

RESEARCH ARTICLE

Excess under-five mortality of children born to immigrants: Longitudinal evidence from France

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ABSTRACT Immigrant children face significant disparities in terms of their survival. To investigate the role of parental origin in explaining these disparities, we used the large French socio-demographic panel, with a sample of 687,535 births from 1990 to 2020, to which a propensity score method and longitudinal approaches were applied.

Our findings reveal that even after accounting for confounding factors by balancing socio-demographic variables, disparities in under-five mortality persist based on the mother's origin. Specifically, notable differences in mortality were observed among three immigrant groups: women born in Sub-Saharan Africa, in North Africa, and in the group of regions including America, Oceania and others. Our results show no protective effect of mixed parenting on under-five mortality. Additionally, we observed that a higher proportion of children born to immigrant mothers in the municipality was associated with increased under-five mortality for children of native mothers and some children of immigrant mothers. Moreover, our study confirmed the influence of paternal support on child survival.

KEYWORDS Under-five mortality • Mother's origin • Mixed parenting • Propensity score • Longitudinal analysis

Introduction

The well-being of immigrant children is a significant public health issue in countries that experience immigration (Kinge and Kornstad, 2014). It not only serves as a crucial measure of equality and overall welfare (Hemminki, 2014), but it also provides insight into potential health disparities among different racial or ethnic groups in the future, when immigrant children enter adulthood (Mehta et al., 2013). Inequalities in child health based on migration origins are prevalent in certain immigrant-receiving countries, including in France.

France has made remarkable progress in improving child health, both within Europe and globally. The under-five mortality rate (U5MR) is below 4%, which is lower than the European average of 5% (UN IGME, 2019). In contrast, the global average stands at 39%. Despite this overall improvement, disparities persist, especially in infant mortality among the immigrant population (Wallace et al., 2020). This is concerning, particularly because the number of children born to immigrant parents has been growing in France, accounting for

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over 30% of births in 2018 and more than a third of births over the past two decades (Insee, 2023). Moreover, infant mortality has risen recently in France (Claris, 2022; Trinh et al., 2022), despite a significant decline throughout the previous decades (Insee, 2018). In addition, the country has experienced a significant and growing lag in infant mortality compared to other European countries (Breton et al., 2024). This situation is particularly worrying given France's role as a reference point in global public health, and it calls for closer examination of the underlying mechanisms, especially among vulnerable subgroups such as children of immigrant origin. These trends warrant special attention and further investigation.

Numerous studies have examined the health of children based on their migration backgrounds. The outcomes vary depending on the choice of indicators and the countries of origin and destination. For instance, Kinge and Kornstad (2014) found higher infant mortality among children of immigrant women from Africa and Asia in Norway. In the U.S., by contrast, infant mortality among children born to Mexican women was shown to be lower (Hummer et al., 2007). Results may even differ within the same country, depending on the chosen indicators. Previous research highlights a health advantage in terms of birth weight among children of North African immigrants in France and Belgium, as well as among children of Mexican immigrants in the U.S. (Guendelman et al., 1999). However, recent studies in France, based on different data and outcomes, have reignited the discussion on the health of immigrant children. One study documented higher infant mortality among children of Maghreb immigrants (Wallace et al., 2020), while another found an advantage not only in terms of birth weight, but also in terms of preterm births and gestational age among children from the same immigrant group (Florian et al., 2021, 2023).

This study adds to the current literature by addressing three important gaps. First, recent work by Claris (2022) and Trinh et al. (2022) has identified an overall increase in infant mortality in France – a trend that requires further scrutiny (Breton et al., 2024). Second, conflicting findings regarding children of North African immigrant parents (Wallace et al., 2020; Florian et al., 2021, 2023) raise the question of whether a “health advantage” truly exists for this group. By applying the propensity score method, this study seeks to disentangle the effect of migration origin from the influence of confounding variables. In other words, are the disparities in infant health attributable to differences in the distribution of confounding variables or to differences inherent to migration origin (Ma, 2008)? Third, this research introduces two novel dimensions that have been largely overlooked in prior studies: the role of paternal involvement, and the specific consideration of mixed parental origins beyond the migrant status of the mother alone. Finally, by adopting a longitudinal approach, this study aims to fill the gaps in cross-sectional approaches (Grosser et al., 2016), as longitudinal research holds immense potential for generating robust estimates and conducting reliable analyses of determinants (Bocquier et al., 2019).

Background

To better understand the disparities in under-five mortality by migration background, it is essential to examine a set of interrelated factors and theories that have been consistently associated with infant health outcomes in the literature. The following subsections review

key explanatory dimensions that may account for differences in under-five mortality, including parental socio-economic status, social capital, discrimination and country of origin context. These elements form the conceptual basis for the empirical analysis presented in the subsequent sections.

Parental socio-economic status and children's health

Parental socio-economic status (SES), which includes income and education, has been extensively examined in relation to children's health outcomes. Income serves as an indicator of the economic resources available to individuals through capital, employment or wages. Parents with a decent income are more likely to be able to meet their family's essential needs and provide their children with a higher standard of living through healthy nutrition and adequate healthcare. Additionally, a higher standard of living can act as a protective factor against maternal postpartum depression, the most common postnatal complication in western countries, which likely impacts maternal quality of life, family functioning and children's development and health (Nakamura et al., 2020). Moreover, income inequality is strongly correlated with infant mortality across all countries, although the causal nature of this association remains to be confirmed in the short term (Avendano, 2012).

The link between women's education and infant mortality is one of the most consistent and robust findings in public health. A high level of education is likely to improve medical knowledge (Hoffmann et al., 2018), promote healthier practices and provide easier access to economic and social resources (Green and Hamilton, 2019). Empirical evidence supporting the positive link between education and children's health has been provided in numerous studies. For example, Smith-Greenaway (2020) showed that parental education is independently associated with a reduced risk of low birth weight in their children in Sub-Saharan Africa. In addition, a higher level of mother's or father's education is associated with lower infant mortality (Saarela and Finnäs, 2014; Balaj et al., 2021).

