Discussion Papers
Statistics Norway
Research department

No. 741
May 2013

Statistics Norway

Statistisk sentralbyrå

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Abstract:
The wellbeing of children of immigrant mothers is of great concern worldwide. In this study, we investigate the relationship between infant mortality and maternal country of origin and whether or not this relationship varies with the number of years since maternal migration. We use an extensive dataset consisting of all births in Norway from 1992 to 2010 augmented by source country and other maternal characteristics. By measuring the source country infant mortality rate at the time the mother came to Norway, we are able to account for circumstances in the country the mother left behind. There are two main findings. Firstly, maternal source country characteristics are significantly associated with the infant mortality rate in Norway. Those with a maternal background from countries with a high infant mortality rate (e.g. countries in Africa and Asia) have a persistently higher infant mortality rate than those from countries with a low infant mortality rate (e.g. countries in Europe). Secondly, an assimilation process takes place, since the effect of maternal source country characteristics declines with the number of years since maternal migration. Hence, those with a non-native maternal background have a higher infant mortality rate upon arrival, but the gap is eliminated after 20 years in Norway. The results cannot be explained by observable characteristics such as maternal age at birth, area of residence, maternal education or marital status.

Keywords: Infant mortality; immigration; assimilation

JEL classification: J15, J13, J18, I10

Acknowledgements: We are grateful for comments and suggestions from Taryn Ann Galloway, Øystein Kravdal, Arvid Raknerud, Hege Marie Gjefsen and seminar participants at Statistics Norway, Norwegian Institute of Public Health and HERO.

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ISSN 0809-733X
Print: Statistics Norway

Sammendrag

Det er mye oppmerksomhet verden over rettet mot levekår blant barn av innvandrermødre. I denne studien undersøker vi sammenhengen mellom mors fødeland og spedbarnsdødelighet, og hvorvidt dette varierer med mors botid i Norge. Vi bruker et datasett bestående av alle fødsler i Norge i perioden 1992-2010, påkoblet opplysninger om mors opprinnelsesland og andre karakteristikker. Vi kobler også på spedbarnsdødeligheten i mors opprinnelsesland på det tidspunktet hun kom til Norge. På den måten kan vi ta hensyn til forholdene i landet mor forlot. Det er to hovedfunn. For det første er spedbarnsdødeligheten i mors opprinnelsesland signifikant forbundet med spedbarnsdødelighet i Norge. De som har mødre som kommer fra land med høy spedbarnsdødelighet (f.eks noen land i Afrika og Asia), har en høyere spedbarnsdødelighet en de som har mødre fra land med lav spedbarnsdødelighet (f.eks land i Europa). For det andre er det en assimilasjonsprosess, da effekten av mors opprinnelsesland avtar med mors botid i Norge. Det betyr at de med mødre som har innvandringsbakgrunn har høyere spedbarnsdødelighet når de kommer til Norge, men gapet elimineres med botid. Resultatene kan ikke forklares med observerbare egenskaper som bosted (fylke), mors utdannelse og mors sivilstatus.

1. Introduction

International migration to industrialised countries has been accompanied by disparities in infant outcomes, such as health, mortality rate and labour market participation, between those born to migrant and non-migrant women. Although differences from the mean infant mortality rate in the population have been well-documented in Norway and in other European countries, the findings diverge greatly depending on the source and destination country (Bollini et al. 2009). For example, while Stoltenberg et al. (1998), Vangen et al. (2002), Villadsen et al. (2009) and Naimy et al. (2013) find an increased infant mortality rate among children of immigrant women from some specific countries (e.g. Pakistan), they do not find this association for other countries (e.g. Vietnam).[1]

In the following study, we aim to gain further insight into why infant mortality rates vary between immigrant groups by investigating what is referred to as the *assimilation model* (Blau 1992). According to this model, the infant mortality rate among immigrant mothers will approach the mean infant mortality rate in the host country over time as the period of residence in the host country increases. Testing this model, we investigate two central questions. (1) Do maternal source country characteristics have an impact on the infant mortality rate? (2) Is the impact of maternal source country characteristics altered by the number of years since maternal migration (YSM)?

This paper addresses the two questions using a unique register dataset covering all births in Norway from 1992 to 2010. Firstly, we document that children of mothers from Africa and Asia have a significantly higher infant mortality rate than children of non-immigrant mothers, while those with a maternal background from Europe have a significantly lower infant mortality rate than children of non-immigrant mothers. However, no significant differences were found for children with a background from North America and South America compared with children of non-immigrant mothers. Secondly, we show that the infant mortality rate in the maternal source country is an important predictor of immigrant outcomes in Norway. Immigrants who come from countries with higher infant mortality rates have a higher infant mortality rate in Norway. However, assimilation measured by maternal YSM takes place among all immigrants. Thus, the importance of the source country infant mortality rate diminishes with maternal YSM and disappears entirely after 20 years in Norway. This means that source country infant mortality is an important predictor of infant mortality close to migration, but that the importance of the source country diminishes with the time spent in Norway. Hence, these findings support the assimilation model.

[1] Several studies, mainly from the USA, but also from Australia and Canada, document favourable birth outcomes among immigrant women. This finding is a phenomenon described as 'the healthy migrant effect'. For example, Wingate & Alexander (2006) and Hummer et al. (2007) find that US-born children with Mexican mothers have significantly lower infant mortality rates than children born to native US mothers.

The structure of the paper is as follows. We start, in section 2, by discussing the theoretical background and some related literature, before the data and analysis are outlined in section 3. The descriptive statistics and empirical results are described in section 4. Finally, section 5 summarises and discusses the results in light of related literature and policy relevance. Shortcomings of the study are also described in this section.

2. Theoretical background and related literature

We use the infant mortality rate in the maternal source country as a measure of source country characteristics. This is intended to represent factors that influence infant mortality in the country the mother left behind. We measure the source country characteristics at the time each woman came to Norway. This is appropriate since we want to measure the conditions the mother left behind when deciding to migrate and changes in their effect over time in Norway (Blau et al. 2011).

Source country characteristics are likely to influence factors that are associated with infant mortality in the host country for two reasons. Firstly, immigrant women's health on arrival in the host country may vary due to differences in cultural and environmental factors in the source country (pre arrival effects). For example, immigrants who are displaced as a result of war are usually in poorer health than residents in the host country (Adanu and Johnson 2009), as they are more likely to be affected by malnutrition and lack of health care services (Naimy et al. 2013).

