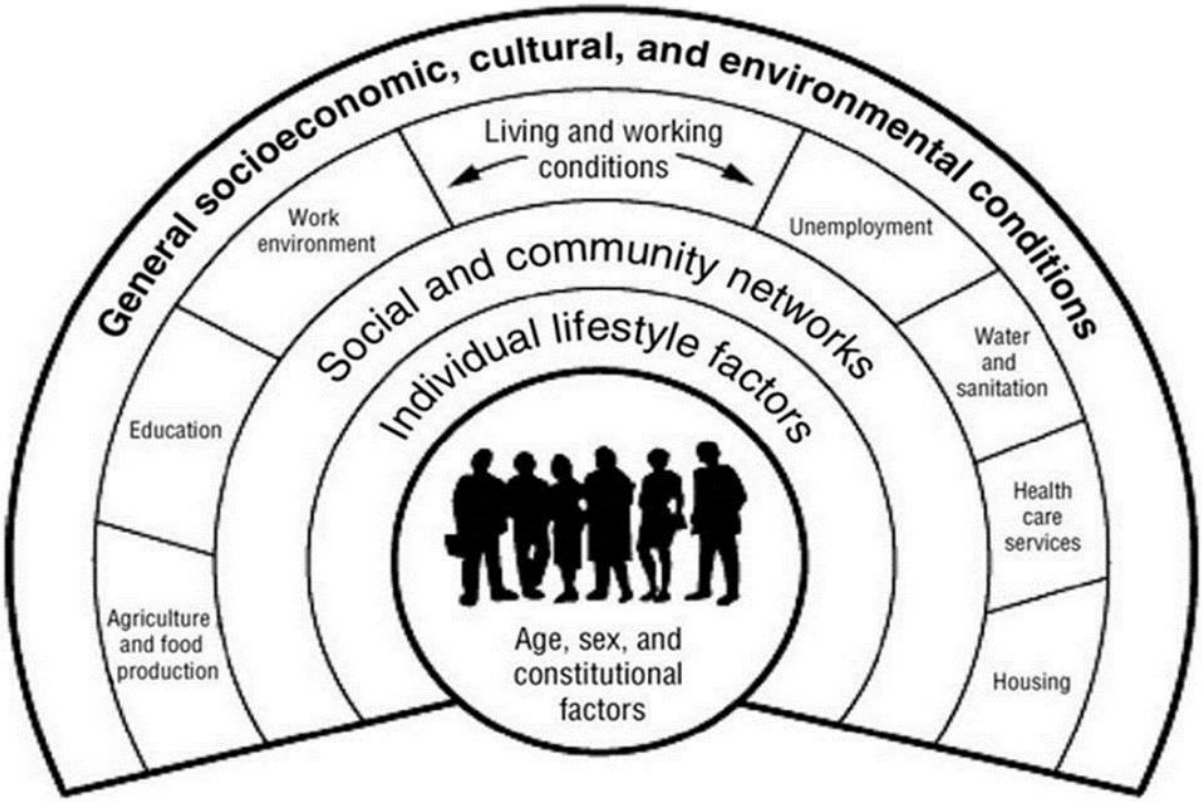
Appendices.

Appendix 1. Social determinants of health model by Margaret Whitehead and Göran Dahlgren (1991).



Source:https://www.google.com/search?q=social+determinant+of+health+model&client=firefox-b-d&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjigM_Tr6LiAhUFAxAIHbDyAXQQ_AUIDigB&biw=2560&bih=1326#imgrc=PaVEneaRXHHC2M:

Appendix 2. Grouping based on early-pregnancy BMI trend.