Healthy immigrant paradox

The healthy immigrant paradox is attributed to the unexpected health advantages of immigrant groups settled in host countries despite their low SES. Although it has long been discussed in relation to the health of adult immigrants, it can also be observed among children born to immigrant mothers (these children of immigrants are not immigrants themselves, but are sometimes called "second-generation immigrants"). Despite their mothers' disadvantaged SES and limited use of prenatal care, the native-born children of Hispanic women exhibit comparable or even better health outcomes compared to those born to non-immigrant mothers in the U.S. (Mendoza, 2009; Green and Hamilton, 2019). A similar advantage is documented in perinatal outcomes for African and Latin American mothers in Spain (Farré, 2016; Stanek et al., 2020, 2021).

The “healthy immigrant” effect suggests that individuals who migrate to host countries are selected by either the host countries themselves, or through self-selection among predominantly healthy individuals (Nørredam, 2015; Agyemang, 2019). In the context of children’s health, this implies that there is an intergenerational transfer of health advantages, i.e., an indirect selection whereby healthy immigrant women of childbearing age are more likely to give birth to healthy babies. Evidence supporting this selection has been found in various settings, including France, Belgium, Austria, Spain, the U.S. and Canada, with respect to infant mortality or other birth outcomes such as low birth weight, preterm births and gestational age (Farré, 2016; Guendelman et al., 1999; Hummer et al., 2007; Vang et al., 2015; Sow et al., 2019; Florian et al., 2021, 2023).

Social capital

The theory of social capital has been proposed to explain the health advantage experienced by immigrants. As described by Putnam (1993), social capital refers to the attributes of a social organisation, including networks, norms and social trust, which benefit both individuals and society as a whole. Coleman (1988) identified three key components of social capital: obligations and expectations, information channels and social norms. These elements collectively shape social relationships and contribute to the concept of social capital.

To quantify social capital, various measures have been employed at both the individual and the community level, although most of the focus has been on the individual level (Kanas et al., 2012; Allen et al., 2014; Siedlecki et al., 2014; Koelet et al., 2017). Thus, participation in charitable activities, affiliation with a political, apolitical or religious group and any situation that enables social ties to be developed and maintained are individual dimensions of social capital.

At the individual level, social capital can be assessed through both formal support provided by midwives, general practitioners and other health professionals and informal support offered by partners, family members or close acquaintances (Nakamura et al., 2020). Formal support is perceived through the lens of the relationships between caregivers and patients, and when these relationships are strong, they can ensure better pregnancy follow-up and improved birth outcomes. Family support also plays a crucial role in pregnancy outcomes (Benza and Liamputtong, 2014) due to its significant influence on the lifestyles and health-related behaviours of its members (Fortin and Le Gall, 2007). Similarly, it has been suggested that the support of the partner is essential to meet the family’s economic needs, and strong paternal involvement contributes to maternal and child health (Fiori, 2020; Nakamura et al., 2020). Evidence supporting this notion was provided by Gaudino et al. (1999), who showed that paternal support during childbirth had a protective effect against low birth weight and infant mortality.

At the community level, most measures assess the socio-ethnic and economic characteristics of the neighbourhood or area. The most commonly used socio-ethnic dimension is the concentration of immigrants from the same origin in the neighbourhood (Muchow and Bozick, 2022). Van Kemenade et al. (2006) referred to a similar concept when discussing

social networks based on ethnicity. This entails relying on close-knit networks of individuals from the same cultural background, which promote immigrants' economic and social integration (Van Kemenade et al., 2006; Gill and Bialski, 2011), as well as improving their understanding of the healthcare system (Albertini Fröh et al., 2017) and their well-being (Van Kemenade et al., 2006; Zhao et al., 2010). The impact of these networks on children's health has also been documented. As shown by Zeitlin et al. (2011), there is an inverse relationship between the proportion of immigrants in the neighbourhood and preterm births among women from Sub-Saharan Africa, and a positive correlation among women born in France. In a cross-sectional ecological study, social capital at a level below the state (trust, association membership) was found to be strongly associated with higher infant mortality rates among Blacks (Kawachi et al., 1997).

The link between the socio-economic dimension of neighbourhoods and children's health has been the subject of numerous studies. Clausen et al. (2006) showed that the risk of pregnancy complications was higher in residential areas of Oslo East with lower SES. Furthermore, Spencer et al. (1999) and Bundred et al. (2003) found that the most deprived neighbourhoods or areas in England (in the north) had higher levels of low birth weight. Even more detailed analyses conducted in the U.S. have confirmed the link between neighbourhood socio-economic level and children's health. In a multilevel cross-sectional analysis, Buka et al. (2003) put these links into perspective by showing a significant decrease in average birth weight as the level of economic disadvantage in the neighbourhood increased, and only for African-American mothers. The findings of Calling et al. (2011), which report an increase in infant mortality in neighbourhoods with high levels of deprivation in Sweden, support the hypothesis that neighbourhood factors are significantly associated with infant health.

Various mechanisms may explain the links between the socio-ethnic and economic characteristics of neighbourhoods and adverse health outcomes in children. Numerous studies have suggested that residential segregation underlies these associations. Indeed, highly segregated areas tend to experience elevated unemployment and crime rates (van San, 2004; Bolt et al., 2010; Balascio et al., 2023), poverty (Schaut, 2001; van San, 2004; Musterd et al., 2008), social tensions, riots and insecurity (Schaut, 2001), which can expose residents to chronic or acute stressors and depression. Additionally, these areas are often sites of racism and discrimination (Osypuk and Acevedo-Garcia, 2008; Balascio et al., 2023), which can induce stress and influence health behaviours (Janevic et al., 2021). Such psycho-social factors have been linked to preterm birth and pregnancy complications (Misra et al., 2001). Another potential mechanism is inadequate language proficiency in highly segregated areas (Bolt et al., 2010), which may hinder understanding of health promotion messages and affect communication between immigrant women and healthcare providers during prenatal and postnatal visits.

Discrimination

Several studies have examined the interactions between caregivers and patients, with a specific focus on discrimination and its role in contributing to health disparities.