Secondly, the health seeking behaviour and cultural practices relating to pregnancy and childbirth in the source country may continue to influence women in the host country (post arrival effects). Such factors can include consanguinity, which has been found to be associated with infant mortality among Pakistani immigrants in Norway (Stoltenberg et al. 1998). Nutrition can be another factor. For example, a practice has been reported of reducing food intake to avoid large infants, and thereby complicated deliveries, among Somali women in Sweden (Essen et al. 2000). Other studies show that immigrant women who come from high-fertility source countries tend to have more children than native-born women (Blau 1992, Fernández and Fogli 2009, Chou 2010). There are also reasons to suggest that characteristics of the source country might have an impact on general perceptions of healthcare services, general knowledge about the healthcare system in the host country, and familiarity with rights to treatment. For example, it has been found that the source country has an impact on females' utilisation of healthcare services (Goth and Godager 2012, Grytten et al. 2012). Little attention has been devoted, however, to characteristics in the source country that can be used to predict infant mortality in the host country, and no study that we are aware of has investigated the association between source country characteristics and infant mortality rates. Our measure of source country infant mortality at the time the mother migrated

was chosen because it is likely to represent cultural and health factors that influence infant mortality in the source country and that might continue to influence factors in the host country.

Our design also allows us to characterise the interface between the source country infant mortality rate and the assimilation profiles. In research on immigrant health outcomes, it is generally assumed that immigrants to a country follow a route of gradual acceptance of the new country, with the effects of the source country disappearing over time. This is important as it can increase our understanding of what happens to the infant mortality rate as mothers are exposed to the Norwegian healthcare system, physical environment and health habits (such as diet, stress and health behaviour). This could also have strong implications for health policy interventions. If immigrant infant mortality eventually assimilates to Norwegian levels, it means that maternal care interventions should be aimed at new arrivals[2] in the country.

A number of studies have considered assimilation on other outcome variables besides infant mortality, and there is evidence to suggest that assimilation takes place on a number of outcomes, for example labour market participation (Borjas 1985) and welfare system participation (Hansen & Lofstrom 2003). Of particular relevance to our analysis is the study by Blau et al. (2011), who find that immigrant women from countries with high female labour supply consistently work more than those from countries with low female labour supply. While both groups of women work less than comparable native women upon arrival, women from countries with high female labour market participation eventually completely close the gap with natives, and women from countries with low female labour market participation eliminate most of it. There is evidence to suggest that assimilation also takes place in Norway. For example, Galloway and Aaberge (2005) used data for the whole Norwegian population from 1995 to 1997 to investigate immigrants' assimilation out of poverty. Their findings suggest that immigrants have a higher probability of being poor close to migration, but that this probability is reduced as YSM increases.

In the introduction, we discussed some studies that look at infant mortality among immigrants, but not studies that investigate infant health and assimilation. Only a few studies have investigated associations between infant health and maternal YSM, and all of them were conducted in North America, where immigrants are found to have a lower infant mortality rate than non-immigrant residents. This differs from studies conducted in Europe, where immigrants are frequently found to have a higher infant mortality rate. Landale et al. (2000) used pooled origin/destination data from the

[2] Besides the gradual acceptance of the new country's norms, there might be other reasons why infant outcomes change with years since migration. As discussed below, it has been found that years since migration is associated with increased income, and increased parental income is positively associated with child health.

Puerto Rican Maternal and Infant Health Study to investigate the association between maternal years in the USA and infant mortality. Their analysis showed that the infant mortality rate among immigrant women was initially lower than the native US infant mortality rate, but that it increased with maternal YSM. Urquia et al. (2010) investigated the association between maternal duration of residence and preterm birth and small for gestational age using natality data from metropolitan areas of Ontario, Canada. They found significant associations between maternal YSM and preterm birth. Recent immigrants were at lower risk of preterm birth than native Canadians, but the risk increased with YSM. However, no significant association was found between maternal YSM and the probability of being small for gestational age. Urquia et al. (2012) used Canadian cross-sectional survey data for women who gave birth in 2006 to 2007 to analyse the association between pregnancy outcomes and maternal YSM. Recent immigrant (<10 years) women had a lower risk of preterm delivery than non-immigrants. No significant difference was found between non-immigrants and immigrants with a longer residence period (>10 years).

Other studies have found a highly non-linear pattern between YSM and infant health. Ceballos and Palloni (2010) used a dataset consisting of a sample of Mexican immigrant women living in the USA to assess the association between maternal YSM and infant health. Infant health was assessed using a composite measure of low birth weight, small for gestational age and less than 37 weeks' gestation. They found a nonlinear U-shaped relationship between maternal duration of residence in the USA and infant health. Having spent 3 or fewer years, or 13 or more years in the USA was associated with less favourable birth outcomes compared to having spent between 4 to 12 years there. Finally, Teitler et al. (2012) used three US datasets to examine the association between the birth weight of children of immigrants and maternal duration of residence. They identified a non-linear U-shaped relationship, where birth weight declined over the first few years of maternal residence and then increased thereafter. This association was robust across the three datasets.

As we can see, there are disparities in the results of the studies that investigate infant outcomes and YSM, and it is difficult to conclude in general about whether or not an assimilation process occurs. Our study will differ from these studies in important ways. Firstly, not only will we investigate differentials in infant mortality in relation to YSM, we will also study how this relationship changes with characteristics of the maternal source country. Hence, we will use source country characteristics to investigate heterogeneity in the immigrant population. As far as we are aware, this will be the first study that has looked at this question. Secondly, our comprehensive dataset, which consists of register data for all births from 1992 to 2010 in Norway, ensures that there are sufficient observations to conduct the analysis and enable detailed analysis of population subgroups. In addition, we do not have issues relating to sample selection and missing responses, which are common in survey data. Thirdly,

the above-mentioned studies analysing YSM were all conducted in the USA or Canada. In both these countries, the healthy migrant effect is the main topic of analysis, while, in European studies, migrants are consistently found to have inferior health. Fourthly, as we will discuss in more detail below, limited attention has been devoted to immigration cohort effects, which will be accounted for in this study.

3. Methods

Data and variables

Using a unique identification key, we link several register datasets from Statistics Norway that encompass the whole Norwegian population[3] from 1992 to 2010. The final dataset consists of all births in Norway during this period, with information about maternal characteristics including source country and arrival time in Norway. Individuals with missing information about source country, date of birth or maternal characteristics are excluded from the sample (1.11% of the sample).