Country of origin	Body Mass Index (BMI)	Sweden	Immigrants by length of residence in Sweden		
		n= 1,455,829 N (%)	≤6 n= 141,579 N (%)	6-15 n= 104,423 N (%)	≥16 n= 69,990 N (%)
Sweden	Normal weight	969146 (66.6)			
	High weight	486683 (33.4)			
North Africa	Normal weight		2487 (56.2)	904 (40.3)	191 (44.3)
	High weight		1935 (43.8)	1312 (59.2)	235 (55.2)
Eastern Africa	Normal weight		818 (58.1)	479 (47.3)	237 (56.6)
	High weight		591 (41.9)	534 (52.7)	182 (43.4)
Sub-Saharan Africa	Normal weight		1635 (51.4)	948 (46.3)	400 (54.9)
	High weight		1549 (48.6)	1099 (58.7)	328 (45.1)
Ethiopia	Normal weight		1801 (67.3)	1630 (61.9)	610 (59.3)
	High weight		682 (32.7)	1002 (38.1)	418 (40.7)
Eritrea	Normal weight		1194 (73.8)	844 (67.5)	175 (62.3)
	High weight		424 (26.2)	406 (32.5)	106 (37.7)
Somalia	Normal weight		4388 (47.7)	1948 (35.6)	226 (35.6)
	Overweight		4808 (52.3)	3531 (64.4)	408 (64.4)
UE-15	Normal weight		5319 (76.5)	3487 (73.1)	2722 (66.2)
	High weight		1636 (23.5)	1284 (26.9)	1389 (33.8)
Rest UE-27	Normal weight		8434 (73.8)	5448 (69.8)	3054 (65.7)
	High weight		2995 (26.2)	2356 (30.2)	1591 (34.3)
Eastern Europe & Russia	Normal weight		4116 (74.6)	1765 (68.3)	216 (68.3)
	High weight		1399 (25.4)	799 (31.2)	98 (31.2)
Rest Nordics	Normal weight		4271 (70.8)	3049 (66.3)	2747 (61.8)
	High weight		1764 (29.2)	1550 (33.7)	1697 (38.2)
Finland	Normal weight		2782 (72.0)	3926 (66.3)	7280 (60.0)
	High weight		1083 (28.0)	1995 (33.7)	4862 (40.0)
Turkey	Normal weight		3598 (68.0)	2777 (54.1)	2640 (59.2)
	High weight		1697 (32.0)	2359 (45.9)	1821 (40.8)
Former Yugoslavia	Normal weight		9736 (67.6)	8839 (63.2)	2099 (64.1)
	High weight		4656 (32.4)	5136 (36.8)	2099 (35.9)
South America	Normal weight		2197 (71.1)	1524 (66.3)	1645 (60.2)
	High weight		892 (28.9)	775 (33.7)	1088 (39.8)
Central America& Caribbean	Normal weight		724 (66.5)	574 (58.5)	368 (49.8)
	High weight		364 (33.5)	408 (41.5)	371 (50.2)
Chile	Normal weight		826 (56.9)	1526 (52.6)	1759 (43.2)
	High weight		1083 (28.0)	1995 (33.7)	4862 (40.0)
Middle East (rest)	Normal weight		2958 (62.7)	935 (49.3)	367 (53.1)
	High weight		1761 (37.3)	960 (50.7)	324 (46.9)
Syria	Normal weight		3011 (64.6)	2016 (54.5)	912 (58.6)
	High weight		1653 (35.4)	1684 (45.5)	644 (41.4)
Iraq	Normal weight		10860 (51.4)	4690 (43.2)	722 (51.0)
	High weight		10276 (48.6)	6177 (56.8)	694 (49.0)
Iran	Normal weight		3330 (67.5)	3109 (62.5)	1622 (65.0)
	High weight		1600 (32.5)	1866 (37.5)	873 (35.0)
Afghanistan	Normal weight		1361 (67.6)	582 (52.5)	55 (50.5)
	High weight		653 (32.4)	526 (47.5)	54 (49.5)
Lebanon	Normal weight		3391 (63.9)	2521 (49.4)	1711 (54.3)
	High weight		1914 (36.1)	2584 (50.6)	1441 (45.7)

East Asia	Normal weight		2925 (89.8)	1572 (86.8)	3480 (76.2)
	High weight		332 (10.2)	239 (13.2)	1089 (23.8)
South-East Asia	Normal weight		8639 (84.8)	5022 (80.1)	2524 (75.6)
	High weight		1544 (15.2)	1245 (19.9)	816 (24.4)
South Asia	Normal weight		1920 (72.0)	1095 (61.9)	2998 (65.6)
	High weight		748 (28.0)	673 (38.1)	1571 (34.4)
New Zealand/Australia/ Oceania/North America	Normal weight		1225 (67.1)	865 (64.6)	712 (67.2)
	High weight		601 (32.9)	474 (35.4)	348 (32.8)

Up-ward trend Mix- trend

Appendix 3. Prevalence of BMI during early-pregnancy by groups of women's country of origin and length of residence in Sweden 1992- 2012. (N= 1,771,821).