A recent United Nations analysis of Black women's experiences during pregnancy and childbirth in the Americas concluded that systemic racism in medical systems is one of the main reasons they are more likely to experience serious complications (UNFPA, 2023). Numerous ethnographic studies in France have documented discrimination against women of foreign origin in hospitals at the time of gynaecological and prenatal consultations and during or after childbirth (Fassin, 2000; Saurel-Cubizolles et al., 2017; Ouanhnon et al., 2022). This can contribute to inequalities in birth outcomes. Increased preterm births, low birthweight and low gestational age outcomes among women who have experienced discrimination (Rich-Edwards et al., 2001; Rosenberg et al., 2002; Mustillo et al., 2004; Giurgescu et al., 2011; Daalen et al., 2022) are illustrative of the link between (the perception of) discrimination and adverse birth outcomes. Indeed, racial discrimination or discrimination linked to migration origin can act on children health's through several mechanisms. It can, via the psychological stress and immunodepression it engenders, stimulate the production of corticotropin-releasing hormone in the placenta, which may in turn increase the risk of preterm delivery (Rich-Edwards et al., 2001). Moreover, discrimination in hospitals can exacerbate tensions during prenatal or postnatal consultations, which can lead to the refusal of care during pregnancy, and thus have a negative impact on pregnancy follow-up. Finally, risky behaviours (smoking, alcohol and psychoactive substance use, etc.) during pregnancy may be a response to the chronic stress generated by racial discrimination (Rosenberg et al., 2002; Brondolo et al., 2009). These risky behaviours, as well as indicators of child health such as preterm births, low birthweight and gestational age, are important predictors of infant mortality (Evans and Alberman, 1989; Reichman and Teitler, 2006; Farré, 2016; Štúpková, 2016; Ballon et al., 2019; Kihal-Talantikite et al., 2019).

Country of origin context

Only a few studies in the literature deal with the context of the country of origin. One such study is Kinge and Kornstad (2014), who focused on infant mortality differentials according to migration origin in Norway. Using the mortality rates prevailing in the mother's country of origin as a proxy for the socio-sanitary characteristics of the country of origin, they found that immigrants from countries with high infant mortality rates have a higher infant mortality rate in Norway. According to them, the attributes of the country of origin are likely to influence the factors associated with infant mortality in the host country.

This finding is consistent with the observation of Väisänen et al. (2022) that women from the poorest countries have the worst reproductive health. This means that "the inequalities observed in a global scale in countries' economic outcomes may reproduce themselves as reproductive health inequalities among migrants living in wealthy countries" (Väisänen et al., 2022). Differences in cultural and environmental factors between the country of origin and the host country, perceptions of healthcare services and a general lack of knowledge about the host country's healthcare system may explain these disparities.

Hypotheses

Based on the aforementioned theories, we have formulated the following four hypotheses:

- Considering the effect of migration origin on children's health and the link between a country's level of development and infant mortality, we posit that disparities in under-five mortality are not only explained by migration origin, but also exhibit a hierarchy based on the level of development of the immigrants' regions of origin (H_1).
- Based on the effect of mixed unions on improving the SES and integration of immigrants, as documented in other studies (Meng and Meurs, 2009; Rodríguez-García, 2015), and the protective effect of parental SES on children's health, we propose hypothesis 2 (H_2): children of mixed-origin parents have mortality risks equivalent to those of children born to native parents, which may be attributed to the integration facilitated by mixed unions and the resulting economic and socio-professional advantages.
- Our third hypothesis (H_3), which is based on the positive benefits of social capital, indicates that paternal support, which includes the psychological and material support provided to the mother, reduces the risk of under-five mortality.
- Our fourth hypothesis (H_4) suggests that living in a neighbourhood with a high concentration of residents of similar migrant origin is associated with higher under-five mortality.

Methodology

Database description

This study uses data from the permanent demographic sample (EDP). The EDP is France's largest socio-demographic panel. It is compiled and regularly updated by INSEE (the French Institute for Statistics and Economic Studies) from a number of files, including birth and death certificates and census data. Eligibility for the sample is based on date of birth. Prior to 2004, the sample consists of individuals born between 1 and 4 October, and from 2004 onwards, it consists of individuals born in the first four days of the first month of each quarter. Our sample contains 687,535 births from 1990 to 2020, which are representative of all births in France. The number of deaths under age five in the sample is 3024. The implementation of the longitudinal analysis is heavily based on the tools developed by Bocquier et al. (2019) for longitudinal data management and analysis within the framework of the event history analysis method in Stata.

Data structuring

To provide our dataset with a longitudinal structure, we have converted from a wide format (individual-level data) to a long format, with each row representing one follow-up period

per individual. This person-period file structure documents each event experienced by an individual in a single entry, containing the individual's identifier, birth date, event type, event date and residency status (binary variable indicating whether or not the individual lives in France at that time). Key residence events, or events that modify the residence status, include births, deaths and end-of-observation.

To ensure temporal ordering and avoid simultaneity (a time gap should separate each event from the next), we have converted dates to milliseconds, assigning distinct times for each event type. This is made possible by the time precision of the data or the precision of the recorded dates, which are in day-month-year format. For instance, birth dates are set to 06:00:00, while death dates are set to 18:00:00. This avoids any confusion between individuals who were born and died on the same day. Thus, babies who died on the same day they were born will always die 12 hours after they were born. All individuals are right-censored as of 31 December 2020, 00:00:00, ensuring a uniform end date across the dataset.

Variables

The outcome variable is death occurring before the child's fifth birthday. This is the probability of survival to the age of five (5q0). The independent variable is the parental origin measured by the country of birth of the parent (father or mother). Six categories of origin are identified: Sub-Saharan Africa, North Africa, Eastern Europe, other European regions, Asia and an "other" group including America, Oceania and other regions. These categories are compared with French-born or native mothers.