The dependent variable is infant mortality, which we define as death of a liveborn child within the first year of life. Hence, the dependent variable is a dummy variable taking the value of one if the child died within the first year of life and zero otherwise.

We generate dummy variables for continent of maternal origin (Africa, Asia, Europe, North America and South America, respectively). These variables take the value of one if the maternal origin is from one of the specified continents and zero otherwise.

A dataset of source country infant mortality rates (SIMR) is assembled from the United Nations, Department of Economic and Social Affairs, Population Division (2011). The data contain the number of deaths per 1 000 newborns in five-year intervals from 1950 until 2010. These data are merged into the register data based on maternal country of origin and maternal date of arrival in Norway. Hence, each child born to a mother who has immigrated is assigned a value for SIMR at the time the mother arrived in Norway.

[3] We include everyone regarded as residents of Norway. Persons are regarded as residents of Norway when they have lived here or intend to live here for at least six months, even though the stay is temporary. Only asylum seekers with residence permits are registered as residents, however (www.ssb.no).

We also include a range of other covariates. The following variables are included in each specification: maternal age at birth, maternal age at birth squared and gender. In addition, depending on the model, we control for maternal education (four categories), maternal marital status (two categories), birth year (dummy variables in 1-year intervals), maternal immigration cohort (10 dummy variables in five-year intervals), county of residence (19 dummy variables), and the mean infant mortality rate in Norway in the year of birth (continuous variable).[4]

Analysis

We investigate infant mortality within the framework of a standard logit model, and estimate four different specifications, where the dependent variable (M_i^*) is a latent variable that cannot be observed in our data. What we observe is whether or not the child died within the first year of life. Therefore, what we observe is the indicator variable:

$$M_i = 1 \quad \text{if } M_i^* > 0$$
$$M_i = 0 \quad \text{otherwise}$$

Assuming ε_1 is logistically distributed, the probability of dying within the first year of life is given by the logit model:

$$M_i = \frac{1}{1 + \exp(-\alpha_0 - C_i\alpha_1 - Y_i\alpha_2)}$$

In the first model, the aim is to estimate whether or not there are differences in infant mortality between children born to mothers who are natives and children born to mothers with immigrant backgrounds. We also investigate whether any observed difference depends on maternal source continent. To do this we estimate the association between infant mortality and maternal continent of origin by fitting the following equation:

[1] $$M_i^* = \alpha_0 + C_i\alpha_1 + Y_i\alpha_2 + X_i\alpha_3 + \varepsilon_{1i}$$

where i indexes the individual; M_i is a dummy for infant mortality; C_i is a vector of dummy variables for maternal source continent; Y_i is a vector of dummy variables for year of birth; X_i is a vector of maternal and individual characteristics; and ε_{1i} is the error term. Moreover, α_0 is a constant term and $\alpha_1, \alpha_2, \alpha_3$ are vectors of parameters. The main parameters of interest are the ones associated with maternal source continent, α_1, which captures the mean difference in infant mortality between

[4] This variable is generated by dividing the number of deaths by the number of births each year.

children born to native mothers and children born to non-native mothers with a background from a given continent.

In the second analysis, we further investigate the interplay between source country characteristics and maternal YSM. To do this, we use a subsample consisting of children of non-native maternal background, and we fit the following two models:

$$[2] \qquad M_i^* = \beta_0 + C_i\beta_1 + T_i\beta_2 + \beta_3 P_i + A_i\beta_4 + X_i\beta_5 + \varepsilon_{2i}$$

And

$$[3] \qquad M_i^* = \gamma_0 + \gamma_1 S_i + T_i\gamma_2 + \gamma_3 P_i + A_i\gamma_4 + X_i\gamma_5 + \varepsilon_{3i}$$

where T_i is a vector of dummy variables for maternal YSM; P_i is the continuous variable for mean infant mortality rate in Norway in the year of birth; and A_i is a vector of cohort-of-arrival dummy variables. The difference between Eq. [2] and Eq. [3] is the specification of the source country characteristics. Eq. [2] includes maternal source continent (C_i), while Eq. [3] includes S_i, which is a continuous variable for source country infant mortality rate (SIMR). To investigate whether the relationship between SIMR and infant mortality varies with YSM, we also fit a model in which the parameters determining the effects of SIMR are allowed to vary with YSM:

$$[4] \qquad M_i^* = \delta_0 + T_i\delta_1 + (S_i \times T_i)\delta_2 + \delta_3 P_i + A_i\delta_4 + X_i\delta_5 + \varepsilon_{4i}$$

In this equation, we do not include a separate term for the main SIMR effects. Instead, this equation allows SIMR (S_i) to affect the level of infant mortality and the impact of time in Norway on infant mortality.[5] Hence, the interaction effects represent the effect of S_i on M_i at different levels of T_i. As described above, we control for X_i, which is a vector of maternal and individual characteristics.

In the following tables, we present the estimated logit coefficients, as well as marginal effects (MEs). The marginal effects are the probability that an event (infant death) will occur. They are estimated by Pr(y)=G(y*). For expositional reasons, we multiply the MEs by 1 000 so that they represent the change in the infant mortality rate (deaths per 1 000 live births). Using the results of the regression models, we also plot curves for predicted infant mortality by YSM at fixed values of SIMR, while the other covariates are fixed at the population mean values.

[5] This is a reparameterisation of a 'full' model with both main effects included. In this case, the coefficients of the interaction term are interpreted as simple effects.

We fit two versions of Eq. [1]─Eq. [4]. In the first version, we only include controls for maternal age and gender (the *less adjusted* regression). In the second version, we add controls for maternal education, maternal marital status and county of residence (the *fully adjusted* regression). The standard errors are clustered by maternal source country level/year of arrival, since this is the level of variation of our group-level explanatory variable SIMR. We regard p-values below the 5% level as statistically significant. Values between 5% and 10% are regarded as weakly significant.

Further details

It is common practice in the labour economics literature to control for immigration-cohort effects (Galloway 2008). To investigate the relationship between YSM and infant mortality it is essential to control for arrival-cohort effects. The reason is that the immigrants who arrive in a particular year may be influenced by unique forces in that year. Such forces could, for example, be relative economic conditions, a refugee crisis or legislative amendments to the rules governing immigration. Hence, studies conducted without controlling for such effects present a joint measure of cohort effects and YSM. As described, we control for maternal immigration-cohort effects by including five-year period of arrival dummies in Eqs. [2]─[4].