Women's country of origin	Body Mass Index (BMI)	Sweden	Immigrants by length of residence in Sweden		
			<6	6-15	≥16
		n= 1,455,829 n (%)	n= 141,579 n (%)	n= 104, 423 n (%)	n= 69,990 n (%)
Sweden	Normal weight	935,019 (64.2)			
	Underweight	34,127 (2.3)			
	Overweight	340,829 (23.4)			
	Obese	145,854 (10.0)			
Europe	Normal weight		19,614 (69.3)	15,256 (66.1)	15,196 (60.0)
	Underweight		1,192 (4.2)	654 (2.8)	607 (2.4)
	Overweight		5,436 (19.2)	5,240 (22.7)	6,511 (25.7)
	Obese		2,042 (7.2)	1,945 (8.4)	3,028 (11.9)
Latin America	Normal weight		3,557 (63.2)	3,516 (56.9)	3,657 (48.4)
	Underweight		190 (3.4)	108 (1.7)	115 (1.5)
	Overweight		1,417 (25.2)	1,814 (29.3)	2,227 (29.5)
	Obese		465 (8.3)	743 (12.0)	1,549 (20.5)
Eastern Europe	Normal weight		16,347 (64.9)	12,772 (58.9)	6,368 (59.9)
	Underweight		1,103 (4.4)	609 (2.8)	241 (2.3)
	Overweight		5,891 (23.4)	5,978 (27.6)	2,807 (26.4)
	Obese		1,861 (7.4)	2,316 (10.7)	1,211 (11.4)
Middle East	Normal weight		22,371 (54.8)	12,823 (48.3)	5,102 (54.8)
	Underweight		1,233 (3.0)	448 (1.7)	232 (2.5)
	Overweight		12,482 (30.6)	9,110 (34.3)	2,632 (28.3)
	Obese		4,722 (11.6)	4,161(15.7)	1,344 (14.4)
Africa	Normal weight		8,428 (46.4)	4,001 (37.2)	999 (45.3)
	Underweight		870 (4.8)	278 (2.6)	55 (2.5)
	Overweight		5,867 (32.2)	3,859 (35.9)	652 (29.5)
	Obese		3,016 (16.6)	2,617 (24.3)	501 (22.7)
South East Asia	Normal weight		9,903 (73.7)	5,958 (73.8)	5,575 (70.5)
	Underweight		1,661 (12.4)	636 (7.9)	429 (5.4)
	Overweight		1,622 (12.1)	1,273 (15.8)	1,463 (18.5)
	Obese		254 (1.9)	211 (2.6)	442 (5.6)
South Asia	Normal weight		1,643 (61.6)	1,018 (57.6)	2,644 (57.9)
	Underweight		277 (10.4)	77 (4.4)	354 (7.7)
	Overweight		635 (23.8)	503 (28.5)	1,071 (23.4)
	Obese		113 (4.2)	170 (9.6)	500 (10.9)
New Zealand/ Australia/ Oceania/ North America	Normal weight		1,165 (63.8)	831 (62.1)	696 (65.7)
	Underweight		60 (3.3)	34 (2.5)	16 (1.5)
	Overweight		393 (21.5)	304 (22.7)	222 (20.9)
	Obese		208 (11.4)	170 (12.7)	126 (11.9)
Afghanistan	Normal weight		1,238 (61.5)	564 (50.9)	52 (47.7)
	Underweight		123 (6.1)	18 (1.6)	3 (2.8)
	Overweight		492 (24.4)	390 (35.2)	43 (39.4)
	Obese		161 (8.0)	136 (12.3)	11 (10.1)
Ethiopia	Normal weight		1,136 (58.8)	1,509 (57.3)	557 (54.2)
	Underweight		165 (8.5)	121 (4.6)	53 (5.2)
	Overweight		488 (25.2)	739 (28.1)	268 (26.1)
	Obese		144 (7.4)	263 (10.0)	150 (14.6)
Eritrea	Normal weight		1,026 (63.4)	763 (61.0)	166 (59.1)
	Underweight		168 (10.4)	81 (6.5)	9 (3.2)
	Overweight		339 (21.0)	316 (25.3)	88 (31.3)
	Obese		85 (5.3)	90 (7.2)	18 (6.4)

Appendix 4. Sensitivity analysis: Missing in the BMI variable.

– **Study population: 1,929,746**
(Sweden-born population: 1,584,269; Immigrants: 345,477).