The mixed parenting variable allows for the distinction of four categories of children: those born to two immigrant parents, those born to two native parents, those born to an immigrant mother and a native father and a final category of children born to an immigrant father and a native mother. For simplicity, the last two categories are considered to indicate mixed parenting, given the methodological ambiguity surrounding the measurement of mixed parenthood or mixed unions (Rodríguez-García, 2015). For greater precision on this variable, we have combined it with migration origins.

By focusing on the variable associated with the support of the father during the child's birth, we can use the availability of the father's date of birth on the birth certificate. In other contexts, this has been used as a proxy for measuring paternal recognition (Castro-Martin, 2010). While this variable may capture a certain level of support, we think it is insufficient to encompass all dimensions, albeit indirectly. Hence, we combine it with another variable indicating whether the child's name includes only the father's name, only the mother's name or both parents' names. This enables us to construct a comprehensive variable representing the father's support. We assume that if the father's name and date of birth are listed on the birth certificate, this indicates that the father provided some level of support to the child at the time of birth. Consequently, we derive a binary variable indicating whether or not the father was providing support to the child.

Our methodology for determining the proportion of immigrant children born within the municipality (PICM) is based on the approach used by Muchow and Bozick (2022) to quantify social capital through co-ethnic proximity. Indeed, immigration patterns and

the distribution of immigrant communities can vary significantly across municipalities. Certain municipalities may have higher concentrations of immigrants, potentially creating distinct community dynamics, including stronger or weaker social support systems. By using the municipality as the spatial unit, the analysis is sensitive to these local variations in immigrant population density and the associated effects on social capital and access to resources. In addition, this proportion may be specific to the years preceding each birth or to the years that each child is exposed to the risk of dying.

Thus, by aggregating the data from the EDP at the municipal level, taking into account the year of exposure to the risk of death for each child, we obtain the PICM indicator as follows:

$$PICM = \frac{n}{N} \quad (1)$$

where n is the number of births to immigrant women in the municipality (of birth) during the year of birth and N is the total number of births in the same municipality in the same year.

Model specification

In order to assess the impact of migration origin on under-five mortality (U5M), the Weibull model is used. This model is chosen because of the similarity of the curve of the U5M hazard function to that of a probability density function of a Weibull distribution (Figure S.1, Supplementary material, available online at <https://doi.org/p-fdgp-bgc3>). The Weibull distribution, which belongs to the family of parametric probability distributions along with the normal and exponential distributions, offers some distinct advantages. As a properly specified parametric model, it helps to address the statistical challenges that arise from limited event occurrences (Schöley, 2019), such as the deaths occurring before one year.

Three models are implemented. We include the logit of PICM in the first (M1) and second (M2) models to analyse the effect of a 1% increase in PICM from PICM = 0.5 on the risk of infant death, with mixed parenting and mixed parenting by region of origin as the main independent variables. According to Ferrari and Cribari-Neto (2004), applying a logit transformation to bounded continuous variables helps to avoid issues related to constant marginal effects in standard linear regression models. The transformation ensures that predictions remain within the [0,1] interval while making the dependent variable unbounded, thus facilitating estimation. We estimate the third model (M3) by including the interaction terms between PICM and migration origins while using PICM as a categorical variable. This allows us to distinguish a low proportion (PICM−) when PICM is less than 0.5 and a high proportion (PICM+) when PICM is equal to or greater than 0.5.

Alongside these variables, we adjust for several other infant and parental characteristics using the propensity score method. These include the child's sex, multiple birth and region of birth in France, distinguishing between children born in mainland France and those born in overseas territories. The same applies to variables related to parents such as the age of the

mother or the father at the child's birth; the father's socio-professional category (SPC),¹ grouped as higher (SPC+) vs lower (SPC-); and parental marital status, indicating whether the parents are or are not married. The mother's SPC is not considered due to the poorer quality of this variable (26% missing values), which is linked in particular to the uncertainty of the "inactive" and "unknown" categories, which are over-represented at the time of child-birth, when many women are on maternity leave (Niel, 2011).

These variables are introduced into the models in the form of a weighting variable used to balance children of immigrant mothers (CIM) and children of native mothers (CNM) on these characteristics using the propensity score method (Rosenbaum and Rubin, 1983). For more information on this method, please see the online supplementary material.

Results

Descriptive analysis

Description of the sample

Table 1 describes the sample according to migration origin and mixed parenting, the main independent variables of interest. The sample covers 3,073,831 person-years, with 3024 deaths in the first five years of the child's life.

Propensity score

Figure 1 provides a concise overview of the mean or standardised proportional differences across all covariates used in the propensity score method. Each point on the plot represents the equilibrium statistic for a specific covariate, colour-coded to indicate whether it is calculated before (unadjusted) or after weighting (adjusted). The dotted lines depict the threshold set to visualise equilibrium.

After applying the weighting, all data points now fall within the acceptable threshold, indicating that equilibrium has been reached. Additionally, the noticeable leftward shift in both the average age difference (between CIM and CNM) of the father and the proportion of married parents suggests that these two variables have achieved the best balance in the dataset.

The univariate visual graphic of the propensity score is an additional tool for assessing its balancing characteristic, as shown in Figure 2. This graph shows the distribution of non-parametric estimate of the density propensity scores (pscore) for CIM and CNM, before and after adjustment. As a reminder, the propensity score is the predicted probabilities of treatment, computed from a single model for all children.

The distributional balance for the propensity score serves as a benchmark to assess the comparability of the groups, ensuring that CIM and CNM have sufficient similarities to allow for meaningful comparisons (Lecocq et al., 2016).

1 SPC+ includes agriculture, commerce, crafts, management and intermediate professions. Employees, workers, inactive people or people of unknown activity are included in SPC-.