It is also important to control for time effects. However, we cannot include both cohort effects and time (birth year) effects if we want to investigate YSM. As we include cohort effects, we need an alternative method to account for time effects. In order to provide a measure of time effects, we include a measure for the infant mortality rate in the year of birth. This measure is constructed by calculating the mean infant mortality rate each year and merging it with the register data based on year of birth. We assume that this variable will pick up time-dependent factors that influence infant mortality, such as developments in medical technology.[6]

4. Results

Descriptive statistics

Table 1 contains descriptive statistics of infant mortality for the full dataset and stratified by continents. Of a total of 1 109 932 births, 194 426 were children born to mothers who immigrated. The table illustrates that the infant mortality rate differs by maternal continent of origin. The highest infant mortality rate of 5.67 per 1 000 live births was found among children born to mothers from Africa and

[6] A related approach has been used in labour economics, where the unemployment rate is used to reflect the general economic development over time (Barth et al. 2004).

the lowest infant mortality rate of 1.72 deaths per 1 000 live births was among children born to mothers from Oceania.[7] Compared with children born to mothers from Norway, children born to mothers from Africa and Asia had a higher infant mortality rate, while the infant mortality rate was lower in children born to mothers from Europe, Oceania, North America and South America. Table 1 also shows the mean SIMR upon migration for each continent. On average, the mean source country infant mortality rate was highest for those who left from Africa (104 per 1 000 liveborn) and lowest for those who left from Europe (18 per 1 000 liveborn) and Oceania (14 per 1 000 liveborn).[8]

Table 1: Number of births and deaths by maternal source continent

	All births	**Deaths**	**Deaths/(1000 live births)**	**Mean SIMR[1]**
Norway	915506	3372	3.68	-
Africa	25590	145	5.67	103.95
Asia	61519	297	4.83	55.09
Europe (excluding Norway)	89363	279	3.12	18.03
North America	9531	27	2.83	21.59
Oceania	1164	2	1.72	13.98
South America	7259	20	2.76	44.39
Total	*1109932*	*4142*	3.73	-

[1]: SIMR: source country infant mortality rate

Summary statistics for the variables across the whole population, and stratified results for children born to mothers who are natives and non-natives, respectively, are shown in Table 2. If we look at the whole population sample first, we see that the mean maternal age was 30 years, that 51% of the sample were males (boys), and that there is not much variation in the percentage born in the years from 1992 to 2010. Similar numbers were found in the sample stratified by maternal origin, but the proportion with non-native maternal background born in more recent years has increased. Turning to the arrival cohorts, we see that most children with a non-native background have mothers who arrived between 1990 and 2005. A larger proportion of native mothers had a college or university education (38%) than immigrant mothers (32%). However, a larger proportion of immigrant mothers (66%) were married when they gave birth than natives (41%). Norway is divided into 19 counties, with large variation in population density. According to the table, most children live in Oslo. However, a relatively higher proportion of those of non-native maternal origin (31%) live in Oslo than of those with native maternal origin (11%).

[7] Caution is necessary when interpreting these results as there were few children born to mothers from Oceania.
[8] As there were only 1 164 births and 2 infant deaths among mothers with a background from Oceania, we do not show results for this continent in the following analysis.

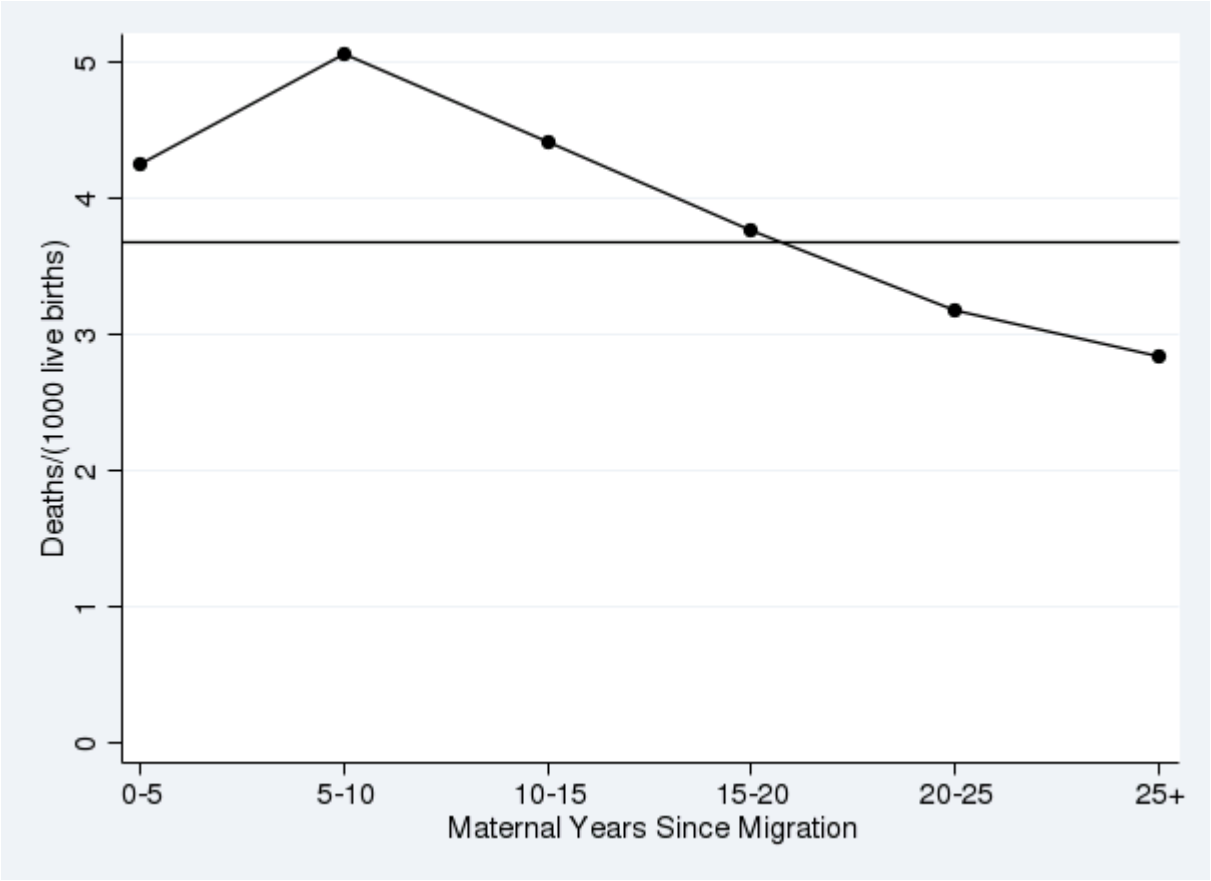
Table 2: Summary statistics variables by maternal background