4.1 Table. Frequency (%) of BMI by women's origin

	Origin		Total
BMI	**Swedes N (%)**	**Immigrants**	
Normal weight	935019 (59.0)	186427 (54.0)	1121446
Underweight	34127 (2.2)	12220 (3.5)	46347
Overweight	340829 (21.5)	82572 (23.9)	423401
Obese	145854 (9.2)	34773 (10.1)	180627
missing	**128440 (8.1)**	**29485 (8.5)**	157925
Total	1584269	345477	1929746

4.2 Table. Frequency (%) of BMI by women´s origin and length of residence

Women´s origin	**Sweden**	**Immigrants by length of residence (N= 345 477)**		
		<6 n= 156,463	6-15 n= 113,286	≥16 n= 75,728
	N (%)	N (%)	N (%)	N (%)
Sweden	1,584,269			
Immigrants		14884 (50.5)	8863 (30.1)	5738 (19.5)
Missing	**128, 440 (8.1)**	**29485 (8.5%)**		

4.3 Table. Frequency (%) of BMI by groups of women's country of origin and Length of residence in Sweden

Groups of women´s country of origin	**Sweden**	**Immigrants by length of residence (n= 345 477)**		
		<6	6-15	≥16
	n= 1,584,269	n= 156,463	n= 113,286	n= 75,728
	n (%)	n (%)	n (%)	n (%)
Sweden	128440 (8.1)			
Europe		2654 (8.6)	2194 (8.7)	2690 (9.6)
Latin America		627 (10.0)	597 (8.8)	537 (6.6)
Eastern Europe		2850 (10.2)	1493 (6.4)	770 (6.8)
Middle East		4374 (9.7)	2192 (7.6)	504 (5.1)
Africa		1894 (9.4)	915 (7.8)	160 (6.8)
South East Asia		1288 (8.7)	692 (7.9)	559 (6.6)
South Asia		300 (10.1)	172 (8.9)	290 (6.0)
New Zealand/ Australia/ Oceania/ North America		293 (13.8)	165 (11.0)	122 (10.3)
Afghanistan		177 (8.1)	76 (6.4)	4 (3.5)
Ethiopia		290 (13.0)	264 (9.1)	80 (7.2)
Eritrea		137 (7.8)	103 (7.6)	22 (7.3)

4.4 Table. Prevalence of BMI by mother´s group of origin and length of residence.

Groups of women´s country of origin	Body Mass Index (BMI)	Sweden	Immigrants by length of residence in Sweden		
		n= 1,584,269 n (%)	<6 n=156,463 n (%)	6-15 n= 113,286 n (%)	≥16 n=75,728 n (%)
Sweden (ref)	Normal weight	969,146 (61.2)			
	High weight	615,123 (38.8)			
Europe	Normal weight		20,806 (67.3)	15,910 (62.9)	15,803 (56.4)
	High weight		10,132 (32.7)	9,379 (37.1)	12,229 (43.6)
Latin America	Normal weight		3,747 (59.9)	3624 (53.5)	3,772 (46.7)
	High weight		2,509 (40.1)	3154 (46.5)	4,313 (53.3)
Eastern Europe	Normal weight		17,450 (62.2)	13,381 (57.8)	6,609 (58.0)
	High weight		10,602 (37.8)	9,787 (42.2)	4,788 (42.0)
Middle East	Normal weight		23,550 (52.2)	13,271 (46.2)	5,334 (54.4)
	High weight		21,578 (47.8)	15,463 (53.8)	4,480 (45.6)
Africa	Normal weight		9,328 (46.4)	4,279 (36.7)	1,054 (44.5)
	High weight		10,777 (53.6)	7,391 (63.3)	1,313 (55.5)
South East Asia	Normal weight		11,564 (78.5)	6,594 (75.2)	6,004 (70.9)
	High weight		3,164 (21.5)	2,176 (24.8)	2,464(29.1)
South Asia	Normal weight		1,920 (64.7)	1,095 (56.4)	2,998 (61.7)
	High weight		1,048 (35.3)	845 (43.6)	1,861 (38.3)
New Zealand/ Australia/ Oceania/ North America	Normal weight		1,225 (57.8)	865 (57.5)	712 (60.2)
	High weight		894 (42.2)	639 (42.5)	470 (39.8)
Afghanistan	Normal weight		1,361 (62.1)	582 (49.2)	55 (48.7)
	High weight		830 (37.9)	602 (50.8)	58 (51.3)
Ethiopia	Normal weight		1301 (58.5)	1630 (56.3)	610 (55.1)
	High weight		922 (41.5)	1266 (43.7)	498 (44.9)
Eritrea	Normal weight		1194 (68.0)	844 (62.4)	175 (57.8)
	High weight		561 (32.0)	509 (37.6)	128 (42.2)