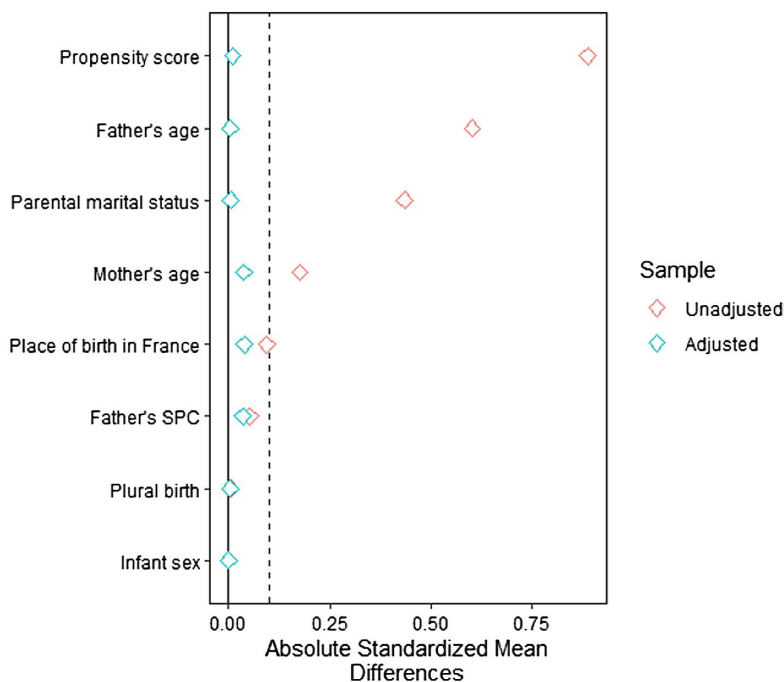
Table 1 Description of the sample

Parents' region of origin		Person-years	%	Deaths
Maternal origin				
French-born		2458879.96	79.99	2203
Sub-Saharan Africa		129518.04	4.21	246
North Africa		215500.61	7.01	267
Eastern Europe		32056.78	1.04	38
Other European regions		68183.80	2.22	64
Asia		86741.43	2.82	92
Other		82950.04	2.70	114
Mixed parenting				
<i>Mother</i>	<i>Father</i>			
Immigrant	Immigrant	363742.33	11.83	511
Native	Native	2122483.47	69.05	1747
Native	Immigrant	311736.34	10.14	399
Immigrant	Native	275868.52	8.98	367
Mixed parenting by region of origin				
Both parents are natives		2122483.5	69.05	1747
Both parents are from Sub-Saharan Africa		84349.37	2.74	167
Sub-Saharan African and native parents		74827.46	2.43	114
Both parents are from North Africa		142862.88	4.65	184
North African and native parents		169037.82	5.50	190
Both parents are from Eastern Europe		16018.58	0.52	26
Eastern European and native parents		15106.86	0.49	11
Both parents are from other European regions		25880.86	0.84	19
Other European and native parents		75371.81	2.45	68
Both parents are from Asia		59109.50	1.92	67
Asian and native parents		45880.32	1.49	44
Other		242901.70	7.90	387
Total		3073830.66	100.00	3024

Source: Author's calculations based on the permanent demographic sample (EDP), 1990–2020

In the left panel (unadjusted sample), there is a noticeable difference between the two groups' distributions. The density for CIM peaks at higher propensity scores, while the density for CNM is lower and is centred around intermediate scores, indicating initial heterogeneity between the groups in terms of covariates. By way of illustration, only 16% of CIM have a propensity score above 0.5.

In the right panel (adjusted sample), the distributions are almost overlapping after adjustment, suggesting that the adjustment improves covariate balance between CIM

Figure 1 Equilibrium statistics before and after weighting

Source: Author's calculations based on the permanent demographic sample (EDP), 1990–2020

and CNM groups, thereby enhancing comparability and reducing selection bias in further analyses.

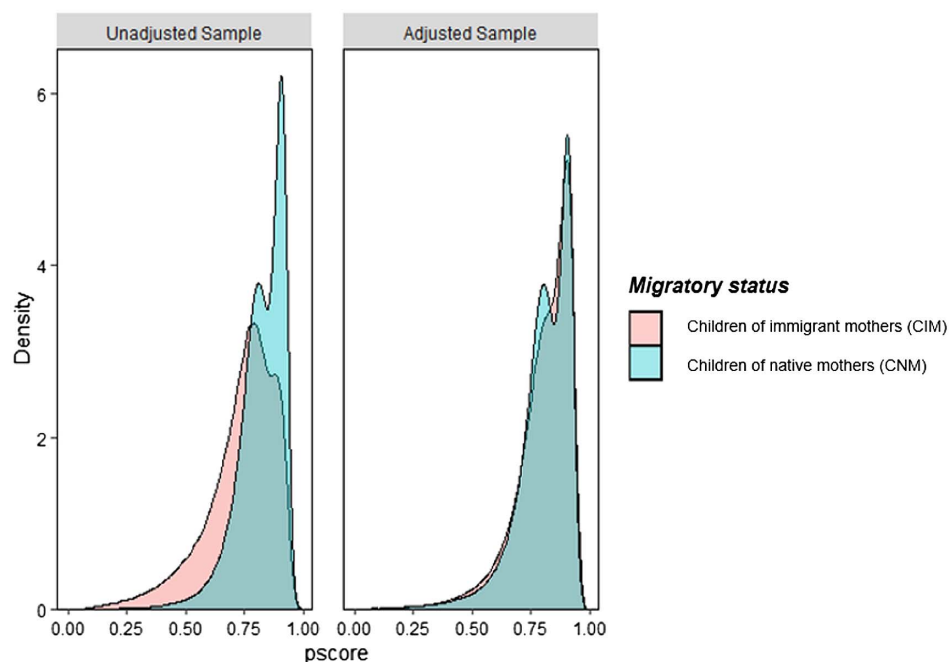
The higher frequency of high scores, even in the untreated group, also reflects the effect of covariates that generally increase the probability of treatment for both groups. This could also be explained by the inclusion of variables in our model that positively influence the likelihood of belonging to the treated group, with limited differentiation between CNM and CIM for certain profiles. As a result, lower scores are less frequent in the untreated group, corresponding to an expected asymmetrical distribution.

In summary, the propensity score method successfully achieves a balance in the characteristics between the two groups, albeit with some minor residual imbalances.