	Whole population	No immigrant background	Immigrant background
Maternal age (years)	30	29	30
IMRYOB (mean)	0,00465	0,00473	0,0043
Gender of infant (%)			
Male	51	51	51
Female	49	49	49
Birth year (%)			
1992	5	6	4
1993	5	6	4
1994	5	6	4
1995	5	6	4
1996	5	6	4
1997	5	6	4
1998	5	5	4
1999	5	5	5
2000	5	5	5
2001	5	5	5
2002	5	5	5
2003	5	5	5
2004	5	5	6
2005	5	5	6
2006	5	5	6
2007	5	5	7
2008	5	5	7
2009	6	5	8
2010	5	5	8
Maternal immigration cohort (%)			
Mother not immigrated	82	100	0
<1965	1	0	6
1965-1970	1	0	7
1970-1975	2	0	9
1975-1980	1	0	7
1980-1985	1	0	6
1985-1990	2	0	10
1990-1995	2	0	14
1995-2000	3	0	16
2000-2005	3	0	16
2005-2010	2	0	9
Education (%)			
Less than high school	24	24	27
High school	24	26	17
More than high school	37	38	32
Missing education	14	12	24
Marital Status (%)			
Single	44	47	27
Married	45	41	66
Missing	11	12	7
County (%)			
Østfold	5	5	4
Akershus	10	10	12
Oslo	14	11	31
Hedemark	3	4	2
Oppland	3	4	2
Buskerud	5	5	5
Vestfold	4	4	4
Telemark	3	3	2
AustAgder	2	2	2
VestAgder	4	4	3
Rogaland	10	10	9
Hordaland	10	11	8
Song og Fjordane	2	3	1
Møre og Romsdal	5	5	3
Sør Trøndelag	6	6	4
Nord Trøndelag	3	3	1
Nordland	5	5	2
Troms	3	4	2
Finnmark	2	2	1

All statistics are either mean (for continuous variables) or % (categorical variables).
IMRYOB: infant mortality rate in Norway the year of birth

Figure 1 shows the observed infant mortality rate in the population by maternal YSM. The horizontal reference line represents the infant mortality rate in the Norwegian population (from Table 1), and the other line shows the infant mortality rate among infants with immigrant mothers. The figure illustrates decreasing infant mortality by maternal YSM. The initial infant mortality rate lies above the reference line. However, the infant mortality rate drops with increasing maternal YSM, and, among those with mothers who have been in the country for 20 years or more, the infant mortality rate is lower than for the Norwegian population. It should be noted that this comparison is flawed to some extent. As the mean Norwegian population infant mortality rate (represented by the reference line) is kept constant at 3.68, there are factors which vary systematically with maternal YSM among immigrants. One such factor is the average maternal age of the immigrant population, which increases with maternal YSM.

Figure 1: Observed infant mortality among infants with non-native maternal background by maternal YSM



Regression model results

Table 3 shows the logit coefficients and the marginal effects (MEs) of the first analysis regressing infant mortality on maternal source continent in a sample including all births between 1992 and 2010 using Eq. [1]. The marginal effects depend on the values of the covariates. They are calculated at sample means. The coefficients in the *less adjusted* model in Table 3 illustrate that, infant mortality is

significantly higher for those with maternal origin from Africa and Asia and weakly significantly lower for those of European origin. The ME is largest for those of African maternal origin and, on average, there are 2.4 additional deaths per 1 000 live births among children with African mothers compared to children with non-immigrant mothers. The MEs are negative for North America and South America, but the logit coefficients are non-significant. Maternal age has a convex relationship with infant mortality, and females (girls) are significantly less likely to die within the first year of birth.

In the *fully adjusted* model, we see that the significantly higher infant mortality rate persists for those with a maternal origin from Africa and Asia, and continues to be weakly significantly lower for those of European origin. The estimated effects are reduced for Africa and Asia, indicating that part of the difference is due to variables such as education, marital status and county of residence. The estimated coefficients for maternal marital status suggest negligible differences in infant mortality. The coefficients for maternal education are highly significant. The MEs show that maternal education is negatively associated with infant mortality. There are 1.6 fewer deaths per 1 000 live births among those who have more than high school education compared with those with less than high school education.

Table 3: Logit estimation of infant mortality. Parameter estimates and marginal effects (M.E.). *N= 1 109 932*

	Less adjusted, Eq. [1]		**Fully adjusted, Eq. [1]**	
	Coef.	*M.E.*	Coef.	*M.E.*
Africa	0.511***	*2.439*	0.401***	*1.8077*
Asia	0.331***	*1.428*	0.241**	*0.9977*
Europe except Norway	-0.108*	*-0.383*	-0.117*	*-0.4134*
North America	-0.253	*-0.833*	-0.228	*-0.7599*
South America	-0.264	*-0.864*	-0.286	*-0.9262*
Maternal age	-0.223***	*-0.830*	-0.163***	*-0.6042*
Maternal age sqrd.	0.004***	*0.014*	0.003***	*0.0108*
Female	-0.245***	*-0.903*	-0.245***	*-0.902*
Marital Status				
Single			Base category	
Married			0.004	*0.0139*
Missing			0.356	*1.5084*
Maternal Education				
Less than high school			Base category	
High school			-0.345***	*-1.3409*
More than high school			-0.415***	*-1.5643*
Missing education			-0.041	*-0.1851*
County	No		Yes	
Birth year	Yes		Yes	

The population consists of all births between 1992-2010. ***, ** and * denotes significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered at the country/arrival year level. The MEs are rescaled so that they are interpreted as deaths/(1000 live births).