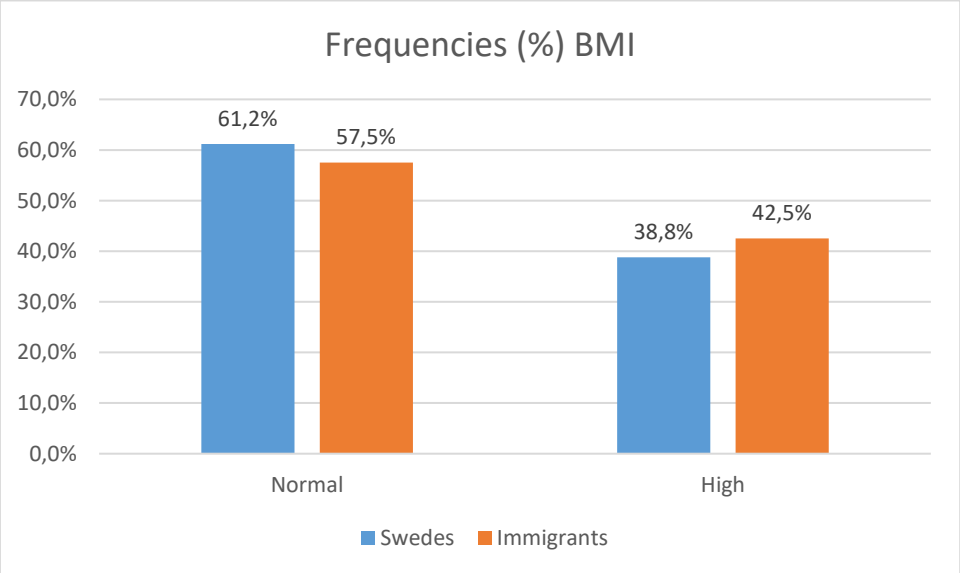


Figure 4.1. Bar graph showing the frequency of BMI categories by Mother´s origin.

4.5 Table. Logistic regression models

COMBINE VARIABLE: Groups of women's country of origin and Length of residence		**N**	**Crude Model**		**Model 1**		**Model 2**	
			OR	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**
Sweden (ref)		1,584,269	**1**		**1**		**1**	
Europe	<6	30938	0.77	(0.75-0.79)	0.79	(0.77, 0.81)	0.75	(0.74, 0.77)
	6 to 15	25289	0.93	(0.91-0.95)	0.89	(0.87, 0.92)	0.88	(0.85, 0.90)
	≥16	28032	1.22	(1.19-1.25)	1.13	(1.11, 1.16)	1.11	(1.08, 1.13)
Latin America	<6	6256	1.06	(1.00-1.11)	1.06	(1.00, 1.11)	1.01	(0.96, 1.06)
	6 to 15	6778	1.37	(1.31-1.44)	1.27	(1.21, 1.33)	1.26	(1.20, 1.32)
	≥16	8085	1.80	(1.72-1.88)	1.75	(1.68, 1.83)	1.76	(1.69, 1.84)
Eastern Europe	<6	28052	0.96	(0.93-0.98)	0.94	(0.92, 0.97)	0.87	(0.85, 0.89)
	6 to 15	23168	1.15	(1.12-1.18)	1.07	(1.04, 1.10)	1.04	(1.01, 1.07)
	≥16	11397	1.14	(1.10-1.19)	1.06	(1.02, 1.10)	1.03	(1.00, 1.07)
Middle East	<6	45128	0.69	(0.68-0.71)	1.40	(1.37, 1.42)	1.30	(1.28, 1.33)
	6 to 15	28734	1.84	(1.79-1.88)	1.59	(1.56, 1.63)	1.54	(1.50, 1.57)
	≥16	9814	1.32	(1.27-1.38)	1.23	(1.18, 1.28)	1.21	(1.17, 1.26)
Africa	<6	20105	1.82	(1.77-1.87)	1.63	(1.59, 1.68)	1.56	(1.52, 1.61)
	6 to 15	11670	2.72	(2.62-2.83)	2.11	(2.03, 2.19)	2.09	(2.02, 2.18)
	≥16	2367	1.96	(1.81-2.13)	1.65	(1.52, 1.79)	1.67	(1.53, 1.80)
South East Asia	<6	14728	0.43	(0.41-0.45)	0.40	(0.42, 0.46)	0.42	(0.39, 0.43)
	6 to 15	8770	0.52	(0.50-0.55)	0.49	(0.46, 0.51)	0.48	(0.46, 0.51)
	≥16	8468	0.65	(0.62-0.68)	0.64	(0.61, 0.68)	0.64	(0.61, 0.67)
South Asia	<6	2968	0.86	(0.80, 0.93)	0.90	(0.84, 0.97)	0.85	(0.79, 0.92)
	6 to 15	1940	1.22	(1.11, 1.33)	1.15	(1.05, 1.26)	1.14	(1.04, 1.24)
	≥16	4859	0.98	(0.92, 1.04)	1.01	(0.95, 1.07)	1.01	(0.95, 1.07)
New Zealand, Australia, Oceania, North America	<6	2119	1.15	(1.06-1.25)	1.20	(1.10, 1.31)	1.16	(1.06, 1.26)
	6 to 15	1504	1.16	(1.05-1.29)	1.13	(1.02, 1.25)	1.12	(1.01, 1.24)
	≥16	1182	1.04	(0.93-1.17)	0.99	(0.88, 1.11)	0.98	(0.87, 1.11)
Afghanistan	<6	2191	0.96	(0.88-1.05)	0.88	(0.81, 0.96)	0.83	(0.76, 0.91)
	6 to 15	1184	1.63	(1.45-1.83)	1.41	(1.26, 1.58)	1.38	(1.23, 1.55)
	≥16	113	1.66	(1.15-2.40)	1.47	(1.01, 2.13)	1.48	(1.02, 2.14)
Ethiopia	<6	2223	1.12	(1.03-1.22)	1.05	(0.96, 1.14)	1.01	(0.93, 1.10)
	6 to 15	2896	1.22	(1.14-1.32)	1.04	(0.97, 1.12)	1.05	(0.98, 1.13)
	≥16	1108	1.29	(1.14-1.45)	1.16	(1.03, 1.31)	1.18	(1.04, 1.33)
Eritrea	<6	1755	0.74	(0.67-0.82)	0.71	(0.64, 0.78)	0.68	(0.61, 0.75)
	6 to 15	1353	0.95	(0.85-1.06)	0.82	(0.73, 0.92)	0.84	(0.75, 0.94)
	≥16	303	1.15	(0.92-1.45)	1.01	(0.80, 1.27)	1.04	(0.83, 1.31)