Multivariate analysis

Figure 3 presents results of the unadjusted (before weighting) and adjusted (after weighting) models

When the hazard ratio is compared before and after weighting, mortality inequalities persist between CIM and CNM. The results with the adjustment for covariates reveal a higher

Figure 2 Distributional balance for propensity score

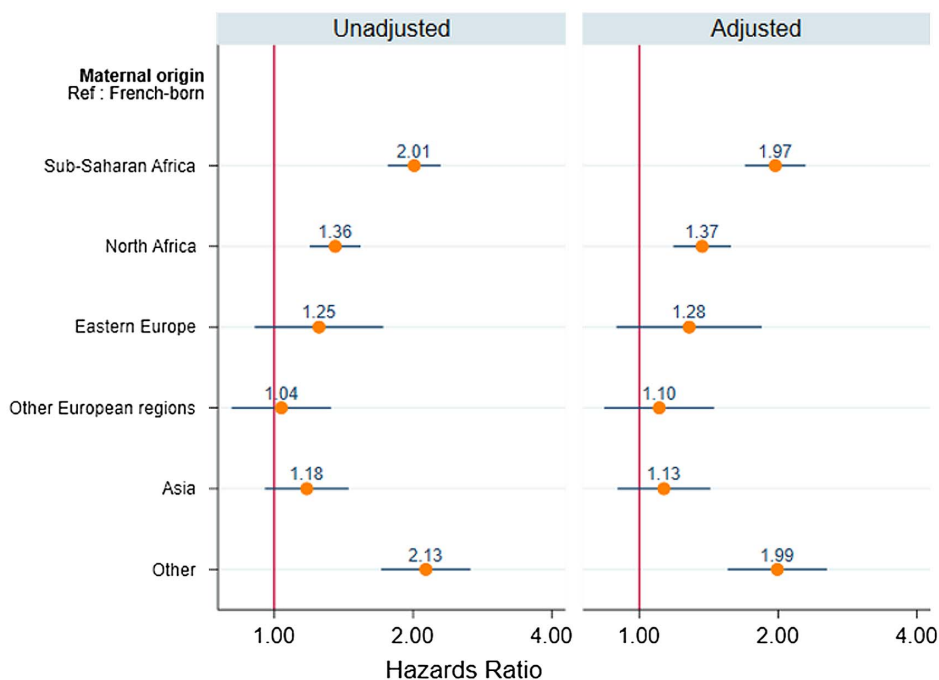
Source: Author's calculations based on the permanent demographic sample (EDP), 1990–2020

U5M among children born to immigrant mothers, except for those from Europe and Asia. Specifically, children of Sub-Saharan African mothers are twice as exposed to the risk of U5M as children of natives. For children of North African mothers, the risk is 1.18 to 1.57 higher, while for children of the group including America, Oceania and other regions, the risk is 1.55 to 2.55 higher. These persistent disparities, despite the adjustment of covariates, are likely attributable to migration origin (Ma, 2008), indicating its central role in the shaping of U5M inequalities independent of other characteristics, and thus confirming our first hypothesis (H_1).

Table 2 displays the results of three Weibull models (M1, M2 and M3) in which child and parent characteristics are used as control variables.

In terms of the impact of mixed parenting on U5M, its protective effect has not been shown. The risk of U5M for children born to mixed parents remains high compared to that for children born to two native parents. Even when distinguishing between the regions of origin, the mortality risk remains higher, although it decreases for children born to mixed parents, as shown in M2. This result, which does not prove the protective effect of being born to mixed parents, lends support to the second hypothesis (H_2).

Our results provide support for the association between paternal support and the proportion of immigrant children in the municipality (PICM), both independently and with

Figure 3 Hazard ratio of U5M before and after weighting

Source: Author's calculations based on the permanent demographic sample (EDP), 1990–2020

potential interactions with migration origins. These models reveal that paternal support during childbirth plays an essential role in reducing under-five mortality. These results, which are consistent with the third hypothesis (H_3), further underline the importance of paternal involvement in child health.

In terms of the impact of the PICM, the results reveal a remarkably significant association. Specifically, being born in a municipality with a high (vs low) proportion of immigrant children significantly increases under-five mortality (U5M). Through the interaction effect between the proportion of immigrant children and migration origins in M3, it is evident that children of French natives born in a municipality with a high proportion of immigrant children exhibit higher U5M. The results indicate that excess mortality among children of women from Sub-Saharan Africa persists regardless of the type of municipality of birth, whereas excess mortality among children of women from North Africa is only observed among those born in a municipality with a low proportion of immigrant children.

By comparing the weighted and unweighted coefficients, the results indicate that the weighted coefficients partially correct the estimation biases observed in the unweighted coefficients, with greater precision in parameter estimation. This is demonstrated, for example, by a narrower confidence interval in the weighted models than in the unweighted models.

Table 2 Weibull models of under-five mortality weighted (or not) through optimal matching

Variables	M1		M2		M3	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Mixed parenting						
Both parents are immigrants	1.47*** (1.33–1.62)	1.48*** (1.39–1.55)				
Immigrant mother and native father	1.27** (1.12–1.44)	1.27** (1.09–1.33)				
Immigrant father and native mother	1.25** (1.09–1.43)	1.15** (1.08–1.34)				
Both parents are natives		Ref				
Mixed parenting by region of origin						
Both parents are from Sub-Saharan Africa			1.93*** (1.59–2.34)	1.94*** (1.67–2.27)		
Sub-Saharan African and native parents			1.50** (1.11–6.93)	1.54*** (1.28–1.86)		
Both parents are from North Africa			1.44*** (1.25–1.67)	1.49*** (1.24–1.78)		
North African and native parents			1.26* (1.04–1.52)	1.28** (1.11–1.48)		
Both parents are from Eastern Europe			1.43 (0.97–2.11)	1.50* (1.27–2.32)		
Eastern European and native parents			0.74 (0.41–1.35)	0.47 (0.23–1.07)		
Both parents are from other European regions			0.98 (0.58–1.63)	0.85 (0.57–1.29)		
Other European and native parents			0.90 (0.66–1.23)	1.04 (0.83–1.31)		