Table 4 presents the estimated coefficients and the MEs for Eqs. [2]─[4], which were fitted using a subsample of individuals of non-native maternal origin. A further distinction between the model in Table 3 and the models we are now studying is the introduction of years since migration (YSM) for the mother. The estimates from the *less adjusted* Eq. [2] in Table 4 show significantly higher infant mortality for those of African and Asian maternal origin compared with European (base category) maternal origin. Those of African maternal origin have 2.8 more deaths per 1 000 live births than those of European maternal origin. Compared with European maternal origin, no significant difference is found for those of North American and South American maternal origin. The results also illustrate that maternal YSM is significantly associated with infant mortality. Compared with maternal YSM between 0-5 years, there is significantly lower infant mortality for those with maternal YSM of 10-15 years, 15-20 years, 20-25 years and 25+ years, respectively. The MEs show, for example, that, compared with 0-5 YSM, there are 3 fewer deaths per 1 000 live births in those with 25 or more years since migration.

Turning to the *less adjusted* Eq. [3] in Table 4, we see that the source country infant mortality rate (SIMR) is significantly associated with infant mortality. The ME of 0.019 is interpreted as the increase in deaths per 1 000 live births in Norway when the infant mortality rate in the maternal source country increases by 1 (i.e. when the continuous SIMR increases by 1). Thus, the infant mortality rate varies with maternal source country. The estimated coefficients of the YSM variables are still significant, which illustrates the importance of assimilation in this specification as well.

Table 4 also shows the estimation results from Eq. [4], which is the specification that includes interactions between SIMR and maternal YSM. This interaction allows the effect of a change in SIMR on infant mortality to vary systematically with YSM. Based on the results from the *less adjusted* Eq. [4], we can see that including the interaction reduces both the absolute value and the significance of the YSM main effects. Only a YSM of 25 or more is significantly associated with reduced infant mortality. This result is not surprising given that the effect of YSM is also reflected in the estimates of the effects of the interaction YSM*SIMR. From the table, we see that the source country represented by SIMR has a significant effect on infant mortality if birth is at 0-5, 5-10 and 10-15 YSM. However, the associ ation between SIMR and infant mortality is not significant when the mother has been in Norway for more than 15 years before the birth. We also conduct tests, illustrated by the †s in the table, of the difference between the indicated coefficients and the effect of SIMR at 0-5 years since migration. This test illustrates that the association between SIMR and infant mortality is significantly lower at 20-25 YSM and at 25+ YSM compared with 0-5 YSM. For example, the effect of SIMR at 25 or more years since migration is 0.004, which is significantly lower than the ME of 0.039 at 0-5 years since migration. Based on this, we can say that SIMR is an important predictor of infant mortality. However, the effect of SIMR decreases significantly with maternal YSM.

Table 4: Logit estimation of infant mortality. Parameter estimates and marginal effects (M.E.). ***N= 194 426***

	Less adjusted						**Fully adjusted**					
	Eq. [2]		Eq. [3]		Eq. [4]		Eq. [2]		Eq. [3]		Eq. [4]	
	Coef.	*M.E.*	Coef.	*M.E.*	Coef.	*M.E.*	Coef.	*M.E.*	Coef.	*M.E.*	Coef.	*M.E.*
Africa	0.5679***	*2.762*					0.4949***	*2.333*				
Asia	0.3672***	*1.541*					0.3015***	*1.247*				
Europe except Norway	Base category						Base category					
North America	-0.0782	*-0.298*					-0.0712	*-0.272*				
South America	-0.1502	*-0.553*					-0.1532	*-0.563*				
SIMR			0.0052***	*0.019*					0.0045***	*0.016*		
YSM												
0-5	Base category		Base category		Base category		Base category		Base category		Base category	
5-10	0.0066	*0.033*	-0.0122	*-0.063*	0.0620	*0.238*	0.0083	*0.039*	-0.0053	*-0.021*	0.0758	*0.281*
10-15	-0.3405**	*-1.464*	-0.3643**	*-1.576*	-0.2898	*-0.936*	-0.3260**	*-1.317*	-0.3450**	*-1.163*	-0.2491	*-0.786*
15-20	-0.5956**	*-2.279*	-0.6259***	*-2.404*	-0.4962	*-1.457*	-0.5589**	*-2.029*	-0.5852**	*-1.767*	-0.4320	*-1.251*
20-25	-0.7445***	*-2.667*	-0.7817***	*-2.804*	-0.3775	*-1.171*	-0.6580**	*-2.286*	-0.6905**	*-1.989*	-0.2664	*-0.834*
25+	-0.8806***	*-2.975*	-0.9096***	*-3.089*	-0.6424**	*-1.766*	-0.7529**	*-2.508*	-0.7765**	*-2.154*	-0.5243	*-1.455*
YSM* SIMR												
0-5* SIMR					0.0077***	*0.039*					0.0070***	*0.033*
5-10* SIMR					0.0061***	*0.031*					0.0053***	*0.025*
10-15* SIMR					0.0060**	*0.022*					0.0049*	*0.017*
15-20* SIMR					0.0051	*0.014*					0.0040	*0.011*
20-25* SIMR					0.0003††	*0.001*					-0.0008††	*-0.002*
25+* SIMR					0.0019††	*0.004*					0.0015††	*0.003*
Maternal Age	Yes		Yes		Yes		Yes		Yes		Yes	
Female	Yes		Yes		Yes		Yes		Yes		Yes	
IMRYOB	Yes		Yes		Yes		Yes		Yes		Yes	
Marital Status	No		No		No		Yes		Yes		Yes	
Maternal Education	No		No		No		Yes		Yes		Yes	
County	No		No		No		Yes		Yes		Yes	
Cohort	Yes		Yes		Yes		Yes		Yes		Yes	

The population consists of all births by mothers with a non-native background between 1992-2010. ***, ** and * denotes significance at the 1%, 5% and 10% level, respectively. †††, †† and † denotes significance level of the difference between the indicated coefficient and the effect of SIMR, at 0-5 years since migration at the 1%, 5% and 10% level, respectively. Standard errors are clustered at the country/arrival year level. The MEs are rescaled so that they are interpreted as deaths/(1000 live births).
IMRYOB: infant mortality rate in Norway the year of birth

Table 4 also shows the estimation results of Eqs. [2]─[4] based on the *fully adjusted* model. By comparing the results for the *less adjusted* and *fully adjusted* model specifications, we see that similar results are obtained in each specification and that the significance levels are not altered substantially, neither for the main effects nor for the interactions. The MEs are slightly reduced, however. In Eq. [4], for example, the *less adjusted* model showed an ME of 0.039 of an increased SIMR at 0-5 YSM, while the corresponding figure in the *fully adjusted* model is 0.033. Hence, the inclusion of the additional covariates does not alter any of the main conclusions. There are source country effects on infant mortality, and the effects of maternal source country characteristics decline with years since migration. This finding indicates that there is an assimilation process among immigrants whereby, over time, they become more and more similar to non-immigrant women with respect to infant mortality.