Appendix 5. Table. Frequency (%) of BMI by women´s origin

	BMI			
	Normal weight n (%)	Underweight n (%)	Overweight n (%)	Obese n (%)
Swedish- born	935019 (64.2)	34127 (2.3)	340829 (23.4)	145854 (10.0)
Immigrants	186427 (59.0)	12220 (3.9)	82572 (26.1)	34773 (11.0)

Appendix 6. Table. Frequency (%) of BMI by Groups of women´s country of origin

Groups of women's country of origin	**BMI**	
	Normal weight n (%)	**High weight** n (%)
Sweden (ref)	969146 (66.6)	486683 (33.4)
Europe	52519 (68.5)	24202 (31.5)
Latin America	11143 (57.6)	8215 (42.4)
Eastern Europe	37440 (65.1)	20064 (34.9)
Middle East	42155 (55.0)	34451 (45.0)
Africa	14661 (47.0)	16512 (53.0)
South East Asia	24162 (82.1)	5265 (17.9)
South Asia	6013 (66.8)	2992 (33.2)
New Zealand, Australia, Oceania, North America	2802 (66.3)	1423 (33.7)
Afghanistan	1998 (61.8)	1233 (38.2)
Ethiopia	3541 (63.3)	2052 (36.7)
Eritrea	2213 (70.3)	936 (29.7)