(table continues)

Table 2 (continued)

Variables	M1		M2		M3	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Both parents are from Asia			1.28* (1.02–1.62)	1.33 (0.98–1.78)		
Asian and native parents			0.95 (0.65–1.38)	1.06 (0.80–1.42)		
Both parents are natives			Ref			
Proxy for paternal support						
Yes	0.56*** (0.50–0.63)	0.54*** (0.45–0.65)	0.56*** (0.47–0.68)	0.57*** (0.51–0.65)		
No	Ref		Ref			
Proportion of immigrant children in municipality (Logit of PICM)	1.10*** (1.05–1.16)	1.12*** (1.08–1.17)	1.11*** (1.07–1.15)	1.07** (1.02–1.13)		
PICM x Migration origins						
French-born x PICM+					1.67*** (1.35–2.18)	1.98*** (1.62–2.43)
French-born x PICM–					Ref	
Sub-Saharan Africa x PICM+					2.37*** (1.89–3.33)	2.05*** (1.51–2.78)
Sub-Saharan Africa x PICM–					1.95*** (1.65–2.46)	1.98*** (1.65–2.37)
North Africa x PICM+					1.25 (0.88–2.09)	1.27 (0.84–1.91)
North Africa x PICM–					1.48*** (1.30–1.77)	1.53*** (1.31–1.78)

(table continues)

Table 2 (continued)

Variables	M1		M2		M3	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Eastern Europe x PICM+					1.66 (0.75–4.73)	1.73 (0.65–4.61)
Eastern Europe x PICM–					1.14 (0.81–2.22)	1.33 (0.90–1.97)
Other European regions x PICM+					0.87 (0.28–3.78)	1.58 (0.60–4.12)
Other European regions x PICM–					0.98 (0.76–1.56)	1.03 (0.76–1.40)
Asia x PICM+					0.91 (0.50–1.93)	0.90 (0.45–1.81)
Asia x PICM–					1.33 (1.08–1.77)	1.26 (0.98–1.61)

Note: Models are weighted through optimal matching (propensity score is computed with the following covariates: infant sex, plural birth, place of birth in France, father's socio-professional category, mother's marital status and age of the father and the mother at the child's birth; see Figure 1). Values above one indicate an increased hazard of under-five mortality, while values below one indicate a reduced hazard, relative to the reference group. PICM+ indicates a high (>=0.5) proportion while PICM– indicates a low proportion. 95% CIs are in parentheses: ***p<0.001; **p<0.01; *p<0.05.

Source: Author's calculations based on the permanent demographic sample (EDP), 1990–2020

Discussion

The persistence of disparities, even after adjusting for covariates, highlights the significant impact of migration origin on inequalities in child health. Our results are in line with previous studies that have already documented excess mortality among infants born to mothers from Sub-Saharan Africa and North Africa (Niel, 2011; Wallace et al., 2020). Compared to French women, these mothers are more likely to experience pregnancy-related hypertension; to have low rates of pregnancy declaration or delayed declaration (Deneux-Tharaux et al., 2009); and to receive inadequate prenatal care and follow-up (Niel, 2011). In addition, these women often have lower SES than women born in France (Zeitlin et al., 2011) and face a disproportionate burden of discrimination (Défenseur des droits, 2019). Simultaneously, these findings could reflect the impact of the origin context, given that African countries exhibit the highest rates of infant mortality globally.

These large disparities in under-five mortality between children of immigrant mothers and children of native mothers could be part of a context of rising infant mortality in France, which is itself linked to the increase in discrimination against immigrant women in France (Pestre et al., 2016). These disparities could therefore be the result of increased discrimination in health services, given the link between discrimination and birth outcomes (Rich-Edwards et al., 2001; Mustillo et al., 2004; Giurgescu et al., 2011; Daalen et al., 2022).

Although migrant women from Eastern Europe arrived in France as recently as migrant women from Sub-Saharan Africa, our findings did not reveal any significant excess under-five mortality (U5M) among these groups. A similar pattern emerges for Asian mothers, consistent with the research conducted by Mehta et al. (2013), which documented favourable health outcomes across 17 health indicators for Asian origin mothers compared to other ethnic groups in U.S. These findings are also supported by research showing that Chinese newborns had satisfactory birth weights that were not statistically different from those of children born in France and Spain (Rovillé-Sausse and Prado Martinez, 2009). In addition, some Asian groups have relatively favourable health behaviours (Wallace and Kulu, 2014). Finally, it is important to note that our findings present a contrast to the concept of the healthy immigrant paradox. The health advantages documented for infants born to North African mothers (Florian et al., 2021, 2023) seem to be more associated with sample bias rather than with an intergenerational transfer of health advantages. As several studies have pointed out, the ELFE² cohort, which is the database used in these previous studies, suffers from selective attrition, excluding more immigrant women (Bournez et al., 2018; Nakamura et al., 2020; Kadawathagedara et al., 2021). Bournez et al. (2018) reported a particularly high rate refusal rate of around 51% among people of low SES, including immigrant women.

The results on the impact of mixed parenting on U5M are surprising given that mixed unions, and therefore mixed parenting, are considered to facilitate social integration (Kalmijn, 1998; Kulu and González-Ferrer, 2014) and economic integration (Meng and Meurs, 2009),

2 ELFE is the French Longitudinal Study of Childhood, the first national longitudinal study of children, addressing the many aspects of their lives from the perspectives of social science, health and the environment. It follows more than 18,000 children born in mainland France in 2011.

which in turn enable parents to have adequate resources to care for their children. These results can be viewed from the perspective of the fragility of mixed unions, as shown in some studies (Goldstein and Harknett, 2006; Rodríguez García and Miguel Luken, 2015), which could, through the deprivation of resources, impact the health of both the mother and the child.

The positive association we observe between paternal support and under-five mortality is in line with the findings of Gaudino et al. (1999), who showed that paternal involvement, as indicated by the inclusion of the father's name on the birth certificate, offers protection against low birth weight and infant mortality in Georgia (U.S.). Furthermore, our results are consistent with studies showing significantly higher adverse outcomes among U.S. mothers with limited or no partner information on their child's birth certificate (Tan et al., 2004; DeSisto et al., 2018).