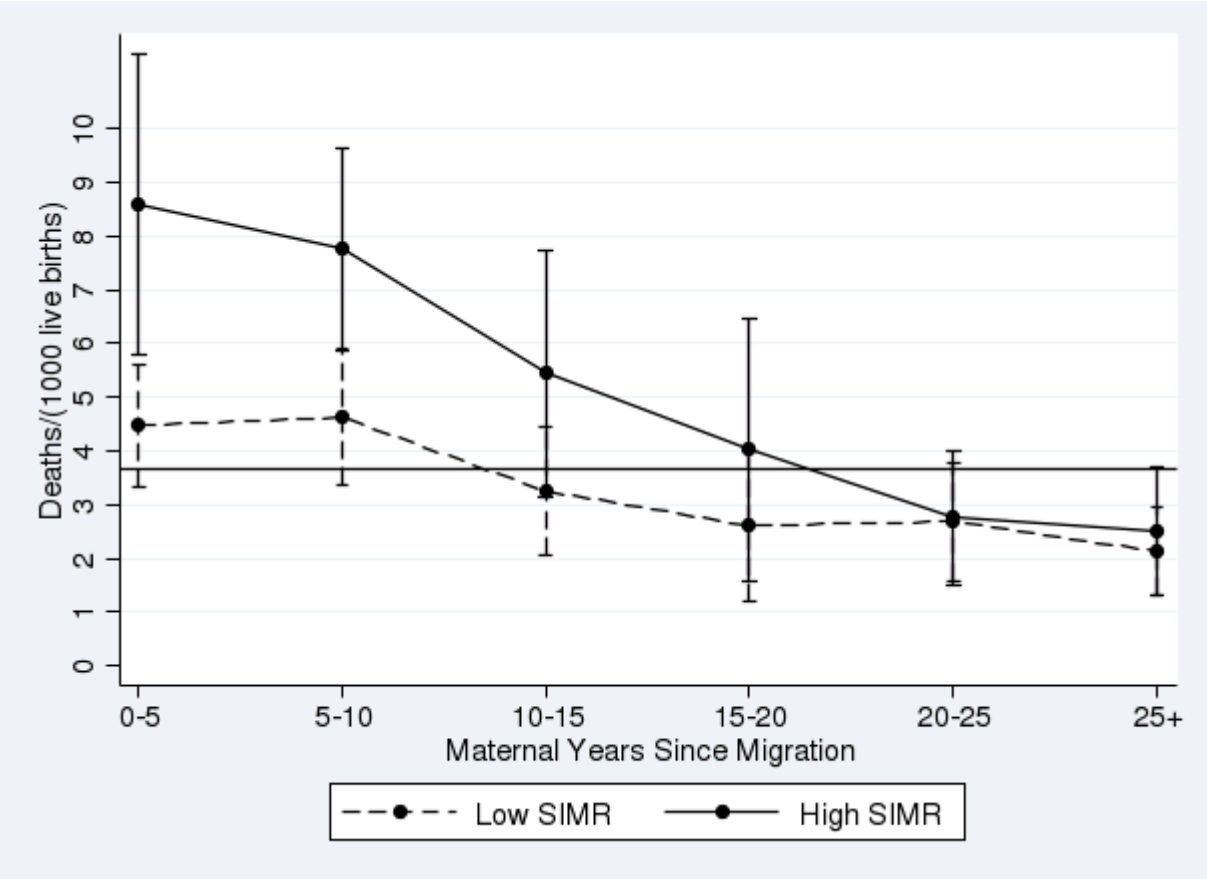
Figure 2 illustrates the association between infant mortality and maternal YSM. It is estimated based on the results for the *less adjusted* Eq. [4] in Table 4, which includes the interactions between SIMR and maternal YSM. The predicted mean infant mortality rate by YSM is computed by fixing the covariates at the whole population mean values. Hence, the variation in the predicted infant mortality rate is a function of the association between SIMR and infant mortality rate and how this varies with YSM, and it is not affected by the values of the other covariates. The figure illustrates two scenarios where the source country infant mortality rate (SIMR) is set to a 'high' value of 104 and a 'low' value of 18, which are the mean population values for those with maternal origin from Africa (High) and Europe (Low) (the values are taken from Table 1). As above, the horizontal reference line shows the mean infant mortality rate in those with non-immigrant mothers. The 'whiskers' show the 95% confidence intervals of the estimates.

Figure 2 also illustrates the importance of maternal source country characteristics. Those with a 'high' SIMR have a higher infant mortality rate than those with a 'low' SIMR. For example, at 0-5 YSM, the mean infant mortality rate is 8.6 per 1 000 live births in the 'high' scenario, while it is 4.5 in the 'low' scenario. The 95% CIs show that this difference is significant. Figure 2 also shows that there is an association between maternal YSM and infant mortality rate. Those with a lower maternal YSM have a higher risk of infant mortality than those with a higher maternal YSM. In both scenarios, there is a higher infant mortality rate among new arrivals compared with the mean infant mortality rate in Norway (the straight line). The significance of SIMR decreases with maternal YSM, however, and after 20-25 years the infant mortality rate among the immigrants is lower than the population mean in

both predicted scenarios.[9] This illustrates that the importance of the source country is reduced by maternal YSM.

Finally, Figure 2 illustrates that those in the 'high' SIMR scenario catch-up with those in the 'low' SIMR scenario. The slope of the curve is steeper for those who initially had a higher infant mortality rate. Hence, the gap between the curves narrows with maternal YSM. This finding is important because it shows that the source country characteristics influence the assimilation process. The assimilation pattern differs, therefore, depending on 'how different' in terms of infant mortality rate the source country is from Norway. Those with a maternal background from countries with a high infant mortality rate have a greater reduction in infant mortality as a result of maternal YSM than those with a maternal background from countries with a low infant mortality rate.

Figure 2: Predicted infant mortality among infants with non-native maternal background by maternal YSM



The "whiskers" represent 95% confidence intervals.

[9] Based on the 95% CIs, we cannot say that the infant mortality rate becomes significantly lower than the reference line in the 'high' scenario. However, in the 'low' scenario, the infant mortality rate is significantly lower after 25 or more years since migration.