Appendix 7. Logistic Regressions models

COMBINE VARIABLE: Women´s country of origin and Length of residence		**N**	**Model 1:** mother age, family situation and parity		**Model 2:** crude + Employment		**Model 3:** Crude +Employment + Education		**Model 4:** Crude+ Employment + Income		**Model 5:** Crude + Employment + Education + Income		**Model 6:** Crude+ Employment + Smoking		**Model 7:** Crude + Smoking	
			OR	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**	**OR**	**CI (95%)**
Sweden (ref)		1,455, 829	**1**		**1**		**1**		**1**		**1**		**1**		**1**	
Europe	<6	28,284	0.74	(0.72, 0.76)	0.70	(0.69, 0.72)	0.74	(0.72, 0.76)	0.70	(0.68, 0.72)	0.74	(0.72, 0.76)	0.71	(0.69, 0.72)	0.65	(0.58, 0.73)
	6 to 15	23,095	0.86	(0.84, 0.89)	0.85	(0.83, 0.87)	0.87	(0.85, 0.90)	0.86	(0.83, 0.88)	0.88	(0.86, 0.91)	0.85	(0.82, 0.87)	0.85	(0.75, 0.95)
	>16	25,342	1.11	(1.08, 1.14)	1.10	(1.07, 1.13)	1.06	(1.03, 1.09)	1.10	(1.07, 1.13)	1.06	(1.04, 1.09)	1.09	(1.06, 1.12)	1.09	(0.85, 1.38)
Latin America	<6	5,629	1.00	(0.95, 1.06)	0.94	(0.89, 0.99)	0.98	(0.92, 1.03)	0.90	(0.85, 0.95)	0.95	(0.89, 1.00)	0.96	(0.91, 1.01)	1.02	(0.96, 1.08)
	6 to 15	6,181	1.30	(1.23, 1.37)	1.27	(1.20, 1.33)	1.23	(1.16, 1.29)	1.23	(1.17, 1.30)	1.20	(1.14, 1.27)	1.29	(1.23, 1.36)	1.32	(1.26, 1.39)
	>16	7,548	1.95	(1.86, 2.04)	1.93	(1.84, 2.02)	1.88	(1.79, 1.96)	1.88	(1.80, 1.97)	1.85	(1.76, 1.93)	1.95	(1.87, 2.04)	1.97	(1.88, 2.06)
Eastern Europe	<6	25,202	0.87	(0.85, 0.90)	0.80	(0.78, 0.83)	0.79	(0.76, 0.81)	0.78	(0.76, 0.80)	0.77	(0.75, 0.79)	0.81	(0.79, 0.83)	0.87	(0.85, 0.90)
	6 to 15	21,675	1.15	(1.12, 1.18)	1.11	(1.08, 1.15)	1.06	(1.03, 1.09)	1.07	(1.04, 1.10)	1.04	(1.01, 1.06)	1.11	(1.08, 1.15)	1.14	(1.11, 1.18)
	>16	10,627	1.12	(1.07, 1.16)	1.10	(1.06, 1.15)	1.05	(1.01, 1.09)	1.07	(1.03, 1.11)	1.04	(0.99, 1.08)	1.10	(1.05, 1.14)	1.11	(1.07, 1.16)
Middle East	<6	40,754	1.41	(1.38, 1.44)	1.28	(1.25, 1.30)	1.30	(1.27, 1.33)	1.24	(1.21, 1.26)	1.28	(1.25, 1.30)	1.31	(1.29, 1.34)	1.44	(1.41, 1.47)
	6 to 15	26,542	1.72	(1.68, 1.76)	1.62	(1.58, 1.66)	1.58	(1.54, 1.62)	1.58	(1.54, 1.62)	1.57	(1.53, 1.61)	1.65	(1.61, 1.69)	1.74	(1.70, 1.79)
	>16	9,310	1.37	(1.32, 1.43)	1.34	(1.29, 1.40)	1.33	(1.27, 1.39)	1.32	(1.27, 1.38)	1.33	(1.27, 1.38)	1.35	(1.30, 1.41)	1.38	(1.33, 1.44)
Africa	<6	18,211	1.70	(1.65, 1.76)	1.56	(1.52, 1.61)	1.54	(1.49, 1.58)	1.56	(1.51, 1.61)	1.55	(1.50, 1.60)	1.62	(1.57, 1.67)	1.76	(1.71, 1.81)
	6 to 15	10,755	2.32	(2.23, 2.42)	2.22	(2.13, 2.31)	2.10	(2.02, 2.19)	2.23	(2.14, 2.32)	2.14	(2.05, 2.22)	2.29	(2.21, 2.39)	2.40	(2.30, 2.49)
	>16	2,207	1.82	(1.67, 1.98)	1.80	(1.65, 1.96)	1.74	(1.60, 1.90)	1.79	(1.65, 1.95)	1.75	(1.61, 1.91)	1.83	(1.69, 1.99)	1.85	(1.70, 2.01)
South East Asia	<6	13,440	0.33	(0.31, 0.35)	0.30	(0.29, 0.32)	0.30	(0.28, 0.31)	0.29	(0.27, 0.30)	0.29	(0.27, 0.30)	0.31	(0.30, 0.33)	0.34	(0.32, 0.35)
	6 to 15	8,078	0.42	(0.39, 0.44)	0.41	(0.38, 0.43)	0.38	(0.36, 0.40)	0.39	(0.37, 0.42)	0.37	(0.35, 0.39)	0.41	(0.39, 0.44)	0.42	(0.40, 0.45)
	>16	7,909	0.63	(0.60, 0.66)	0.63	(0.59, 0.66)	0.62	(0.58, 0.65)	0.62	(0.59, 0.66)	0.62	(0.59, 0.65)	0.63	(0.60, 0.66)	0.63	(0.60, 0.66)
South Asia	<6	2,668	0.82	(0.75, 0.89)	0.75	(0.69, 0.82)	0.78	(0.71, 0.85)	0.71	(0.66, 0.78)	0.75	(0.69, 0.82)	0.77	(0.71, 0.84)	0.83	(0.77, 0.91)
	6 to 15	1,768	1.16	(1.05, 1.27)	1.11	(1.01, 1.23)	1.07	(0.97, 1.18)	1.06	(0.97, 1.17)	1.04	(0.95, 1.15)	1.14	(1.03, 1.25)	1.18	(1.07, 1.30)
	>16	4,569	1.08	(1.01, 1.15)	1.07	(1.00, 1.14)	1.07	(1.01, 1.14)	1.03	(0.97, 1.10)	1.04	(0.98, 1.10)	1.08	(1.01, 1.15)	1.07	(1.02, 1.15)
New Zealand, Australia, Oceania, North America	<6	1,826	1,02	(0.93, 1.13)	0.97	(0.88, 1.07)	1.10	(1.00, 1.22)	1.01	(0.92, 1.12)	1.13	(1.03, 1.25)	0.98	(0.90, 1.09)	1.03	(0.94, 1.14)
	6 to 15	1,339	1.05	(0.94, 1.18)	1.03	(0.92, 1.16)	1.18	(1.05, 1.32)	1.11	(1.00, 1.24)	1.02	(1.01, 1.03)	1.05	(0.93, 1.17)	1.06	(0.95, 1.19)
	>16	1,060	0.92	(0.81, 1.05)	0.92	(0.81, 1.04)	0.94	(0.83, 1.08)	0.95	(0.83, 1.08)	0.97	(0.85, 1.11)	0.92	(0.81, 1.05)	0.92	(0.81, 1.05)
Afghanistan	<6	2,014	0.87	(0.79, 0.96)	0.79	(0.72, 0.87)	0.77	(0.70, 0.84)	0.79	(0.72, 0.87)	0.77	(0.70, 0.85)	0.82	(0.75, 0.90)	0.90	(0.82, 0.99)
	6 to 15	1,108	1.55	(1.38, 1.75)	1.46	(1.30, 1.65)	1.41	(1.25, 1.58)	1.43	(1.27, 1.61)	1.40	(1.24, 1.57)	1.51	(1.34, 1.70)	1.60	(1.42, 1.80)