By contrast, our results on the link between the proportion of immigrant children in the municipality and children's health diverge from the findings of Zeitlin et al. (2011), who observed in France, specifically in the Seine-Saint-Denis district, an inverse association between the proportion of immigrants in the neighbourhood and preterm births among Sub-Saharan African women. These discrepancies can be explained in several ways. Zeitlin's methodological approach takes account of the hierarchical structure of the data using a multi-level logistic model. Additionally, the analyses were limited to the Seine-Saint-Denis district, so the conclusions cannot be generalised to the whole of France. Moreover, several studies conducted in other contexts have reported contradictory results, depending on the immigrant groups considered, regarding the effect of this variable on children's health (Fang et al., 1999; Pearl et al., 2001; Kaufman et al., 2003; Reagan and Salsberry, 2005), which suggests that caution is needed when interpreting such a variable.

Our observation that a higher proportion of immigrant children in the municipality is associated with a significant risk of U5M for CNM and some CIM is important for child health outcomes. The aggregation of immigrants in a specific area or the clustering of births to children of immigrants could be a catalyst for social cohesion and the promotion of various forms of solidarity and mutual assistance, which can have a positive impact on health outcomes. However, our results highlight its association with excess mortality in children, which is consistent with the literature. Does it reflect the adverse effects of ghettoisation on child survival? Providing a definitive answer to this question is challenging. One possible interpretation may be the spread of risky health behaviours in these segregated areas. Adverse health behaviours, such as deciding against an abortion in the event of a high-risk pregnancy, non-compliance with the vaccination schedule and late detection of abnormalities, particularly in the case of maternity or perinatal care (Fortin and Le Gall, 2007), may be influenced or even reinforced by the community through cultural norms (Mendoza, 2009). In addition, segregated areas are often plagued by insecurity and high unemployment (van San, 2004; Bolt et al., 2010; Balascio et al., 2023), which can expose their inhabitants to stress and risky health behaviours, the effects of which on preterm births and pregnancy complications have been demonstrated (Misra et al., 2001).

Finally, it should be noted that reverse causality is also possible. Our results may overshadow the influence of other factors, including the insufficient availability of social and healthcare services and infrastructure within these areas. As a higher proportion of immigrants is often found in working-class neighbourhoods and sometimes in depressed or

impoverished communities, the higher under-five mortality among native and immigrant women in these areas could be explained by the lower living conditions rather than the relative proportion of immigrants.

These findings contribute meaningfully to the growing literature on infant health disparities by migration background in France and Europe. In contrast to the widely debated healthy migrant paradox, which posits that some migrant groups have better health outcomes than natives despite their lower SES, our results challenge this assumption, particularly in the case of children of Sub-Saharan and North African immigrants. One of the key contributions of this study lies in its comprehensive analytical framework, which goes beyond maternal origin to include paternal involvement and mixed parental origins. These dimensions have often been overlooked in previous studies and offer a more nuanced view of how social disadvantage is transmitted across generations. To address the potential confounding effect of observed covariates, we used the propensity score method, which allowed us to isolate the impact of migrant status on under-five mortality. This approach shows that the poorer outcomes of certain immigrant groups cannot be entirely attributed to socio-economic background, and may indeed reflect the disadvantage associated with migrant status itself. However, it remains uncertain whether the available data are sufficient to fully capture the complexity of this issue. Important factors such as medical conditions, income, living standards, informal support and maternal health behaviours during pregnancy were not included in the propensity score adjustment. This limitation reflects the constraints of both the data and the methodological approach used. Moreover, our findings underscore a broader structural issue: disentangling the effects of migration status from those of SES is particularly challenging, especially in contexts where the two factors intersect and compound vulnerability. While some migrant groups (e.g., from other European countries) do not show worse outcomes than natives, some children born to natives living in deprived areas also experience higher mortality risks. This indicates that neighbourhood effects, social services availability and systemic inequalities are critical determinants of child survival in addition to individual characteristics.

Conclusion

The aim of this study was to clarify the role of migration origin in under-five mortality, while examining other factors such as mixed parenting, the proportion of immigrant children born in the municipality and paternal support. The survival analysis method enabled us to consider the person-years at risk in different birth cohorts and the events associated with them in order to obtain reliable regression estimates from quality data. Using the propensity score instead of directly including some socio-economic covariates in the regression, we were able to address bias in the measure of the immigrant-native gap arising from differences in observable characteristics (Rosenbaum and Rubin, 1983).

This research is not without limitations. Indeed, while the propensity score method is a valuable tool in our study, it is sensitive to the choice of variables. It focuses primarily on selection based on observable characteristics, while neglecting unobservable factors (Lecocq et al., 2016). Another limitation is the operationalisation of paternal support.

In France, despite a 2005 law allowing parents to freely choose their child's surname, the tradition of giving children their father's surname remains prevalent. Thus, in 2018, around 91% of children had their father's surname, either alone or in combination with their mother's surname (Breton et al., 2020). While our results indicate that paternal support, as measured by the inclusion of the father's name and age on the birth certificate, is associated with protection against U5M, we lack information on why this information has been omitted from some birth certificates, or on whether it really reflects involvement or support during pregnancy.

Despite these drawbacks, event history analysis associated with propensity score weighting effectively reveals disparities between CIM and CNM while mitigating the effect of socio-economic disparities, and allows us to confirm the importance of the role of migration origin in inequalities in under-five mortality. Our results on excess infant mortality among children born to North African women contradict the epidemiological paradox found by certain recent studies on children's health in France. Our research enriches the literature on children's health based on migration origin by highlighting the negative association between the high proportion of immigrant children born in the municipality and children's health, and emphasising the crucial role of paternal support in child survival.

Supplementary material

Available online at <https://doi.org/10.1553/p-fdgp-bgc3>

Supplementary file 1. Weibull model (S1); Propensity score method (S2)



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