We attempted a number of alternative specifications of Eqs. [2]─[4]. Each of them led to qualitatively similar results to those shown in Table 4. First, to further investigate the effect of birth year we fitted Eqs. [2]─Eq. [4] controlling for year of birth. In this specification, we removed maternal immigration-cohort effects to allow estimation of YSM. The SIMR remained highly significant close to migration but decreased significantly with YSM. We have also experimented with models without immigration-cohort effects and year of birth effects, and the trends were similar. In addition, we experimented by including other variables. These were parity (four categories) and risky birth interval (dummy variable). Risky birth interval was defined as giving birth within one year of the previous child, and regressions including this variable were fitted in a subsample where we exclude all immigrants who have been in the country for less than a year. This did not alter the findings.

5. Summary and conclusion

The aim of this study was to investigate the relationship between maternal source country and infant mortality and whether or not this relationship varies with maternal YSM. Our main findings are that maternal source country characteristics are significantly associated with infant mortality rate in Norway. Those with a maternal background from countries with a high infant mortality rate (e.g. countries in Africa and Asia) have a persistently higher infant mortality rate than those from countries with a low infant mortality rate (e.g. countries in Europe). Secondly, there is evidence of an assimilation process since the effect of maternal source country characteristics declines with maternal years since migration. We will now discuss these findings in light of related literature.

We find that the infant mortality rate in children born to mothers who have immigrated to Norway varies with maternal continent of origin. Our findings also show that gender, birth year and maternal age are significantly associated with infant mortality. We obtain similar results after controlling for area, maternal education and marital status, although at slightly reduced levels. The results are supported by other studies conducted in Scandinavia, which find that there is variation in infant mortality depending on maternal source country, and that the association is diminished but not eliminated after controlling for individual and household characteristics. For example, Villadsen et al. (2009) found that the Pakistani, Somali, and Turkish population had substantially higher infant mortality rates compared with individuals of Danish maternal origin. While Vangen et al. (2002) used a Norwegian dataset and found a significantly higher infant mortality rate among those with a mother who emigrated from Pakistan, no significant effects were obtained for those with a mother from Vietnam and North Africa. Similar findings are suggested by Essen et al. (2000), who used a Swedish dataset and found that children born to mothers who had migrated had a higher risk of infant mortality than those with ethnic Swedish mothers. They found that the risk was particularly high if the mother

was from sub-Saharan Africa, and the findings could not be explained by maternal health and smoking status. All these studies also control for socioeconomic conditions, which do not alter the conclusions. Although these studies show that infant mortality rate varies with source country, they do not investigate whether the host country infant mortality rate varies with characteristics of the source country or years since migration.

A number of studies have been conducted on assimilation and infant health (see: Landale et al. 2000; Urquia et al. 2010; Ceballos & Palloni, 2010; Teitler et al. 2012; Urquia et al. 2012). As discussed in the introduction, the results of these studies are mixed. Our findings differ from the findings in these studies since we are the first to find a clear and negative association between maternal YSM and infant mortality. There might be a number of reasons for this. Firstly, we use data on the Norwegian population, which has a different mix of immigrants and a different set of immigration policies. Secondly, and related to this, we look at immigrants who have poorer infant outcomes in general, while the studies described above investigate immigrants who generally have superior infant outcomes compared with native-born infants (the healthy migrant effect). Thirdly, we control for maternal immigration cohort effects. Fourthly, we include maternal source country characteristics in the analysis, which allows the assimilation process to vary with conditions in the maternal source country. Fifthly, we have register data that include all individuals in Norway. Thus, we do not have survey data and sample selection problems that might be related to infant mortality.

Our findings are in line with the results of other studies that have looked at assimilation in relation to other outcomes such as wages (Antecol 2000; Blau et al. 2011) and fertility (Blau 1992; Fernanadez & Fogli 2009; Chou 2010). Hence, we have found evidence in support of the *assimilation model* (Blau 1992) with regard to infant health. This means that, in the case where the infant mortality rate is higher in the source country, immigrants' infant mortality rate will initially exceed that of their non-immigrant counterparts (reflecting conditions in the country of maternal origin). However, the infant mortality rate will approach the mean infant mortality rate in the host country over time with increasing residence in the host country.

The main implications of our findings are that more attention needs to be devoted to maternal YSM and maternal source country in maternity and follow-up care of immigrants. A higher rate of infant mortality among children of immigrants is primarily an issue in the short to medium-term period following migration among immigrants from source countries with high infant mortality rates. Not only do our findings narrow the time span during which these children can be seen as an at-risk group, they contribute to identifying who has the highest infant mortality risk based on maternal source country. This suggests that the health service should devote particular attention to immigrant women

from countries with a high infant mortality rate who give birth close to immigration. Furthermore, the findings suggest that immigrants become integrated into Norwegian society and learn to make use of the public health care system. This integration process is more distinct for immigrants from countries that differ more from Norway (in terms of infant mortality rate). However, more research needs to be done to investigate whether this pattern exists for other types of health outcomes and types of health services.

Shortcomings of the analysis

In this analysis, we have studied the association between infant mortality, maternal YSM and source country. We have presented unadjusted results based on raw data and generated predictions based on regressions, controlling for time and maternal immigration-cohort effects together with both exogenous and potentially endogenous control variables. The results all support the same conclusions. However, we cannot establish that this association is causal for the following reasons. Firstly, YSM at time of birth may be endogenous. There may be unobserved factors that affect the timing of birth, which might also affect infant mortality. Such factors could be maternal socioeconomic factors or the rate of time preference. Although we control for maternal age and education, we are not able to control for all factors that can alter the relationship. Secondly, there may be a selection of immigrants to Norway. This is important since we do not compare children born to mothers who have immigrated with children born to identical mothers who did not decide to immigrate. Maternal age/year of birth profiles in native-born Norwegians might not be representative of the maternal age/year of birth profiles the immigrants would have experienced had they not emigrated. Thirdly, immigrants might move from Norway. If maternal health is related to the probability of moving, this might bias the results. Nevertheless, providing estimates of the association is important as, in addition to the implications above, it suggest that a causal relationship might exist and that further analysis is needed. The other studies discussed above also suffer from these potential biases.

To summarise, those with a maternal background from a source country with a higher infant mortality rate also have a higher infant mortality rate in Norway. However, this difference is reduced with maternal YSM. This means that immigrant infant mortality rate is only an issue among those giving birth close to migration.

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ISSN 0809-733X

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Design: Siri Boquist