	>16	109	1.72	(1.18, 2.52)	1.70	(1.16, 2.48)	1.72	(1.17, 2.53)	1.58	(1.08, 2.31)	1.62	(1.11, 2.38)	1.73	(1.18, 2.53)	1.76	(1.20, 2.57)
Ethiopia	<6	1,933	0.91	(0.83, 1.00)	0.85	(0.77, 0.93)	0.79	(0.72, 0.87)	0.83	(0.76, 0.92)	0.79	(0.72, 0.88)	0.88	(0.80, 0.96)	0.94	(0.85, 1.03)
	6 to 15	2,632	1.04	(0.96, 1.13)	1.02	(0.94, 1.10)	0.91	(0.84, 0.99)	0.98	(0.91, 1.06)	0.90	(0.83, 0.97)	1.05	(0.97, 1.14)	1.07	(0.99, 1.16)
	>16	1,028	1.23	(1.08, 1.39)	1.22	(1.08, 1.39)	1.17	(1.03, 1.33)	1.16	(1.02, 1.31)	1.13	(0.99, 1.28)	1.24	(1.09, 1.41)	1.25	(1.10, 1.41)
Eritrea	<6	1,618	0.68	(0.61, 0.76)	0.63	(0.56, 0.70)	0.55	(0.50, 0.62)	0.60	(0.54, 0.67)	0.54	(0.49, 0.61)	0.65	(0.58, 0.73)	0.70	(0.62, 0.78)
	6 to 15	1,250	0.83	(0.74, 0.94)	0.82	(0.73, 0.92)	0.72	(0.64, 0.81)	0.78	(0.69, 0.87)	0.70	(0.62, 0.78)	0.85	(0.75, 0.95)	0.86	(0.76, 0.97)
	>16	281	1.06	(0.83, 1.35)	1.06	(0.83, 1.36)	1.00	(0.78, 1.27)	1.00	(0.78, 1.27)	0.96	(0.75, 1.22)	1.09	(0.85, 1.38)	1.08	(0.85, 1.38)

Results adjusted for mother age, family situation and number of children (Model 1), for employment (Model 2), employment and education (Model 3), employment and income (Model 4), Employment, Education and income (Model 5), Employment and Smoking (Model 6) and Smoking (Model 7).

Ref= reference category; OR= Odds Ratio; CI= Confidence Interval.